National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling

The History of Offshore Oil and Gas in the United States

(Long Version)

Staff Working Paper No. 22

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March 1938 was an eventful month in the world of oil. The government of Mexico nationalized its oil industry, establishing a precedent for later nationalizations elsewhere. A hemisphere away, Standard Oil of California (later, Chevron) completed the first discovery well in Saudi Arabia, the greatest oil find of all time. These events overshadowed another milestone that took place in the Gulf of Mexico that very month – the first production of offshore oil.

Beginning in the 1890s, oil companies had drilled wells in the ocean, but from wooden piers connected to shore. In the 1930s, Texaco and Shell Oil deployed moveable barges to drill in the South Louisiana marshes, which were protected from extreme conditions in the ocean. In 1937, two independent firms, Pure Oil and Superior Oil, finally plunged away from the shoreline, hiring the East Texas construction company, Brown & Root, to build the first freestanding structure in the ocean. It was located on Gulf of Mexico State Lease No. 1, in fourteen feet of water, a mile-and-a-half offshore and thirteen miles from Cameron, Louisiana, the nearest coastal community. In March 1938, this structure brought in the first well from what was named the Creole Field.[1]

The Creole platform severed oil extraction from land. Just as importantly, it did so profitably. When future generations look back on the history of oil, they may see this event as equal in importance to the other two developments set in motion in the spring of 1938. The march of innovation into ever-deeper waters and new geological environments offshore is already one of the most important stories in the history of the oil business, if not modern business in general. The largest additions to world hydrocarbon reserves and production during the next several decades will likely come from offshore and increasingly from "deepwater," beyond 1,000-foot depths.

The Gulf of Mexico is where the offshore and deepwater drilling began, and it remains a vital source of oil and gas for the United States. Its geology is complicated, but enticing. The large, sand-rich depositional system of the Mississippi River that spilled onto the continental margin for tens of millions of years created a world-class petroleum province. The salt domes that pocked the Gulf Coast provided excellent traps for oil and gas, which became easier to decipher over time.[2] Prior to 1938, oil hunters had made hundreds of discoveries under the Louisiana and Texas coastal plain. There was no reason to believe that this geology would stop at the shoreline.

The Creole platform highlighted the risks as well as rewards encountered offshore. A hurricane knocked out many of the pilings during the early phase of construction. The lack of crew quarters on the platform created hardship for workers commuting back and forth from shore on shrimp boats in choppy seas. Many more challenges lay ahead. The marine environment imposed a unique set of hazards for oil companies trying to adapt land-drilling methods offshore. They would have to squeeze complex drilling and production facilities onto small platforms standing or floating in open water. Building and operating such structures, in a part of the ocean that was exposed to hurricane-force winds and waves, initially called for untested designs and procedures. High costs intensified the time pressures to find solutions to these challenges and speed up work. The remoteness of facilities and their space constraints amplified the perils of working under adverse conditions with dangerous equipment and combustible materials. "Nobody really knew what they were doing at that time," recalled a member of Kerr-McGee's earliest offshore drilling crew. "It was blow-by-blow. And it wasn't easy living out there."[3]

Each step into deeper waters posed new and daunting challenges. As geologists and drillers chased opportunities and made discoveries in deeper water, existing production technology could be pushed only so far. Development would stall at a limiting depth, sometimes for several years, until advances were made to catch up with exploration. Blowouts, drilling vessel disasters, and platform failures often forced engineers back to the drawing board. Steadily, the offshore industry pioneered ways of meeting economic and environmental challenges offshore, first in the Gulf and then around the world. But the risks never went away.

Wading Into Shallow Water

The concerted push offshore came after the Second World War, which put development on hold as oil companies diverted their attention to mobilization. On August 15, 1945, the day after the Japanese surrender in the Pacific War, the United States lifted gasoline and fuel oil rations. The roar of car engines filled streets and highways everywhere. Soon, bulldozers were grading miles of new roads to usher families into sprouting suburban neighborhoods. Americans renewed their love affair with the automobile, which once again could provide a degree of mobility and independence that always had appealed to American sensibilities. In the first five years after the war, they bought an astounding 14 million automobiles, increasing the number of cars in service to 40 million. The average car in the United States annually traveled a distance equal to halfway around the world (12,500 miles). By 1954, Americans purchased 7 million tankfuls of gasoline per day.[4] Booming demand for gasoline and other oil products caught oil companies by surprise. They had predicted healthy growth, but not like this. Increased automotive demands, coupled with growing use of home heating oil, edged petroleum ahead of coal as the leading source of energy in the United States.

Oil firms responded by embarking on a quest to find new reserves at home and abroad. The intrepid ones returned to drill in the open waters of the Gulf on leases offered by the state of Louisiana. Many war veterans contributed to this endeavor, both as managers and laborers, and key wartime technologies and equipment provided essential new tools. Sonar and radio positioning developed by the U.S. Navy for warfare at sea proved valuable for oil exploration offshore. The method of unspooling pipelines across the English Channel to supply Allied forces in Europe with fuel eventually found application in the Gulf. The Navy Experimental Diving Unit trained schools of divers in underwater salvage operations and introduced mixed-gas and saturation diving techniques, seeding the commercial diving business that became vital to offshore operations. Gulf Coast construction companies, such as Brown & Root and J. Ray McDermott, and numerous boat operators cheaply acquired war-surplus landing craft and converted them to drilling tenders, supply and crew boats, and construction and pipelaying vessels.[5]

Each new drilling project advanced the state of technology. In 1947, Kerr-McGee Oil Industries drilled the first productive well "out-of-sight-of-land," on a platform located 10.5 miles off the Louisiana coast in the Ship Shoal area. This platform, called the Kermac 16, used a war-surplus tender barge to house mud and most other supplies, plus the quarters and galley for workers. The size of the self-contained drilling and production platform therefore could be reduced (about 1/20 the area of the Creole platform), and sunk costs minimized, in case of a dry hole. In 1948, on the Grand Isle 18 lease, Humble Oil (the Texas affiliate of Standard Oil of New Jersey) introduced the concept of latticed steel templates, or "jackets," which provided greater structural integrity compared to those built with individual wood piles.[6]

Just as these pioneering projects opened up a new oil horizon, an epic legal and political impasse abruptly halted exploration. In 1945, President Harry Truman had proclaimed federal authority over the subsoil of the U.S. Continental Shelf. California, Texas and Louisiana defied this proclamation and continued to lease offshore land. The U.S. Justice Department responded with a series of suits against the states. The U.S. Supreme Court ruled against California in 1947 and against Louisiana and Texas in 1950, declaring that the federal government possessed "paramount rights" that transcended the states' rights of ownership. Offshore leasing and exploration stalled for three years, as Congress held seemingly endless rounds of hearings and the 1952 presidential candidates postured around proposals to return, or "quitclaim," submerged coastal lands to the states.[7]

After months of rancorous debate, Congress finally passed compromise legislation signed in May 1953 by newly elected President Dwight D. Eisenhower. The Submerged Lands Act validated all state leases awarded before the Supreme Court decisions and reserved to the states all land within three nautical miles of their shore (Texas and the West Coast of Florida were later able to obtain a boundary out to three leagues, or 10.4 miles, based on historical claims). "Where's Texas?" Eisenhower playfully called out as he signed the bill into law, acknowledging the state that had voted Republican in the Electoral College for only the second time in its history, largely because of Eisenhower's support for the state's offshore claims.[8] Two months later, he signed the Outer Continental Shelf Lands Act (OCSLA), which placed all offshore lands beyond the three-mile limit under federal jurisdiction and authorized the Department of the Interior (DOI) to issue leases.

One month after Eisenhower signed the OCSLA, Universal Pictures released the film, *Thunder Bay*, starring Hollywood legend, Jimmy Stewart. Shot on Kerr-McGee facilities in Morgan City, Louisiana, the film celebrates "the brawling, mauling story of the biggest bonanza of them all!"[9] *Thunder Bay* depicts the conflict between the shrimp fishermen and oilmen, who eventually reach a rapprochement after an offshore platform helps attract a record shrimp harvest. Despite the movie's fanciful plot, the two industries did indeed learn to live with each other, a relationship Morgan City commemorates annually in September at its "Shrimp and Petroleum Festival."[10]

Upon the legislative settlement of the Tidelands dispute, offshore activity revived. In 1954, the Department of the Interior's Bureau of Land Management (BLM) office in New Orleans held the first federal lease sale. Meanwhile, the U.S. Geological Survey's (U.S.G.S.) Conservation Division opened a new office to supervise operations and collect revenues.[11] To explore and develop their new leases, oil firms tapped into a pre-existing Gulf Coast oil-service sector, but they also promoted the formation of a distinct offshore industry by contracting out for specialized services in marine geophysical surveying, offshore engineering and construction, transportation (boats and helicopters), diving, and, most importantly, mobile drilling.[12]

Mobility in drilling was crucial to the offshore industry's long-term viability. The costs of drilling exploratory or "wildcat" wells from fixed platforms, most of which would not discover oil, were exorbitant. In 1954, the Offshore Drilling and Exploration Company (ODECO), founded by Navy veteran Alden J. "Doc" LaBorde, capitalized on a novel approach to the quest for mobility, using its $2 million *Mr. Charlie* "submersible" drilling barge. *Mr. Charlie*'s hull could rest submerged on the bottom in 30 feet of water and then be refloated and moved to other locations, like a bee moving from flower to flower to extract nectar. Working for Shell Oil on the industry's first ever "day rate" contract ($6,000/day), *Mr. Charlie* drilled and developed two of the Gulf Coast's largest oil fields in East Bay, near the mouth of the Mississippi River. "That's a great rig you have there!" exclaimed Shell's New Orleans vice president to Laborde after the first well. "I can see the day when you will need several more of them."[13]

Giant salt dome fields discovered offshore Louisiana -- such as Shell Oil's East Bay and West Delta, the California Company's (Chevron) Bay Marchand and Main Pass, Magnolia's (Mobil) Eugene Island, and Humble Oil's Grand Isle, all discovered in less than 30 feet of water -- encouraged operators to move further out in the Gulf. As ODECO expanded its fleet of submersibles, other companies such as the Zapata Offshore Company, formed in 1954 by future president of the United States, George H.W. Bush, experimented with new-fangled "jack-up" rigs. These ungainly sea monsters hoisted their platforms out of the water by jacking a series of cylindrical or truss-type legs to the bottom, taking drilling into water depths exceeding 100 feet. By 1957, there were 23 mobile units in operation along the Gulf and 11 more under construction.[14]

In the 1950s, drilling offshore was a relatively costly proposition. A Gulf Oil executive described it as "a billion dollar adventure in applied science."[15] It was nevertheless astoundingly successful. During 1949-1956, the increase to domestic reserves found offshore Louisiana and Texas was nine times the average of onshore wells. In 1956, twenty-six percent of wildcat wells struck oil and gas, compared to 11 percent onshore. One out of 20 wildcat wells discovered fields with more than 50 million barrels of reserves, compared to less than 1 percent of onshore wells with the same success rate. By 1957, there were more than 250 production platforms in federal waters and 446 total in state and federal waters. Offshore Louisiana and Texas were producing 200,000 barrels a day. This production found a ready market in the vast refinery complexes that already existed along the stretch of the Mississippi River between New Orleans and Baton Rouge, in the "Golden Triangle" area (Beaumont-Port Arthur-Orange) of coastal East Texas, and along the Houston ship channel. Offshore production accounted for only 3 percent of total U.S. production, but it was a percentage on the rise.[16]

Pushing Beyond Limits

In the late 1950s, offshore exploration in the Gulf slowed from its frantic pace of mid-decade. Dry hole and capital costs increased significantly in water depths beyond 60 feet. A few jack-up rigs lacked reliable stability and capsized in rough seas. Glasscock Drilling Company's *Mr. Gus* dramatically demonstrated both the cost and operational problems of so-called "deepwater" (at that time, defined as 60 feet). After drilling a $1 million dry hole for Shell Oil in 100 feet of water in 1956, the vessel sank in transit a year later during Hurricane Audrey. Although improved jack-up designs were in the works, insurance premiums for offshore operations soared.[17]

Problems seemed to multiply. Hurricane Audrey caused substantial losses to offshore infrastructure and destroyed the offshore support center of Cameron, Louisiana, where an estimated 500 people tragically perished. Underwater pipelines, necessary for bringing in production, were expensive and tricky to lay in deeper water. Economic constraints in the form of a national recession in 1958, an oversupply of crude oil due to growing imports, and declining finds in deeper water tempered enthusiasm for new exploration. At the same time, Louisiana's legal challenge to the state-federal boundary offshore delayed federal lease sales for several years beginning in 1955 (although drilling on leases obtained earlier continued during these years). For some people in industry, this did not matter, as they believed that offshore exploration had reached its limits.[18]

Others were more optimistic. In August 1962, after seven years of top-secret research and development, Shell Oil announced it had successfully tested a new kind of "floating drilling platform." This mobile unit, the *Blue Water 1*, was a converted submersible consisting of three large columns on each side that connected the drilling platform to a submerged hull. Giant mooring lines kept the vessel on position. Until then, companies had been experimenting with ship-shaped vessels called "drillships" to explore in water depths beyond 150 feet, but these could not withstand heavy wave action. Because the *Blue Water 1*'s hull could be ballasted to rest safely below wave level, the vessel demonstrated a remarkable degree of stability. Classified as the first "semi-submersible," the *Blue Water 1* made its successful test in 300 feet of water, and it was equipped to operate in 600 feet. To complement the new floating platform, Shell also tested the first successful subsea wellhead completion, using remote controls because the practical limit of diving at the time was only 150 feet. As one Shell representative told reporters who visited the rig, "We're looking now at geology first, and then water depths."[19]

The semi-submersible drilling vessel redefined the marine geography of commercially exploitable hydrocarbons. The achievement was akin to John Glenn's space orbit the same year, and this was only the first of many parallels that would be drawn between space and offshore exploration. Shell's competitors were incredulous. Even more astonishing was Shell's decision, in early 1963, to share its revolutionary technology with other oil companies and contractors. At Shell's now legendary three-week "School for Industry," seven companies, along with the U.S. Geological Survey, paid $100,000 each to learn about all facets of Shell's "deepwater" drilling program. Shell put its work on display in order to bring suppliers and contractors up to speed on the latest innovations and to ensure that there would be at least some competition from other oil companies for deepwater (beyond 300 feet) leases. Otherwise, such leases would not be awarded at auction. The diffusion of Shell's technology led to the construction of purpose-built semi-submersibles at shipyards all along the Gulf Coast and enabled the industry as a whole to move into deeper water. In his closing remarks at the School for Industry, Douglas Ragland of Humble Oil remarked that he had never seen an industry presentation that would have such a giant impact on the future.[20]

Federal government policies also helped accelerate offshore exploration and development. Mandatory import quotas went into effect in 1959 and were tightened in 1962. These measures protected the domestic market for higher-cost offshore oil (average offshore wells were double the cost of onshore wells in 1965). In 1960 and 1962, sensing pent-up demand after the hiatus in federal leasing during the late 1950s, the New Orleans BLM office auctioned large swaths of offshore acreage in the Gulf. The industry's response was overwhelming. In the historic March 1962 sale, the BLM leased 411 tracts, nearly two million acres, more than all previous sales combined. The sale opened up new areas off western Louisiana and Texas and extended the average depth of leases to 125 feet.[21] Because so much land was put up for auction, the "cash bonus" price for the average lease at that sale was driven down. Therefore, a broader range of companies could now afford to participate in the Gulf.[22]

Drilling on that vast inventory of leases set off one of the greatest industrial booms the Gulf Coast had ever seen. By September 1963, nearly 90 drilling operations were in progress. Workers flocked from around the Gulf region to take high-paying jobs offshore or in the growing onshore support centers of New Orleans, Morgan City, Lafayette, Beaumont, and Houston. These workers developed fierce company loyalty, in part due to their elite blue-collar employment status, but also from company policies prohibiting them from purchasing products from or communicating with other companies. The work environment was distinctly southern, reinforced by the segregation of the Deep South and anti-unionism bred from local distrust of outside organizers and active anti-union campaigns by industry leaders.[23]

Although exploratory success offshore Louisiana in the immediate years after 1962 could not match the extraordinary record of the late 1950s, the discovery rate for large fields (100 million barrels) was impressive: 155 for offshore Louisiana versus 3,773 for the United States as a whole. By 1968, 14 of the 62 the large 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 348,000 barrels per day in 1962 (4.8 percent of total U.S. production) to 915,000 barrels per day in 1968 (8.6 percent of the U.S. total), most of this increase coming from federal areas, especially acreage leased in 1962.[24]

The March 1962 sale also elevated the profile of the OCS program in federal policy circles. The $445 million in cash bonuses earned by the government at that sale alerted many officials in Washington to the importance of OCS leases as a source of federal revenue. "My office began receiving daily attention, rather than only on sale day," remembered John Rankin, head of the BLM New Orleans office at the time, which only had about 30 employees, many of whom devoted only part of their time to OCS matters.[25] The next year, the BLM opened an office in Los Angeles and offered the first OCS oil and gas leases off the coasts of Oregon and Washington. Three years later, in 1966, the BLM offered the first leases in California's Santa Barbara Channel. The federal OCS program took on national scope.[26]

During the 1960s, drilling innovations revitalized the offshore industry in the Gulf and generated interest in other ocean basins. New well designs and well-logging techniques resolved deep subsurface drilling problems and reduced well costs. In 1961, Project "Mohole," sponsored by the American Miscellaneous Society and the National Science Foundation, outfitted the *CUSS 1* drillship with manually controlled dynamic positioning, which enabled it to drill cores in 11,700 feet of water. Project Mohole was a bold effort to test the possibility of drilling to the earth's mantle, an "inner space" counterpart to the Kennedy Administration's manned outer space exploration program. The federal government terminated funding for Mohole in 1966 long before it could reach its objective, but the project developed important insights into the problems of drilling at extreme depths. In 1962, Shell Oil's research lab equipped the drillship *Eureka* with the first automatic dynamic positioning system and embarked on a core-drilling program in 600-4,000 feet of water in Gulf of Mexico. Pioneering geologic work conducted in the 1940s and 1950s had discovered that the Mississippi River over time had created a broad alluvial valley, repeatedly entrenched and filled since at least the Pleistocene era, and that a submarine trough with bottom-hugging currents had transported denser-than-seawater sediment onto the continental slope and abyssal plain. The *Eureka*'s cores confirmed for the first time that oil had been generated in these sands. How much was still a question. Then, beginning in 1968, the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) project launched the famous voyage of the *Glomar Challenger* drillship, whose core samples not only provided definitive proof for the theory of plate tectonics but also gave further evidence of oil generation in extreme ocean depths.[27]

Although exploratory drilling capabilities raced ahead of commercial producing depths -- a recurring theme in the history of offshore oil – the industry nevertheless made great advances during the 1960s in all phases of offshore exploration and production. By 1962, magnetic sound recording and playback had greatly enhanced the quality of reflection seismic signals used in geophysical surveying. Later in the decade, digital sound recording and processing enhanced the quality of seismic data and fortified geoscientists' ability to interpret subsurface geology. Data collected from platform instruments installed in the mid-1950s helped engineers refine oceanographic criteria. Improvements in soil boring techniques led to greater understanding of seabed soil mechanics and foundations. Steel-jacket construction advanced through the use of higher-strength steel and larger installation equipment. Digital computers made possible the three-dimensional modeling of platform jacket designs. Together, these developments moved production operations into 350-foot water depths by 1969.[28]

The offshore industry's record in the 1960s, however, was far from an unbroken success. Toward the end of the decade, the cost of bringing in productive leases began to outrun the price of oil, which in the United States had remained in the $2-3 per barrel range since the end of World War II. Many of the large, easy-to-identify structures in the Gulf had been picked over and drilled. Offshore Texas proved to be largely gas-prone, and regulated prices made natural gas less profitable than oil. Some companies were fooled by geology into making costly mistakes. At a federal offshore Texas lease sale in 1968, an Exxon-Texaco partnership spent a whopping $350 million for leases that yielded nothing.[29] Perhaps this is one reason why Exxon chairman, Lee Raymond, remarked in 2002 that "the best thing ExxonMobil could have done after drilling its first well in the Gulf of Mexico was to never drill another one again."[30]

Hurricanes wreaked havoc with production. In 1961, Hurricane Carla activated soil movements in the Mississippi Delta that destroyed a large number of pipelines. Hurricanes Hilda (1964) and Betsy (1965) knocked out 20 platforms and damaged 10 others, largely because platform decks were set too low for wave heights that reached 70 feet, far exceeding earlier estimates. Hurricane Camille (1969), a monster Category 5, passed directly over 300 platforms, most of which survived the pounding from waves, but the storm caused violent mud slides that wiped out three large platforms in 300 feet of water.[31]

On top of the business failures and natural disasters, the sheer technological challenges and the necessity to complete work as quickly as possible compromised safety. Project profitability depended on how soon production could be brought online. Drilling vessels were contracted on day-rates, increasing time-cost pressures. Production processes were highly interdependent. Delay in one section could cause delays elsewhere. And delays cost money. So there was incredible time pressure to drill the wells, install the platforms, and get the oil and gas flowing. "When I first started working, they didn't care whether they killed you or not!" remembered one offshore veteran. "In other words, 'we are going to get it done, regardless.' There was no suing like people are suing now. Back then, if you got hurt, they just pushed you to the side and put somebody else in."[32]

Operators and contractors alike did not overly concern themselves with safety. At times, they even cut corners. Accident rates for mobile drilling vessels remained unacceptably high, especially for jack-ups. Blowouts, helicopter crashes, diving accidents, and routine injuries on platforms were all-too-common. Safe processes and designs either did not exist or remained untested ideas in the minds of technicians. Facilities engineering on production platforms was a novel concept. Platforms were often stick-built with equipment squeezed or slapped together on the deck with little concern or foresight for worker safety. Crew quarters, for example, could sometimes be found dangerously close to a compressor building.[33]

Federal oversight followed the philosophy of "minimum regulation, maximum cooperation."[34] OCS orders were worded very generally. Between 1958 and 1960, the U.S.G.S. Conservation Division, which at the time was the regulatory agency overseeing offshore drilling, issued OCS orders 2 through 5, requiring procedures for drilling, plugging and abandoning wells, determining well producibility, and the installation of subsurface safety devices, or "storm chokes." But the Offshore Operators Committee (representing leaseholders) persuaded regulators to dilute Order 5 to permit waivers on requirements for storm chokes. Significantly, the orders did not specify design criteria or detailed technical standards, and they did not have any test requirements. Companies had to have certain equipment, but they did not have to test them to see if they worked.[35] In general, as a 1973 National Science Foundation study of OCS issues concluded, "the closeness of government and industry and the commonality of their objectives have worked against development of a system of strict accountability."[36]

Lax enforcement contributed to the lack of accountability. The U.S.G.S. freely granted waivers from complying with orders and did not inspect installations on a regular basis. Federal and state regulatory bodies were underfunded and understaffed. In 1969, the Gulf region's lease management office had only 12 people overseeing more than 1,500 platforms. Even those inspectors and supervisors who had the appropriate training and competence often did not have the requisite experience in the oil business and grasp of its changing technological capabilities. "Each oil well has its own personality, is completely different than the next, and has its own problems," observed one consultant in 1970. "It takes good experienced personnel to understand the situation and to cope with it." Too often on drilling structures, he complained, one found inexperienced supervisors, employees who overlooked rules and regulations, the purpose of which they did not understand, and sometimes orders from bosses to cut corners, all of which created conditions for an "explosive situation." "Disaster might not strike the first time, but it will come!"[37]

Disasters Strike

On January 28, 1969, a blowout on Union Oil Company Platform A-21 in the Santa Barbara Channel released an 800-square-mile slick of oil that blackened an estimated 30 miles of Southern California beaches and lethally soaked thousands of sea birds in the gooey mess. Although the well's blowout preventer worked, an inadequate conductor and surface casing design allowed the hydrocarbons to escape through near-surface fractures. Union Oil had received a waiver from the U.S.G.S. to set casing at a shallower depth than that required by OCS Order 2, highlighting the lack of accountability that had come to characterize offshore operations.[38] The 11-day blowout spilled an estimated 80,000 to 100,000 barrels of oil[39]—the largest offshore drilling accident in American waters until the Macondo blowout. It generated intense opposition to offshore oil in California, but the fallout also reverberated nationally, setting the stage for the passage of the National Environmental Policy Act (NEPA), a symbol of the growing strength of the national environmental movement, as well as a host of other increasingly demanding environmental protection laws throughout the 1970s.[40]

Offshore operators suddenly faced a potentially hostile political and regulatory climate. Ten days after the accident, Secretary of the Interior Walter Hickel, with the support of President Richard Nixon, issued a moratorium on all drilling and production on offshore rigs in California waters. On February 11, 1969, Nixon directed his Presidential Science Advisor, Dr. Lee A. DuBridge, a physicist, to assemble an advisory team and recommend measures to restore the affected beaches and waters. Nixon also requested that DuBridge "determine the adequacy of existing regulations for all wells licensed in past years now operating off the coast of the United States [and] to produce far more stringent and effective regulations that will give us better assurance than the Nation now has, that crises of this kind will not recur." With DuBridge at his side, Nixon remarked three months later, when unveiling his new Environmental Quality Council that "The deterioration of the environment is in large measure the result of our inability to keep pace with progress. We have become victims of our own technological genius."[41]

The Department of the Interior acted swiftly. In April, Secretary Hickel completed a preliminary assessment of the leases affected by the moratorium and allowed five of the 72 lessees to resume drilling or production. In August, the Department of the Interior issued completely revised OCS Orders 1-7 – the first update since the orders were established – with more specific requirements about company plans and equipment for prevention of pollution and blowouts. It also issued two new Orders (8 and 9) pertaining to the installation and operations of platforms and pipelines. These were the first rules in which the Department claimed authority to prohibit leasing in areas of the continental shelf where environmental risks were too high.[42]

The industry protested the new OCS regulations, but calamities in the Gulf undermined its case. In February 1970, Chevron's Platform C in Main Pass Block 41 blew out and caught fire. The spill forced a postponement of a federal lease sale, damaged wildlife, and drew a $31.5 million suit against the company by Louisiana oyster fisherman and a $70 million suit from the shrimp fishermen. A U.S. District Court also fined Chevron $1 million for failing to maintain storm chokes and other required safety devices, the first prosecution under the 1953 OCS Lands Act. The Justice Department proceeded to obtain judgments against other major oil and gas companies for similar violations. Then in May, explosions and fire broke out on a Chambers and Kennedy platform 12 miles southeast of Galveston, Texas, killing five workmen and four others on a workboat moored below the platform. The explosion erupted when an arc-welding operation, without adequate supervision or safety precautions, ignited vapors between two crude oil storage tanks. Finally, in December, Shell Oil Company suffered a major blowout on its giant Platform B in the Bay Marchand area (South Timbalier Block 26), killing four men and seriously burning and injuring 37 others. Investigators attributed the cause of the accident to human error resulting from several simultaneous operations (i.e. drilling, production, and wireline operations) being performed without clear directions about responsibility. It took 136 days to bring eleven wild wells under control, at a cost of $30 million. The failure or leaking of subsurface-controlled storm chokes contributed to the size of conflagration.[43]

In the wake of these disasters, the government further strengthened its regulatory program. The Department of the Interior again revised and expanded OCS orders to mandate new requirements: surface-controlled storm chokes; the testing of safety devices prior to and when in use; more careful control of drilling and casing operations; prior approval of plans and equipment for exploration and development drilling; and updated practices and procedures for installing and operating platforms. To enforce the new regulations, the U.S.G.S. tripled its force of inspectors and engineers, ceased using industry furnished transportation for inspection purposes, and introduced a more systematic oversight program based on a newly developed Potential Incidents of Non-Compliance (PINC) list.[44]

The industry finally got serious about safety and environmental protection. The Offshore Operators Committee and the American Petroleum Institute's Offshore Safety and Anti-Pollution Equipment Committee worked closely with the U.S.G.S. not only in advising changes in the OCS orders but in drafting, in a short period of about six months, a new set of API "recommended practice documents" for the selection, installation, and testing of safety devices, as well as for platform design. The major offshore operators revamped personnel training for offshore operations with the aid of the API, universities, and suppliers. They also formed an organization called Clean Gulf Associates to upgrade oil-spill handling capabilities.[45] In addition, the industry's annual Offshore Technology Conference (OTC), first held in 1969, became an important forum for publishing and sharing technical information that led to safer designs and operations.[46]

On the mobile drilling front, certifying agencies issued new standards and guidelines. In 1972, Lloyd's Register of Shipping published for the first time its "Rules for the Construction and Classification of Mobile Offshore Units." In 1973, the American Bureau of Shipping revised its "Rules for Building and Classing Offshore Mobile Drilling Units," first issued after the 1967 *Sea Gem* disaster in the U.K. sector of the North Sea, based on studies that subjected the wide range of mobile drilling designs to more rigorous tests. These rules were then incorporated into the Coast Guard's regulatory requirements for mobile offshore drilling units (the Coast Guard had jurisdiction over vessels in transit) and the OCS Order No. 2 pertaining to "Drilling from Fixed Platforms and Mobile Drilling Units," enforced by the U.S.G.S.[47]

The offshore oil industry's safety record in the Gulf improved significantly after the introduction of new regulations and practices. Both the reported incidence and rate of fatalities and injuries in the OCS decreased.[48] The rate of fires and explosions also declined.[49] During the 1970s and 1980s, the industry did not achieve a significant reduction in blowout frequency, largely because of serious limitations in methods for controlling shallow gas influxes. However, there was a sharp drop in the number of catastrophic blowouts and a significantly lower number of casualties and fatalities associated with them.[50]

Design and equipment problems were steadily being solved. However, reducing accidents caused by human error, poor safety management, or simultaneous operations continued to be a vexing challenge for the industry.

Constrained Expansion

As new regulations brought more caution to OCS development, countervailing forces emerged to speed it up. Domestic oil supply could not keep up with demand. In the postwar period, Americans' consumption of petroleum climbed steadily for more than three decades. Most of that consumption, then as well as today, occurred in the transportation sector. Auto sales soared from about 1 million annually at the end of the war, to 6.7 million in 1950, to 9 million in 1965. The construction of the federal interstate highway system, authorized in 1956, laid tens of thousands of miles of roadway across the nation, stimulating the auto craze and the massive demographic shift toward suburbanization.[51] American consumption of motor gasoline rose from 243 gallons per capita in 1950 to 463 gallons per capita in 1979.[52]

U.S. oil production peaked, however, in 1970. Along with the OPEC oil embargo of 1973 and consequent skyrocketing price of oil products, this event spurred the quest to develop new offshore reserves. With oil prices tripling to $10 per barrel, oil companies found they could justify more expensive offshore drilling and development. Under the mandate of "Project Independence," the Nixon Administration announced a dramatic increase in the pace of leasing in the Gulf and a resumption of OCS sales off the Atlantic, Pacific, and Alaskan coasts. At the March 1974 federal lease sale of offshore Louisiana acreage, the industry spent a record $2.17 billion in cash bonuses for leases covering 522,000 acres, including a few tracts ranging beyond 1,000-foot depths.[53]

In June 1975, Shell made a monumental discovery on one of those new leases. Shell geophysicists had employed an innovative seismic interpretation technique called "bright spot" to lead drillers to an attractive prospect code-named Cognac, in 1,000 feet of water in the Mississippi Canyon, not far from the mouth of the great river. The drilling uncovered an estimated 100-million-barrel reserve.[54] Cognac pioneered other discoveries in what would come to be known as the "Flex Trend," an area in the Gulf that reaches just beyond the edge of the continental shelf, where there is a flex in the seafloor. The Flex Trend would be the world's first true oil play in 1,000-foot water depths, the modern definition of deepwater.[55]

Developing Cognac was one of the most technologically sophisticated efforts ever attempted offshore. When Shell purchased its leases, the company did not yet have a design concept for deepwater production. Barges were not big enough to launch a 1,025-foot steel jacket in one piece. Therefore, following on a precedent established by Exxon to install its "Hondo" jacket in 850 feet of water in the Santa Barbara channel in 1976, Shell chose to build the Cognac structure in three pieces and assemble or "stack" them vertically in place. The complex, nerve-wracking installation inflated total development costs to nearly $800 million. But Cognac was both a technical and commercial success. It won the American Society of Civil Engineers (ASCE) 1980 award for "Outstanding Civil Engineering Achievement," the first ever received by an oil company. Production commenced in 1979, just as the supply shock caused by the Iranian Revolution drove the price of oil to nearly $40 per barrel.[56]

Along with Hondo and major developments in the North Sea pioneered by Phillips, Conoco, and British Petroleum, Cognac paved the way for truly enormous, offshore engineering-construction projects. North Sea experience using improved materials, full-size tubular joint testing, data from field measurement programs in 500-foot waters, and ever-larger construction equipment assisted Gulf operators in moving rapidly up the learning curve. In 1976, Brown & Root and J. Ray McDermott opened giant new construction yards at Harbor Island, Texas, near Corpus Christi Bay, to accommodate the assembly and load-out of deepwater structures. In these yards, they built jackets lighter and cheaper than Cognac and launched them in single pieces. In the late 1970s, Brown & Root built a 700-foot structure for Chevron's Garden Banks field and a 650-foot jacket for Atlantic Richfield (Arco). In 1980-1981, McDermott built two platforms for Union Oil in the 1,000-foot waters of the East Breaks area, 100 miles south of Galveston. Union named its platforms “Cerveza” and “Cerveza Light” to emphasize their beer-budget cost savings compared to Cognac. During 1979-1983, Brown & Root built and installed a novel “guyed tower” for Exxon in 1,000 feet of water just to the southwest of Cognac.[57]

During the 1970s boom, the composition of the labor force in the offshore industry began to change. Demand for labor outstripped supply. Local chambers of commerce and companies devised new recruiting schemes, such as driving vans through the poor neighborhoods of New Orleans to gather able-bodied young men, load them on boats, and ship them offshore. The national recession of the 1974 attracted workers from around the country, especially from the declining industrial manufacturing regions of the upper Midwest. Civil rights laws and federal guidelines forced the industry to begin hiring women and racial minorities for offshore work. Highly skilled “Cajun mariners,” many with little formal education, became increasingly vital for providing specialized boats and vessels to transport people, equipment, and supplies to offshore facilities. At a moment when Cajunism was experiencing a cultural revival, the large numbers of Cajuns who obtained well-paying jobs and the few who achieved wealth and prominence in the industry strengthened the bonds between southern Louisiana and offshore oil.[58]

Desperate for new reserves after the nationalization of foreign holdings in the 1970s, and caught between rising crude prices and declining onshore production, U.S. oil firms increasingly cast their sights offshore. By the late 1970s, however, they found their options narrowing, due to economic, geologic, and political factors.

In the Gulf of Mexico, oil operators encountered both economic and geological limits. Bonus bids soared beyond the estimated value of the oil that might be discovered and produced. The September 1980 sale in New Orleans, for example, brought in $2.8 billion in cash bonuses, shattering all previous records. “I got a three-letter description: W-O-W!” exclaimed John Rankin, head of the New Orleans BLM office, after the sale. Shell’s executive vice president had a similar reaction, but with a different emphasis: “The bidding just got ridiculous,” he said. “The whole business got ridiculous!” During the 1970s, the ratio of bonus paid per barrel of oil equivalent discovered among the top companies had increased by a factor of four or five, undermining the economics of deepwater.[59] Furthermore, initial per-well production rates from some of the early producing fields in the deepwater Flex Trend were disappointing, and many exploration managers in the industry believed that after twenty-five years of development only lean prospects remained in the Gulf of Mexico. The best hope for increasing national reserves, they concluded, was from other parts of the U.S. outer continental shelf (OCS).[60]

Political opposition to offshore development progressively restricted drilling along most of the Pacific OCS and, by the 1980s, the Atlantic OCS as well. After the Santa Barbara blowout, outraged citizen groups formed, such as Get Oil Out! (GOO), "to protect California from further oil development and exploitation."[61] One of GOO's founders was so angered by the sight of platforms in the channel, he suggested, "we should go out there and blow the goddamn things up."[62] Allied with leaders in state and local government, GOO failed to stop a 1975 sale, but this failure only strengthened the anti-oil movement as a political force.

At the national level, Nixon's Project Independence initiative elicited reaction in the form of proposals to amend the OCS Lands Act. Concerned politicians from coastal states saw OCS decision-making as a closed-door process involving only the Department of the Interior and industry. This denied affected states a mechanism for addressing the glaring problem with the OCS program revealed by Santa Barbara: that the benefits of OCS development were distributed nationally, while the costs were often concentrated locally.[63] After four years of debate, Congress finally responded to these concerns by passing the OCS Land Act Amendments of 1978. These amendments introduced a five-year lease schedule and provided for phased decision-making with NEPA environmental impact studies (EIS) at each stage of the leasing and development process. The amendments also created a new environmental studies program and opened up avenues for state and local participation in OCS decision-making.[64]

After passage of the 1978 Amendments, the system was immediately put to test at the proposed lease Sale 53 in the Pacific. Unlike previous sales there, which had been concentrated in one geographic region, Sale 53 called for nominations of tracts from the Santa Barbara Channel to the Oregon state line. A bevy of interest groups formed an umbrella organization, the Coalition on Lease Sale 53, to stop the sale. At the same time, opposition gathered against the five-year leasing schedule proposed by Interior, leading to court challenges by the states of California and Alaska. They argued that the schedule violated Section 18 of the 1978 Amendments, which mandated that the laws, goals, and policies of the affected states be considered in the plan. After protests escalated into huge public rallies in 1980, Secretary of the Interior Cecil Andrus withdrew the entire northern and central California portion of the sale. "California thought the coast was saved," recalled Richard Charter, a leader of the Coalition on Lease Sale 53.[65]

But this would not be the last of it. In 1980, the issue passed into the hands of a new Republican president, Ronald Reagan, and his secretary of the interior, James Watt, a leader of the so-called "Sagebrush Rebellion" of western states conservatives who were dedicated to throwing open federal lands to resource development. "If the press is here," Watt announced defiantly at a National Ocean Industries Association meeting early in Reagan's first term, "I hope they will write this down. We will offer one billion acres for leasing in the next five years. We will not back away from our plans to have 42 lease sales."[66]

Beyond the Shelf

Rising lease bonuses still did not deter major companies (such as Chevron, Exxon, Mobil, and Amoco), along with some of the larger independents (such as Pennzoil, Union, and Tenneco), from drilling and developing fields in the deepwater Flex Trend. But discoveries could not offset overall production declines in the Gulf. Oil production on the shelf had peaked in 1972 at just above 1 million barrels per day; by 1978, it had fallen below 800,000 barrels per day. Few companies and indeed few people in the industry believed that deepwater could revive the Gulf's fortunes. Discoveries in the Flex Trend play were relatively small with discontinuous sands and fairly low flow rates.[67] Most oil and gas produced in the Gulf still came from shallow water, despite declining overall production there. In 1970, the average production-weighted depth in the Gulf was just 100 feet, and by 1980 it was still below 200 feet.[68] After examining average field sizes and the state of production technology, many managers had concluded that there would never be economic developments more than 60 miles from shore. Upon studying unproductive wells in shallow water that companies had drilled deep to test the older sediments laying beneath productive shelf reservoirs, other experts became convinced that significant oil-bearing sands would never be found beyond the shelf. In the late 1970s and early 1980s, “never” was the conventional wisdom about deepwater. “But what conventional wisdom really tells you,” as one Shell geophysicist later explained, “is that you just don’t know what you don’t know.”[69]

Some geologists were finding clues that made them question the conventional wisdom. Combining information from deepwater cores with a regional seismic survey acquired and processed by Petty-Ray Geophysical in 1977, scientists from industry and academia had begun to piece together a regional picture of deepwater geology in the Gulf. This picture showed that massive salt pillars, or diapirs, had squeezed up from the mother layer of salt called the Louann sheet. The Louann was deposit during the Jurassic period beginning 165 million years ago when cycles of seawater rushed into and evaporated from a slowly forming Gulf of Mexico, leaving behind layers of salt that grew as thick as 30,000 feet in places. As the diapirs pinched up, sandstones overlaying the salt slowly subsided, forming cup-shaped “mini-basins” featuring many different kinds of configurations for trapping oil. These sandstones were named “turbidites” because they had been deposited when ancient underwater rivers called turbidity currents channeled huge volumes of sediment onto the continental margin. The structural anomalies in these mini-basins looked similar to productive features on the shelf, but the spotty seismic coverage made these anomalies speculative at best. Meanwhile, Shell Oil, always the leader in frontier exploration in the Gulf, had drilled a number of oil discoveries along the shelf margin in similar rocks. Deltaic and turbidite reservoirs on the shelf were highly faulted and required many wells to develop. Turbidites in deepwater, by contrast, were potentially much larger and less faulted, thus requiring fewer wells. Theory held that they would also be unusually porous due to the sifting of the sands carried by turbidity currents over long distances and that they might be more tightly sealed and under higher pressure.[70]

During 1978-1980, hoping to test its theories about the Gulf’s regional geology, Shell nominated deepwater tracts for auction. But no other companies seconded their nominations, so the BLM never selected the tracts for sales. Then, a major policy shift provided a new opportunity to look more closely at deepwater geology and piqued the interest of a few companies other than Shell. In 1981, Interior secretary James Watt honored his pledge to lease a billion acres of the OCS by announcing a new system of "area-wide" leasing offshore. This policy put into play entire planning areas (e.g., the central Gulf of Mexico) up to 50 million acres, rather than rationing tracts through a tedious nomination and selection process as in the past. Oil companies could bid on any tract they wanted in a lease sale for a given planning area, rather than having to choose from a limited number of carefully selected ones. AWL thus gave them access to far greater offshore acreage at much cheaper prices. At the time, there were compelling reasons to proceed this way in the Gulf of Mexico, where oil companies had long operated, where there was established infrastructure, and where there was abundant geological information that could be put to more flexible use under a more open system. The introduction of AWL also coincided in 1982 with the merging of the BLM OCS program and the U.S.G.S. Conservation Division into a new agency, the Minerals Management Service (MMS). The purpose of creating the new agency was to better manage oil and gas royalty revenues from federal and tribal lands and to create what Watt called "a more efficient leasing program."[71]

The expanded program for OCS leasing drew sharp criticism from environmental groups, who were alarmed by what they considered a fire sale of offshore territory. Ignoring, minimizing, and even mocking their concerns, James Watt forged ahead with his one-size-fits-all, "market friendly" approach. He restored the controversial Sale 53 off California to its original offerings and pushed for the first area-wide sale in the eastern Gulf, which included tracts south of the 26th parallel near the Florida Keys, opposed by majority of the state's residents. Watt withdrew the contested Sale 53 offerings after a federal court ruled that the sale did not meet consistency requirements under the Coastal Zone Management Act of 1972. However, in January 1984, the U.S. Supreme Court overturned lower courts and ruled by a slim 5-4 vote that the sale itself did not cause impacts and so the Federal Government could ignore the objections of affected states in moving ahead with lease sales.[72]

Stymied in the courts, coastal states and environmental organizations brought pressure in Congress. In 1982, the House of Representatives began writing provisions into yearly appropriations bills that prohibited the expenditures of funds for leasing activities, first, off the shores of California, and then off New Jersey, Florida, and Massachusetts. Circumventing the decision-making process within Interior, Congress in the 1980s increasingly shut down leasing on the OCS outside the western and central Gulf of Mexico.[73]

After the beleaguered Watt left Interior in October 1983, his successor, William Clark, scaled back the 1982 leasing plan but moved forward with area-wide leasing in the Gulf of Mexico. Some officials from Gulf Coast states, such as Representative John Breaux (D-LA), were troubled by the size of the leases being offered. These officials feared that placing so much acreage on the market would dilute tract values, at the very moment they were attempting to obtain a share of federal OCS revenues for their states, in part to compensate for the offshore industry's contribution to the accelerating erosion of the state's coastal wetlands.[74] The Mineral Leasing Act of 1920 granted states 37.5 percent of mineral leasing revenues from onshore federal lands within their borders (increased to 50 percent in 1976), but the OCS Lands Act of 1953 made no provision for sharing revenues with states adjacent to oil and gas production in federal offshore waters. Reagan and Clark resisted this push by the states for revenue sharing, viewing the billions earned from leasing as a painless way to stem the exploding budget deficit. In April 1986, after considerable political maneuvering and lawsuits filed by Louisiana and Texas, the White House and coastal states reached an agreement for sharing a relatively small portion of revenues derived from the three-mile-wide strip of federal lands lying immediately outside the offshore territory owned by the states.[75]

As the sideshow over federal-state revenue sharing played on, Interior pressed ahead with area-wide leasing in the Gulf. Oil companies responded to the new system by bidding aggressively for attractive blocks on the shelf while making a number of speculative bids on acreage ranging into 3,000-feet depths beyond the edge of the shelf. "While rigs stood idle in the inshore shallows of the Gulf of Mexico," reported *Newsweek* on the first sale under the new system, "more than 1,200 oilmen gathered last week in New Orleans' Superdome to testify to their faith in the health of their industry."[76] The May 25, 1983 sale harvested a record $3.47 billion in high bonus bids. But with so much acreage put up for sale, the average price per acre was only about $1,000, three to four times lower than the average in the 1979-1980 sales. In subsequent sales, held in 1984-1985, bonuses plummeted to under $500/acre, as the industry staked greater claims in deepwater. All told, in seven lease sales held during 1983-1985, the MMS leased 2,653 tracts, more than had been leased in all the federal sales since 1962 combined. About 600 of these tracts lay in deepwater beyond 1,000 feet.[77]

Shell Oil acquired the lion's share of deepwater tracts at the March 1983 sale and immediately started drilling. In 1982, it had contracted with Sonat Offshore Drilling to lease the drillship, *Discoverer Seven Seas*, one of the few vessels in the world rated for 6,000-foot depths. Shell then spent more than $40 million to extend the vessel's depth capability with a larger marine riser, enhanced dynamic positioning, and a new remote-operated vehicle (ROV) to enable sophisticated work where humans could not venture. In October 1983, the *Seven Seas* made a major discovery at Shell's Bullwinkle prospect. The discovery established what came to be known as the deepwater "Mini-Basin Play," which targeted the turbidite sandstones in the basins flanking the salt structures.[78]

In the next Central Gulf area-wide sale, in April 1984, many different operators jumped in to compete for deepwater tracts. This prompted Shell to move quickly in deploying the *Shell America*, a $45 million custom-designed, state-of-the-art seismic vessel that provided company geophysicists with high-quality, proprietary seismic data. Armed with these new data and other intelligence gained from drilling its 1983 leases, Shell dominated the May 1985 Gulf sale, winning 86 of 108 tracts on which it submitted bids, in water depths ranging out to 6,000 feet. For Shell, pushing deeper was an imperative for its operations in the United States, as onshore reserves continued to decline.[79] "Exploration has been called a poker game," explained one Shell Oil official. "But there's more to it than that. In this game, we don't have chips or coins or dollar bills that can change hands over and over again. We're dealing with a declining resource base, and every barrel we find is never going to be found again."[80]

The Era of Uncertainty

The long cycles of oil exploration and development do not always align well with the shorter cycles of the economy. Just as Shell bet heavily on deepwater, the severe recession of 1981 further depressed falling oil demand. For the first time in 34 years, U.S. oil consumption hit a plateau and began moving downward.[81] The now "forgotten victory" of energy conservation and efficiency measures passed in the mid-1970s, in response to historically high oil prices, reversed the long trend in the increasing petroleum intensity of the U.S. economy. During 1985-1986, oil prices collapsed down to $10 per barrel, as both OPEC and non-OPEC producers—principally Mexico and the North Sea—saturated the market with crude. Combined with the rising price of lease bonuses (before area-wide leasing) and disappointing finds, the recession sucked the wind out of drilling in the Gulf of Mexico. Expensive development projects in the Gulf of Mexico were canceled or shelved. The construction of mobile drilling vessels and other kinds of offshore servicing equipment, which was a major part of heavy industry along the Gulf Coast, fell sharply. Some analysts began to write off the Gulf of Mexico as the "Dead Sea."

The depression afflicting the oil industry in the United States spread to other sectors of the economy, such as real estate and banking. Once flourishing coastal communities entered a period of economic decline, as tax revenues from companies serving the oil industry evaporated. Unemployed oil field workers either transitioned into new trades, or they migrated out of southern Louisiana in search of better opportunities. This human and capital flight marked the beginning of what one scholar called "the inevitable disassembly of the offshore system and its onshore support network for the Gulf of Mexico."[82]

The offshore projects that went forward faced intimidating challenges. The Bullwinkle find was encouraging, but the bright spot game Shell was playing in seismic interpretation also threw the company some curves, leading to some expensive dry holes in excess of $10 million. On the production side, many economic and technical questions remained about how to produce deepwater discoveries. The anticipated reservoir model -- characterized by large, continuous sands and high-flow rates -- was still unconfirmed.[83] Moreover, no consensus had been achieved about new production concepts. Shell developed Bullwinkle by installing, in May 1988, a massive $500 million fixed platform, 162 stories high, taller than Chicago's Sears Tower (now the Willis Tower), the tallest building in the world at the time. But the Bullwinkle platform was the largest and last of its kind. The scale and costs of constructing anything bigger were simply prohibitive.[84]

Moving deeper would require alternative methods of producing, using subsea wells, tension-leg platforms, or floating production systems. Operators had put subsea wells to practical use in the North Sea, but they were still extremely expensive. The tension-leg platform was an innovative concept consisting of a production facility situated on a floating hull held in place by long tendons that kept the hull from bobbing like a cork but allowed a degree of side-to-side motion. In 1984, Conoco installed the first design of this type in the North Sea's Hutton field in 485 feet of water, and in 1989 the company placed its Jolliet mini-tension-leg platform in 1,760 feet of water in the Gulf.[85] But tension-leg platforms would have to be scaled up for major projects in deepwater. In 1987-1988, Placid Oil (owned by the personal trusts of the oil scions Nelson, Herbert, and Lamar Hunt) developed a field in 1,500 feet of water with a floating production facility converted from a semi-submersible drilling vessel. But Placid soon abandoned the development, sold the semi-submersible, and sought Chapter 11 protection from creditors, a story that was profiled in a *Texas Monthly* feature, "Lifestyles of the Rich and Bankrupt."[86]

The deepwater costs were matched by the safety and environmental risks. In 1985, an Office of Technology Assessment study of Arctic and deepwater oil drilling highlighted the "special safety risks" of "harsh environments and remote locations." It identified "a need for new approaches to preventing work-related injuries and fatalities in coping with new hazards in the hostile Arctic and deepwater frontiers." It also presciently warned of the glaring deficiencies in safety oversight offshore, observing that "there is no regulatory requirement for the submission of integrated safety plans which address technical, managerial, and other aspects of offshore safety operations."[87]

The study was published during a period when catastrophic accidents offshore and in other hazardous industries around the world were occurring at an alarming rate. First, in 1979, came the partial meltdown of the Three Mile Island nuclear plant in Pennsylvania. Also that year, Pemex's Ixtoc 1 blowout in Mexico's Bay of Campeche released 3 million barrels, the industry's largest spill before Macondo in

2010. In 1980, the Alexander Kielland accommodation platform in the North Sea capsized, leaving 123 dead. In 1982 the Ocean Ranger semi-submersible platform sank off Newfoundland, killing 84 people. In 1984, Union Carbide's pesticide plant in Bhopal India leaked toxic gas and chemicals, resulting in thousands of deaths. Then, in 1988, 167 workers perished when Occidental Petroleum's Piper Alpha production platform in the North Sea exploded. Both the chemical and nuclear industries in the United States adopted new approaches to safety process management, overseen by reformed regulatory agencies. Meanwhile, regulators in the U.K., Norway, and Canada overhauled their oversight of offshore oil. The offshore industry in the United States became more attuned to safety in the wake of these disasters and after a 1989 explosion at South Pass 60 the Gulf of Mexico that killed seven workers. However, changes in offshore safety management did not happen across the board, and the Department of the Interior's Minerals Management Service did not implement mandatory regulations on safety (see chapter 4).

As the Office of Technology Assessment's study indicated, deepwater was not the only frontier that captured the industry's interest. In the 1980s, companies also had their sights set on Alaska. In the early 1980s, they believed the Arctic region held the highest resource potential of anywhere in the United States. It was big structure country. Since the 1960s, major firms had produced oil from Alaska's Kenai Peninsula and Cook Inlet. In 1977, the massive onshore Prudhoe Bay field on the North Slope started pumping oil through the Trans-Alaska Pipeline. Many explorers expected to find the next great oil frontier to the north of Prudhoe Bay, in the Bering, Beaufort, and Chukchi Seas. Although the industry lost a contentious struggle to gain access to the Bering Sea's Bristol Bay, a place of stunning natural beauty and home to the world's largest commercial salmon fishery, they did win the right to lease and drill in the Beaufort and Chukchi Seas.[88]

Everywhere operators drilled in the federal waters off Alaska, however, they came up empty. Either they found no source rocks or the deposits they did find were not large enough at that time to turn a profit in the Arctic's forbidding environment. The symbol of the industry's failure in Alaska was a prospect called Mukluk in the Beaufort Sea. In 1982, a number of companies spent $1.5 billion on Mukluk leases, only to find that the oil the giant structure had once contained had leaked out long ago in geologic history. "We drilled in the right place," observed the president of Sohio. "We were simply 30 million years too late."[89] After some futile efforts to explore in the Chukchi Sea in the midst of slumping oil prices, the industry temporarily lost its craving for the Arctic. Furthermore, the public relations fallout from the *Exxon-Valdez* oil spill in 1989, which resulted in congressional and presidential moratoria on leasing in Bristol Bay, contributed to the industry's fading interest, for the time being, in offshore Alaska.[90]

The mid-1980s collapse in oil prices also ruined many companies' appetite for the deepwater Gulf of Mexico. Leasing slowed considerably as some operators scaled way back or pursued different opportunities. Others, led by Shell Oil, chose to take a longer-term view of the deepwater play. The failures in Alaska helped reinforce this choice. Additional reinforcement came in 1987, when the MMS dropped the minimum bid requirement for deepwater tracts from $900,000 to $150,000 – enabling companies to lock up entire basins for 10 years for only a couple million dollars.[91] The National Gas Wellhead Decontrol Act of 1989 led to swift declines in natural gas prices, hurting producers on the Gulf's natural gas-prone continental shelf and impelling some companies into the more oil-prone deepwater. During the next five years, the industry acquired 1,500 tracts in deepwater, despite persistently flat oil and gas prices.[92]

Another reason for the upsurge in deepwater leasing was Shell Oil's announcement, in December 1989, of a major discovery at a prospect called Auger, located in the Garden Banks area 136 miles off the Louisiana coast. Two years earlier, Global Marine's new, giant semi-submersible, the *Zane Barnes*, struck oil for Shell after drilling through 2,860 feet of water and another 16,500 feet beneath the seafloor. Shell kept the discovery quiet as it delineated the extent of the field, which turned out to be huge, containing an estimated 220 million barrels of oil equivalent, the company's third largest offshore discovery in the Gulf. Underpinning Shell's decision to go forward with Auger was the discovery of relatively high flow rates from wells drilled into turbidite sands at Bullwinkle, perched along the margin of the continental shelf. On shallower parts of the shelf, a good well produced 1,000 barrels per day and an excellent well produced 2,000 barrels per day. Shell's engineers found that they could open Bullwinkle's wells to 3,500 barrels per day without any attendant loss in bottom-hole pressure. If Auger had similar flow rates, the field could be profitably developed, even if its water depth was more than twice Bullwinkle's. Few people knew that Auger was only one of a number of deepwater discoveries made by Shell in the mid- to late-1980s. But for an uncomfortable period of time, the company was not sure what to do with them all. After Bullwinkle demonstrated the production potential of turbidites, Shell formulated an ambitious strategy to launch a series of major platforms.[93]

A gloomy economic outlook, however, tempered the euphoria within Shell that greeted the Auger discovery and the production breakthrough at Bullwinkle. Oil prices had not rebounded, and Shell's net income was sinking. The company had just spent $300 million to drill a succession of dry holes offshore Alaska. The projected cost of developing Auger was in excess of $1 billion. In appraising the next prospect, code-named Mars, Shell's exploration managers looked for ways to save money and offload some of the financial risk. In 1988, they brought in British Petroleum (BP) as a partner with a 28.5 percent interest in Mars, a tactical decision that would later come back to haunt Shell. At the time, Mars seemed like a risky project, with low probability for a major discovery. Furthermore, BP posed little threat. The company had been kicked out of Iran and Nigeria in 1979 and was struggling along with a bloated management structure, poorly performing global assets, and uninspiring leadership. Shell viewed BP's role in Mars as merely a banker.[94]

All that changed in 1989, when Sonat's *Discoverer Seven Seas* drilled into Mars. The field, located due south of the mouth of the Mississippi River, lay in nearly 3,000 feet of water under leases acquired in 1985 and 1988 for the small sum of $5.3 million. With BP on board as a partner, Shell shot more seismic, including a 3-D survey (see below), which revealed huge potential for the prospect. The discovery well encountered multiple oil and gas bearing layers stacked on top of each other over several hundred meters. Mars was more than twice the size of Auger -- the largest field discovered in the Gulf of Mexico in 25 years. For Shell, Mars promised a big payoff for large bets on deepwater leases. For the industry, Mars confirmed the deepwater Mini-Basin trend in the Gulf as a bona fide play. For BP, Mars allowed the company's managers, engineers, and scientists to go to school on Shell's deepwater technology. Perhaps just as importantly, according to BP's chief in the United States, "Mars saved BP from bankruptcy."[95]

During the next several years, major oil companies—and even more significantly, contractors in the offshore-service industry—propelled the evolution of technology in innovative new directions. The 1970s revolution in digital, three-dimensional (3-D) seismic imaging, pioneered by Geophysical Services Inc. (GSI), and the 1980s move to computer workstations, which enabled faster processing of the massive amount of data generated in a 3-D survey, dramatically enhanced the industry's accuracy in locating wells for field development—a critical factor when drilling a single well in deepwater could cost as much as $50 million. In 1989, only 5 percent of the wells drilled in the Gulf relied on 3-D; in 1996, nearly 80 percent did. Companies acquired the majority of that data between 1990 and 1993.[96] Increasingly, operators relied on 3-D seismic not only for field development, but for wildcat exploration as well. Shell demonstrated the value of using 3-D for exploration at Mars. By many accounts, 3-D seismic boosted wildcat finding success from less than 30 percent (three out of every ten wells struck oil) to 60 or 70 percent. As the majors began to divest from older producing properties in favor of new deepwater prospects, smaller firms purchased older properties and redeveloped them with significant reserve additions using 3-D seismic. In all, 3-D seismic tripled or even quadrupled oil and gas reserves in the Gulf of Mexico.[97]

Drilling and subsea engineering advanced in a similar fashion. Drilling contractors developed a new generation of vessels that took drilling from 5,000 to 10,000 feet of water, and from 20,000 to 30,000 feet of sub-seafloor depth. New directional drilling techniques, made possible by downhole steerable motors, allowed engineers to maneuver a well from vertical to horizontal to achieve greater accuracy and more fully exploit reservoirs. Drillers also found ways to obtain information from deep inside wells, using breakthroughs in "measurements-while-drilling" tools and sensors that provided position, temperature, pressure, and porosity data while the borehole was being drilled. Improvements in marine risers using lightweight composite materials and tensioners, along with new methods for preventing oil from cooling and clogging in deepwater pipelines, enabled the industry to make long tiebacks between subsea wells and production facilities. To support subsea installation and operations, the industry turned to sophisticated remote-operating vehicles (ROVs) mounted with TV cameras and umbilical tethers containing fiber-optic wire for the transmission of vivid images. These swimming robots replaced divers, whose physical capabilities were stretched to the limit at 1,000 feet.[98] The work done in the ocean depths was still human, but most of it was now remotely performed from the surface. “The dark and forbidding depths of the Gulf of Mexico, once frequented by only the hardiest of sea creatures, are now alive with human activity,” reported *Time* magazine in 1990. “This is the new geological frontier, and a daring breed of modern-day explorers is using technology worthy of Jules Verne and Jacques Cousteau to find fresh supplies of oil and natural gas.”[99]

Even as the major operators pushed into deepwater, they outsourced more of the research and development (R&D) of new technologies. The bust of the 1980s had driven the exploration and production companies to decrease internal R&D and adopt policies of buying expertise as needed, rather than cultivating it from within. The era of the great technology labs run by the majors was ending. Upstream R&D investments by the majors declined from nearly $1.3 billion a year in 1982 to $600 million a year by 1996, with the sharpest drop coming in the early 1990s. According to a National Petroleum Council study in 2006: “This ‘buy versus build’ strategy resulted in a significant reduction in the number of skilled people within operating companies who understood technology development and deployment.”[100] Service companies such as Schlumberger, Halliburton, Baker Hughes, and Oceaneering became the major source of technology development, raising their R&D spending almost in direct proportion to the decline in exploration and production firms. A symbol of this trend in the deepwater business was the 1992 creation of the “Deep Star” consortium, initiated by Texaco. Deep Star brought together eleven operators to fund contractor-generated R&D that addressed “technical issues that are barriers to economically viable deepwater production.”[101] Research universities also took up the slack. A prime example was the 1990 creation of the Offshore Technology Research Center at Texas A&M, financed largely by the National Science Foundation, which featured a giant 150-foot-long wave basin used to simulate deep water environments, the only place outside of Europe where companies could test deepwater designs.[102]

Rapid technological advances in the early 1990s did not immediately translate into more economically feasible practices. Cost overruns, delays, and strained relationships with contractors plagued the fabrication and installation of the Shell's tension-leg platform for Auger, the industry's bellwether deepwater project. The continuing slump in oil prices threatened its viability. In addition, Shell discovered that crude oil from the Auger field was sour (containing sulfur, which had to be separated out at the refinery) and thus had to be discounted. The company's only salvation on this project was if Auger's wells flowed at higher rate than Bullwinkle's, the most productive field in the Gulf.[103]

Fortunately for Shell and entire offshore industry, Auger's wells did not disappoint. In the spring of 1994, after ordeals in mating the deck and topsides with the hull and some early setbacks in drilling, Shell began to bring in wells that flowed at more than 10,000 barrels per day, almost three times the initial rate of Bullwinkle's wells. This was a massive breakthrough. Even with oil prices depressed at $20 per barrel or less, deepwater now promised handsome profits. The Auger wells confirmed the reservoir model for turbidites in deepwater and even exceeded Shell's most optimistic estimates. Engineers designed Auger to handle 42,000 barrels of oil (and 100 million cubic feet of gas) a day from twenty-four wells, but by July 1994 the first three wells were already producing 30,000 barrels per day. By the late 1990s, debottlenecking efforts had raised the TLP's capacity to 105,000 barrels per day of oil and 420 million cubic feet per day of gas.[104]

Subsea completions also came of age in the Gulf of Mexico at Auger. In a subsea completion, the wellhead is located on the ocean floor rather than on a production platform at the surface. First developed by Shell in the early 1960s, subsea wells could never stay commercially competitive with platforms in the Gulf, although they were used increasingly in the North Sea. With the discovery of high flow rates in deepwater, however, subsea technology began to make economic sense in the Gulf as well, especially for gas fields and smaller fields that could not justify a large platform. With tension-leg platforms like Auger, subsea completions became important as a component of an early production system or as a remote subsea development. In 1996, Shell pushed the boundaries of offshore technology with subsea well installations at Popeye, which extended riser water-depth capabilities beyond 3,500 feet, and then at the Mensa gas field, in a recording-setting depth of 5,400 feet with a 68-mile tieback to the West Delta 143 platform.[105]

Auger's multiple blessings also came at a cost to Shell and the environment. Expanding production at Auger was extremely difficult. At the start of production in April 1994, Shell continuously flared or vented between one and six million cubic feet of natural gas per day, without the required federal permission. The flaring and venting continued for more than four years until August 1998, when the Minerals Management Service announced it had discovered this violation as well as Shell's failure to record and report the releases. In a 2003 civil settlement, Shell agreed to pay $49 million, an amount equivalent to the market value of about two weeks of production from Auger. [106] If the company was chastened after having to admit to these serious violations, Shell management also must have been tempted to look at this charge as an incidental cost of doing business in the deepwater Gulf.

Deepwater Treasures

Once news broke about the productivity of the Auger wells, the Gulf of Mexico became the hottest oil play in the world. And it was mostly about oil. Deepwater proved to be largely oil-prone. The source rocks for most of the deepwater region are an Upper Jurassic kerogen that generates natural gas only when subjected to very high temperatures. But subterranean thermal gradients and reservoir temperatures are in this region are modest, despite the enormous pressures exerted several miles below the seabed. The massive amounts of salt (see below) has acted like a heat sink keeping hydrocarbons from getting too hot and thus cooking up large amounts of natural gas.[107]

Despite downward pressure on oil prices in the late 1990s, the promise of prolific production from deepwater was too much to resist. Exploration and production firms with deepwater leases consolidated their positions. Companies that had sat on the sidelines during the 1980s stampeded into unclaimed areas. Newly developing or commercialized exploration and production technologies found vibrant new markets. Contractors all along the Gulf Coast and, indeed, around the world geared up for a surge of activity. Port Fourchon, Louisiana's southernmost port on the tip of Lafourche Parish, came to life as the jumping-off point for supplying and servicing deepwater operations in the Gulf.[108] "What Shell has done out there is truly extraordinary," reported *Platt's Oilgram News*. "They basically opened up a new vista."[109]

The next landmark on the deepwater horizon was Mars. In July 1996, the company began producing from its Mars platform, six months before NASA launched its Pathfinder probe to the planet Mars. At a total cost of $1 billion, Shell's Mars was more than three times as expensive as the Mars Pathfinder, and its remote technologies and engineering systems were arguably more sophisticated. The investment of money and technology paid dividends: the Mars platform tapped into the largest field discovered in the United States since Alaska's Prudhoe Bay. Creating a system to produce the field also established a new paradigm for large projects and revealed how exploration and production strategy was being reshaped in the Gulf.[110]

To reduce costs and avoid the headaches experienced at Auger, Shell introduced a different contracting model at Mars based on "alliances." The alliance with BP broke new ground in the industry by establishing an arrangement for sharing technology and patents. Shell ended up contributing more than BP, which had little experience in deepwater. But the costs and risks were too large to go it alone, which Shell had usually preferred to do. The partners carried the alliance concept over to their relationship with contractors. Key relationships created in this alliance included the Italian firm, Belleli, which built the tension-leg platform hull; J. Ray McDermott, which fabricated the topsides; and Aker Gulf Marine from Corpus Christi, which integrated the two. Rather than following the traditional adversarial model, in which operators drew up specifications and took bids, the project team brought in contractors early on to collaborate on developments and share risks and rewards. The key advantage of this approach was that it reduced the so-called "cycle time" of design, bidding, and contracting by an estimated six to nine months. On a platform such as Mars, where the first well came in at 15,000 barrels per day, the time-value of money made at the beginning rather than at the end of the platform's life was quite significant. Like Deep Star, Shell's contracting model at Mars, replicated on subsequent Shell tension-leg platforms, established the growing importance of alliance networks to global upstream developments in technologically complex frontier regions characterized by high costs and risks.[111]

In the late 1990s, having control of one-third of all Gulf of Mexico leases in depths greater than 1,500 feet, Shell rolled out one tension-leg platform after the other.[112] In 1997, the TLP Ram/Powell, a Mars "clone" developed in a joint venture with Exxon and Amoco, went on-stream in 3,200 feet of water in the Viosca Knoll area 80 miles southeast of Mobile, Alabama. In March 1999, Shell and its minority partners, BP, Conoco, and Exxon, started up the massive TLP, Ursa, on a lease two blocks to the east of Mars. Nearly double the weight of Mars, Ursa was designed to accommodate astounding initial well-production rates of 30,000 barrels per day; in September 1999, the A-7 well at Ursa broke all records with a daily production rate of nearly 50,000 barrels of oil equivalent per day. Finally, in 2001, Shell brought in production from the Brutus tension-leg platform, which tapped into a 200-million-barrel field in 3,000 feet of water in the Green Canyon.[113]

Shell's new technologies solidified the company's position as the leading "basin master" in the Gulf. A 1994 McKinsey study coined this term to describe those companies who, in a world of shrinking exploration and production opportunities, built dominant acreage and logistical positions in new plays, not only through technical skill in finding and developing resources, but by getting a jump on competitors in frontier locations where scale and control over infrastructure conferred strategic advantage. McKinsey pointed to Shell's operations in the deepwater Gulf as a hallmark of basin mastery.[114] Shell's tension-leg platforms, as well as major fixed platforms such as Bullwinkle and West Delta 143, not only produced hydrocarbons from the fields beneath them, but also served as "hubs" used to take and process oil and gas production from satellite subsea wells, thus extending the life of those platforms once their own production declined.[115]

Deepwater output from Shell platforms and subsea wells, and eventually from other companies in the vicinity, fed into network of Shell-owned or operated crude oil trunk pipelines, gathering systems, and natural gas pipelines. Shell also made special arrangements to transport crude oil production from its growing deepwater properties into the Clovelly storage facilities owned by the Louisiana Offshore Oil Port (LOOP) in South Louisiana.[116] In late 1994, Shell began plans to build its $100 million, 200,000 barrels per day Mars pipeline system to move crude oil to Clovelly. The main artery of the system included a 130-mile, large diameter pipeline from the Mars field to the onshore terminal at Port Fourchon. Shell also laid an equally large pipeline—called the Amberjack pipeline—from the Bullwinkle field at Green Canyon Block 143 to the LOOP Fourchon facilities. By 1996, LOOP began receiving shipments of crude from these first deepwater pipelines. Five years later, Shell operated 11 of the 16 key oil trunk pipelines servicing deepwater. This position enabled Shell to capture a large share of the value creation, extract rents from competitors through access charges, and erect barriers to entry in the three major corridors offshore Louisiana.[117]

Shell's lead on the rest of the industry in the deepwater Gulf was substantial but not unassailable. During the latter half of the 1990s, many companies gained ground, including a rising percentage of small and mid-sized independents. But the only company that chased down and eventually overtook Shell was BP.

Deeper Still

In the 1990s, technological breakthroughs in imaging and drilling through massive salt sheets opened a new "subsalt" play, first on the shelf and then ranging into deepwater. Discoveries in at least four different "fold belts" across the Gulf of Mexico extended the search for oil into "ultra-deepwater" and led to another wave of innovation in floating production. In 1990, most oil and gas from the Gulf still came from shallow water; average production-weighted depth had barely reached 250 feet. By 1998, the weighted average passed the 1,000-foot milestone, at which point deepwater production (at about 700,000 barrels per day of oil and 2 billion cubic feet per day of gas) surpassed that from shallow water for the first time.[118]

As the industry moved deeper, the abandonment and decommissioning of older platforms on the shelf became a thriving business. During the 1990s, 1,264 platforms were removed, more than twice the total prior to 1990; after 2000, removals continued at a rate of 150 per year.[119] Some obsolete platforms found use as “artificial reefs” through a creative program coordinated between the Minerals Management Service and the states of Texas and Louisiana to place old platforms in specially designated locations on the sea bottom, where they attracted marine life much like natural reefs.[120]

Meanwhile, another relaxation in the terms of access to Gulf of Mexico leases helped sustain industry interest and draw in more players. In 1995, Congress enacted the Deep Water Royalty Relief Act, which provided a suspension of royalty payments on a portion of new production from deepwater operations. The United States was facing global competition for upstream capital during a period of low prices, and royalty relief’s sponsor, Louisiana senator Bennett Johnston, designed the legislation to entice investments in economically “marginal resources” in deepwater. Royalty relief appeared to have the desired effect. In 1996 and 1997, the Minerals Management Service issued a record number of leases. The Central Gulf of Mexico sale held on March 5, 1997 awarded 1,001 leases, more than 5 million acres, the largest sale of all time. The number of Gulf leases issued in deepwater climbed from about 1/3 the total number before royalty relief to about ½ the total after passage of the act. Before royalty relief, only a handful of major oil companies and larger independents dared to explore in deepwater. By 2001, more than 40 different operators had drilled deepwater wells.[121]

Critics of royalty relief, on the other hand, argued that its proponents greatly overstated the act’s effects in promoting deepwater expansion.[122] They viewed the purpose of the legislation not as “relief,” but rather as corporate welfare for a “highly profitable world-class hydrocarbon province where large oil companies enjoy an overwhelming presence, and cash-strapped small companies do not form a part of the picture.”[123] Royalty relief no doubt enticed more oil companies, especially non-majors, into deepwater. But judging from the huge up swell in bidding at the May 1995 Central Gulf of Mexico sale, before the royalty relief passed in November, the race appeared to be already under way.[124] Oil explorers were clearly gunning for fields like Auger with high flow rates and high ultimate reserves. Many of them were also on the hunt for petroleum in a new geological location: beneath the Gulf’s massive sheets of salt.

Salt is the dominant structural element in the Gulf of Mexico petroleum system. Oil explorers had long discovered oil in the Gulf trapped against the flanks of salt domes or between the salt diapirs (autochthonous salt) in the deepwater mini-basins. But geologists typically had assumed that there could be no oil reservoirs lying beneath any salt they encountered. By the 1970s, advancing knowledge about the basin's regional geology suggested that oil *could* be found under the salt. In many places, the salt pillars that extruded upward into sandstone and shale flowed horizontally in elastic plumes over vast expanses of younger, potential oil-bearing sediment, covering more than 35,000 square miles across the Gulf. Geologists invented new terminology to describe different kinds of salt formations (allochthonous salt) in the picture they pieced together – canopies, tongues, nappes, egg crates, and turtle domes– and established a special subfield of geology, called "salt tectonics," to explain how the salt moves. What they were really interested in, however, was what lay beneath the salt.[125]

As the geology came into focus, companies rushed to drill below these salt plumes. In 1990, Exxon (with partner Conoco) made the first subsalt discovery at a prospect called Mickey, a name given in association with Exxon's famous promotional comic book for Disney, *Mickey and Goofy Explore the Universe of Energy*. Located in 4,352 feet of water on the Mississippi Canyon 211 lease (about ten miles northeast of where BP drilled Macondo), Mickey was not a large enough discovery at the time to put into production.[126] Two years later, Chevron drilled a well in Garden Banks 165 through almost 7,000 feet of salt and another 5,000 feet of subsalt sediment, but found no oil. Still, the well was a milestone because it demonstrated that the technology existed to drill through an enormous body of salt.[127]

Finally, in 1993, Phillips Petroleum made headlines in announcing the first commercial subsalt oil discovery. Years earlier, Phillips had begun to look systematically for places where salt sheets might be obscuring oil reservoirs. Company geologists studied the basin-wide distribution of known oil and gas fields and pinpointed gaps where there was a probability fields might exist. They found one noticeable gap around Ship Shoal 349 on the edge of the shelf in about 375 feet of water. In 1989, Phillips acquired 15 leases including one at this location they called Mahogany. It was a speculative move based on 2-D seismic data, which did not provide clear enough vision to see through the salt.[128] This was the big challenge. Salt plays havoc with seismic sound waves, which travel through salt at a much higher velocity than the surrounding sediments and also get refracted, similar to how the image of a pencil gets bent when stuck in a glass of water. Obtaining clear images of rocks in their proper location under the salt seemed almost impossible. "It was pretty much like a blurry, snowy TV picture," said one industry geophysicist.[129]

To get a better focus, Phillips shot a 3-D seismic survey over the prospect. And to share the substantial costs of conducting a 3-D survey and drilling through the salt, which was twice the cost of a normal well, the company took on Anadarko and Amoco as partners. Phillip's geophysicists then processed the seismic data with a newly developed computing algorithm, called "pre-stack depth migration." Simply stated, this was a fancy way of repositioning the return signal to show more accurately the coordinates of the seismic reflection from under the salt. Neither Phillips nor any other company at the time had overcome the imaging problems presented by the salt, but the processing improved the picture enough to make an informed stab at the target. Drilled by a Diamond Offshore semi-submersible, the first well passed through 3,800 feet of salt, at one point encountering an interval of unstable rock that threatened to collapse the well. Eventually, the drill hit a 100 million barrel field. In 1996, Phillip's Mahogany platform began producing at 20,000 barrels per day.[130]

The subsalt play progressed, haltingly, from Mahogany. In 1994, Shell, with partners Amerada Hess and Pennzoil, discovered the Enchilada oil field; in 1995, Texaco and Chevron found gas at Gemini; and in 1996, Phillips and Anadarko made a discovery at Agate, near Mahogany. Drilling through salt involved a myriad of technical complications. Under high temperature and pressure, salt masses flow, creep, and deform like plastic. Among other problems, this movement can shift the well casing and production tubing. Subsalt wells also had to be drilled to great depths, and thus individual well costs escalated very quickly. Most importantly, from an exploration perspective, computers were not powerful enough to run the algorithms needed to obtain reliable seismic images from beneath the salt. Subsalt wells missed hydrocarbons a lot more often than they hit them. [131]

As operators drilled a string of dry holes in the subsalt, the post-Mahogany euphoria ebbed. In the 1995-1997 lease sales, companies began to leap past the shallow subsalt play into “ultra-deep” water (greater than 5,000 feet), looking for easier-to-image prospects in foldbelts formed by the lateral movement of salt and sediment. The dynamic interaction between mobile salt and deepwater turbidite deposits created gigantic anticlincal structures called compressional box folds.[132] These had the potential to harbor massive oil reservoirs. In 1995, Oryx Energy made a discovery at Neptune, opening a new play in the Western Atwater Foldbelt. The next year Shell announced a strike at its Baha prospect in the Alaminos Canyon in far western Gulf. This discovery initiated the Perdido Foldbelt play in more than 8,000 feet of water near the edge of the deep Louann salt. “In many cases,” reported the *Houston Chronicle* in 1997, “interpreting seismic shot through the flatter salt beds in deeper waters is easier than compensating for the distortions caused by the jagged, irregular structures in the shallower depths.”[133]

A deeper ocean frontier, once again, beckoned the industry. But achieving consistent success in modeling subsalt prospects anywhere still required more innovation in acquiring, processing, and interpreting seismic data.

Industry Restructuring

As geologists and geophysicists in Houston dedicated themselves to solving the riddles presented by depths of the Gulf of Mexico, the world oil industry began a radical restructuring. Oil and gas companies had not yet recovered from the 1980s bust and were coping with global surpluses when oil prices swooned again in the late 1990s, driven in large part by the drop in global demand precipitated by the Asian financial crisis. Increased shareholder pressure on oil firms to improve short-term financial results and demonstrate long-term profitability spurred one of the greatest oil merger movements in history. In 1998, BP acquired Amoco. The next year, Exxon merged with Mobil in an $80 billion deal to create the world’s largest company. BP-Amoco countered by acquiring Arco, Total merged with Fina and Elf (renamed Total in 2003), Chevron combined with Texaco, and, finally Conoco and Phillips joined to create the sixth “super major” (along with Royal Dutch Shell). During these turn-of-the-century consolidations, many companies relocated staff from New Orleans and other places to Houston, reinforcing that city’s claim as the international capital of oil.[134]

Mergers boosted results as management pared away overlapping functions and laid off employees, reinforcing the trend toward outsourcing R&D and reducing internal technological expertise. Mergers benefitted the oil industry, on the other hand, by equipping firms with new capital reserves needed to finance long-term growth strategies—some of them dependent on riskier, but potentially higher-return, ventures. The deepwater Gulf figured significantly in the growth strategies of all the “super major” oil companies—albeit as only one among several frontier provinces worldwide. They took renewed interest in Arctic and sub-Arctic regions and began to invest in other deepwater basins from the northeast Atlantic west of the Shetland Islands, to the Campos Basin off Brazil, to West Africa’s Gulf of Guinea and offshore Angola, to northwest Australia. By the early 2000s, analysts regarded the three provinces rimming the central Atlantic Ocean—the Gulf of Mexico, Brazil, and West Africa—as the “New Golden Triangle,” the place where the largest future reserves were likely to be found.[135]

Echoing the oil companies, consolidation also swept through offshore contractors. After half of the world’s seismic crews were idled in 1999, the ensuing shakeout left only handful of big firms standing, led by Western-Geco, owned by Schlumberger and Baker-Hughes; Petroleum Geo-Services; and CGG and Veritas (which merged in 2007). The major oil-service companies also felt the heat at this time, leading to the merger in 1998 between Energy Ventures and Weatherford Enterra to become Weatherford International, and between the two oil field giants, Halliburton and Dresser Industries, who combined their subsidiaries, Kellogg and Brown & Root, into the engineering and construction subsidiary, KBR.[136] Most significantly, the drilling-contractor industry—continuously in the process of mergers, acquisitions, and bankruptcies—consolidated further. In 1999, Sedco-Forex and Transocean, both the product of a series of earlier mergers, became Transocean Sedco Forex, later simplified as Transocean. In 2000, this new company acquired R&B Falcon, whose assets included a semi-submersible under construction by Hyundai Heavy Industries in Ulsan, South

Korea called the *Deepwater Horizon*. In 2001, Global Marine merged with Santa Fe, and six years later this firm became part of the modern Transocean, by far the largest offshore drilling firm in the world.[137]

During this era, offshore oil exploration and production became an increasingly global enterprise. U.S. operators searched for oil in deepwater basins outside the Gulf of Mexico, and more than ever, foreign companies such as Norway's Statoil, Brazil's Petrobras, and France's Total, were drilling in the Gulf of Mexico. Shipyards along the Gulf Coast—the pioneers in design and construction of mobile offshore drilling units—had by the 1990s almost totally surrendered this work to competitors in Korea and Singapore. Many of the largest offshore engineering, construction, and pipelaying firms (Heerema Marine Contractors, Technip, Worley Parsons, and others) were globally oriented companies based outside the United States.[138]

Offshore contractors headquartered in the Gulf survived by expanding internationally themselves. Morgan City's J. Ray McDermott branched out around the world more aggressively after the 1980s depression and eventually moved its headquarters to Houston. Louisiana-based companies Gulf Island Fabricators, Chet Morrison Contractors, Global Industries, and even Frank's Casing Crew and Rental Tools grew from small, family owned firms servicing operations in the Gulf of Mexico to become major offshore contractors active worldwide.

BP's Moment

In the late 1990s, the global company making the biggest news in the Gulf of Mexico was BP. The company was founded in 1908 as the Anglo-Persian Oil Company (in 1954, its name changed to British Petroleum; in 2001, the name was shortened to BP) and for decades had built its business around access to crude oil from Iran and neighboring Middle East countries. In the 1960s and 1970s, BP achieved great success in discovering and developing oil reserves in the North Sea and in Alaska's Prudhoe Bay. By the early 1990s, however, the company tottered on the brink of bankruptcy. BP had been exiled from the Middle East and Nigeria. Production from Prudhoe and the North Sea were in decline. Billions of dollars had been invested in unprofitable nonpetroleum ventures. And an ambitious exploration program had yet to bear fruit.[139]

John Browne, a forceful exploration manager whose father had also worked for BP, orchestrated the company's stunning turnaround. In the 1980s, as executive vice president of Sohio, BP's American subsidiary, he reined in spending and cut staff in order to place the company on better footing. Returning to London in 1989, he reorganized BP's exploration arm in a similar manner. Browne slashed expenditures, established a rigid if not ruthless performance ethic, and refocused on high-risk but potentially high-reward opportunities. "If we didn't take risks, we wouldn't be in the exploration business," said Browne in 2002.[140] Upon becoming chief executive in 1995, Browne (who assumed the title "Sir" when he was knighted by the Queen of England in 1998) directed a major part of BP's upstream focus to the deepwater Gulf. In the deals he negotiated to acquire Amoco and Arco, BP emerged with a greatly expanded portfolio of Gulf leases and assets.[141]

In the late 1990s, BP's exploration team in the Gulf made a series of remarkable deepwater discoveries. Once the fields came online, they vaulted BP ahead of Shell as the Gulf's large oil producer. BP prided itself as a "fast follower," rather than an "early adopter," in exploiting technological innovations. BP had closely followed Shell at Mars and quickly applied what it had learned to develop the Marlin field with a tension-leg platform in 3,400 feet of water. "We were certainly riding Shell's coattails at that point," admitted Dave Rainey, BP's deepwater exploration manager, "but those successes did allow us to predict a production stream that would grow to about 150,000 barrels per day from essentially nothing."[142] BP also joined with Exxon in developing deepwater discoveries at the Hoover and Diana fields in the East Breaks area of the western Gulf. After the string of subsalt dry holes in the mid-1990s, some of BP's competitors began looking for other kinds of plays the Gulf might still present. Shell shifted to a more process-oriented structure to manage production from its large number of deepwater developments. But BP sprang faster than anyone to confront the Gulf's nagging exploration challenge—the salt.[143]

"Follow the salt," Rainey implored his team.[144] They responded by stepping up their quest to clarify seismic images beneath the salt. Computing technology was constantly evolving to handle ever-greater amounts of seismic data. Most notably, this included four-dimensional, or “time-lapse” methods of analyzing how reservoirs change over time (from a series of 3-D surveys collected from different points in time). Processing algorithms were improving just as steadily. There were still limitations, however, in the quality of the subsalt seismic data. Data acquisition, not processing, presented the main constraint. Geoscientists needed to be able to capture data over wider expanses and from many different directions. The solution in deepwater was to shoot seismic data with “wide-azimuth” streamers (sound receivers towed behind a seismic vessel). Azimuth refers to the angle of linear horizontal direction. Until the mid-1990s, seismic surveys typically involved towing streamers along one azimuth. A wide-azimuth survey meant acquiring data in multiple directions using several seismic vessels at the same time.[145]

Conducting a wide-azimuth survey required a flotilla of vessels as well as a fundamental understanding of the geology -- its salt history, its stratigraphy, and the sources and migration pathways of oil. “We need to find the plumbing,” said Rainey.[146] So in 1995, BP exploration launched a far-reaching study of the deepwater Gulf, looking more closely at the migration history of producing regions on the shelf and drawing geological analogies with deepwater. They found that in deepwater there were areas just as big as the shelf with equally good “charge systems” and traps. Considering those factors, they began to believe that the deepwater should evolve in a similar fashion as the shelf and concluded that this frontier could ultimately hold 40 billion barrels of commercial oil. This defied the conventional wisdom, which predicted ultimate reserves in the deepwater Gulf to be one-fourth that amount. But history teaches one thing about the conventional wisdom in the Gulf – that it has been repeatedly defied. “One of the lessons we have learned about the Gulf of Mexico is never to take it for granted,” said Rainey.[147]

BP combined a solid understanding of salt geology with dramatically improved sub-salt images gathered from wide-azimuth surveys. They saw hints of larger, potentially simpler traps under the salt. The new generation of drilling vessels coming onto the market, along with the new advances in drilling, enabled BP to take the risk on exploring those prospects. Outpacing most of the industry by a year, BP shifted its prospect inventory much deeper. Then the company made a historic string of giant oil strikes in subsalt formations ranging out to 7,000 feet of water. In 1998, it struck oil in the deepwater subsalt of the Green Canyon's Mississippi Fan Foldbelt at Atlantis (minority partner BHP Billiton) and Mad Dog (minority partners BHP Billiton and Chevron), two of the largest fields ever discovered in the Gulf of Mexico: Atlantis's original reserves estimates were 400-800 million barrels of oil equivalent and Mad Dog's were placed at 200-450 million barrels. In 1999, working for BP (and minority partner Exxon) in 6,000 feet of water in the Mississippi Canyon, Transocean's *Discoverer Enterprise* drilled the largest Gulf of Mexico field of all time at a "turtle" structure, subsalt prospect called Crazy Horse. Containing more than 1 billion barrels of recoverable reserves, Crazy Horse symbolized yet another rebirth of offshore oil in the Gulf of Mexico.[148]

There was one group of people, however, who were not initially pleased with the Crazy Horse discovery – the descendants of the Lakota warrior and spiritual leader who regarded the use of his name outside of a spiritual context as sacrilegious. A BP geologist with a passion for the music of rock star Neil Young actually had named the prospect after his band. But this did not matter to the Lakota. In 2002, BP yielded to the Lakota's objections and renamed the field Thunder Horse.[149]

The discoveries kept coming. One month after the discovery well at Thunder Horse, BP made another oil and gas hit at Horn Mountain in the Mississippi Canyon, on leases originally acquired by Arco's subsidiary, Vastar Resources. In 2000, BP discovered a major above-the-salt deposit at Holstein (a 50 percent joint venture with Shell) near the Mad Dog and Atlantis fields in the Green Canyon. That same year, the two partners announced their Na Kika project, a joint subsea development of five independent fields, four predominantly oil and one natural gas, tied back to a central semi-submersible floating production facility, an industry first for the Gulf of Mexico. In 2001, BP found another giant oilfield five miles away from Thunder Horse called Thunder Horse North, containing an initial reserve of 500 million barrels. Also that year, BP and yet another partner, Chevron, discovered oil in 7,000 feet of water at their Blind Faith prospect in the Mississippi Canyon. (In the harsh glare of hindsight following the Macondo blowout, the executive director of the National Resources Defense Council commented that, in the name Blind Faith, "It would be hard to find a more fitting symbol of the oil industry's steady and assertive advance into the Gulf's deep waters, or the corporate thinking behind it.")[150]

In August 2002, BP's Browne boldly announced that the company would spend $15 billion during the next decade on drilling and developing these discoveries. BP had become the largest-acreage holder in the deepwater Gulf, with more than 650 tracts in water depths greater than 1,500 feet, and in possession of one-third of all deepwater reserves then discovered. The deepwater Gulf of Mexico, he assured his audience, would be the "central element" of BP's growth strategy.[151] "The question is how they will manage the embarrassment of riches they have," said one analyst at the time. "They have a bunch of projects and they need to coordinate people and contractors. There is the sheer scale of the facilities and the size of the investment required – all this before a drop of oil ever comes out of the ground."[152]

Clouds on the Horizon

After BP's impressive series of discoveries, the industry dove into deeper waters across the Gulf. From 2001 to 2004, operators found eleven major fields in 7,000-foot depths or more. Most deepwater discoveries were made in relatively young geologic-age sandstones of the lower Miocene era. But companies increasingly explored down into the deeper and older Paleogene, or "Lower Tertiary," strata found in the foldbelts in ultra-deepwater near the edge of the Sigsbee Escarpment, a salt sheet that resembles a near-surface moonscape extending to the base of the continental slope. In 2006, Chevron and its partners Devon Energy and Statoil disclosed promising test results from a two-year-old discovery at its Jack prospect in the Walker Ridge area. The "Jack-2" test proved that Lower Tertiary reservoirs could produce oil at pressures encountered at great depths, creating excitement that the Lower Tertiary play may ultimately yield between 3 and 15 billion barrels of hydrocarbons—collectively rivaling the size of the great Prudhoe Bay discovery. This implied a future for ultra-deep drilling, ranging out to 10,000-foot water depths and 25,000 feet beneath the seafloor. Reported the *Oil & Gas Journal*, "The Jack-2 test results boost confidence in that potential and highlight the central role technology plays in future supply."[153]

The industry was in need of a confidence booster after the previous three years of development challenges that had sorely tested BP's and the industry's confidence and conviction about deepwater.

BP's decision to develop multiple deepwater fields at once was an incredibly ambitious undertaking. Its program focused on the four major fields at Holstein (a discovery above the salt), Mad Dog, Atlantis, and Thunder Horse—with total potential reserves of 2.5 billion barrels of oil, in water ranging from 4,000 to 7,000 feet deep, requiring wells reaching 30,000 feet in total depth. To produce oil at these four places, BP selected "truss spars" for Holstein and Mad Dog, and semi-submersibles (such as the one BP and Shell had introduced at Na Kika), for Thunder Horse and Atlantis.[154]

Beyond about 4,000-foot depths, tension-leg platforms could no longer be used because the weight of the tension cables at those depths was too great. In 1996, Kerr-McGee had successfully demonstrated the viability of the spar concept at its Neptune field. The spar resembles a giant buoy, consisting of a large-diameter, single vertical cylinder supporting a deck for drilling and processing. It contains a deep-draft floating caisson, which keeps about 90 percent of the structure underwater, giving the structure favorable motion characteristics compared to other floating concepts. Neptune knocked down many barriers – technical and regulatory – to deploying spars as production platforms in the deepwater Gulf. During 2000-2005, Kerr-McGee went on to pioneer innovations in spar designs, with so-called "truss" spars at the Nansen, Boomvang, and Gunnison fields, and the "cell" spar the Red Hawk field.[155]

BP's choice between spars and semi-submersible production facilities came down to different economic, functional, and safety factors at each field. All four projects would be linked by pipeline to the Ship Shoal 332 platform hub, where crude would be transferred into a 390-mile pipeline, the Cameron Highway, and transported to refineries at Texas City and Port Arthur, Texas. All four projects, as well as Na Kika, also would connect to the BP-operated Mardi Gras transportation system. A major, $1 billion project itself, the Mardi Gras system integrated five different pipelines covering a total of 450 miles with the capacity to transport 1 million barrels per day of crude and 1.5 billion cubic feet per day of natural gas.

The selection and development of technology on all these projects was a major challenge at every step, given the extreme water depths, reservoir conditions, and associated environmental issues. Thunder Horse had an unusually high pressure/high temperature reservoir, creating a "cascading effect on subsea facilities and the floater." Atlantis was located under complex seafloor topography near the steep Sigsbee escarpment, and a large portion of the field was subsalt. Mad Dog lay under a massive salt canopy, causing large uncertainties in describing the actual reservoir. The Holstein geology forced BP to use a spar with wells housed on the platform. As BP production managers admitted in 2004, "None of the projects can be categorized as 'business as usual.'"[156]

The $5 billion Thunder Horse project was especially fraught with difficulties. A major incident in drilling occurred even before the semi-submersible facility was put in place. In May 2003, the top of the drilling riser on the drillship *Discoverer Enterprise* broke loose from the vessel, ripped apart again 3,000 feet under the surface, and left the lower marine riser package to collapse on and around the top of the blowout preventer, where the riser and drill pipe snapped off. The blowout preventer's blind shear rams were activated and worked as designed, averting any spill. "No one was hurt, and the well was secure," BP reported, "but the initial scene was daunting."[157]

An even bigger scare awaited the Thunder Horse semi-submersible production facility, which was towed to the field and moored on location in April 2005. As work proceeded to connect the pre-drilled subsea wells and commission all the facilities above and below the water, Hurricane Dennis neared in July, forcing the evacuation of all personnel and leaving the production facility unmanned. "No one could have anticipated the major shock that awaited the first helicopter flights after the storm had passed," according to one official BP account. The columns and other areas of the hull had filled up with water, causing the facility to list to one side. Investigations later revealed that a valve in the bilge and ballast system had been installed backward, allowing seawater to move *into* the hull, a failure exacerbated by electrical pathways that were not watertight. Had BP not arrived when it did, the structure might have been lost. Crisis management crews were able to right the facility within a week, but reworking Thunder Horse's hull systems delayed commissioning for a year. Similar work on the Atlantis semi-submersible production platform pushed its installation back several months, too, until July 2006.[158]

Nor was that the end of BP's major shocks, as it discovered that a weld had cracked open on one of the Thunder Horse manifolds that collected oil from the network of satellite subsea wells. "Befitting its name, BP's massive Thunder Horse offshore platform has been beset by dark clouds ever since it was on the drawing board," reported the *Houston Chronicle*.[159] The company made the difficult decision to pull out all the manifolds and subsea equipment that had a similar weld configuration— adding hundreds of millions of dollars to the cost of the project. After a lengthy investigation, engineers found that minute cracks had formed in the thermal insulation on the manifold pipe work, leading to reactions that embrittled the weld interface. BP and contractors developed new weld techniques, created more rigorous inspection and assurance procedures, and refurbished all the affected subsea equipment on Thunder Horse and at Atlantis. Thunder Horse finally delivered its first oil on June 2008, three years behind schedule.[160] By March 2009, production ramped up to 250,000 barrels per day, 4.5 percent of total U.S. daily production (Atlantis went online a year before Thunder Horse, in 2007, but BP has been dogged by accusations that Atlantis has not been in compliance with safety and environmental regulations.)[161]

BP was not alone confronting environmental challenges. During 2002 and 2004-2005, hurricanes ravaged the Gulf Coast, with major impacts on offshore infrastructure and operations. In September 2002, Hurricane Lili blew into the heart of the Ship Shoal, Eugene Island, and South Marsh Island areas, damaging platforms and pipelines. Two years later, Ivan, a Category 4 storm, swept through the alley east of the Mississippi River delta, causing mudflows and anchor-dragging by mobile drilling units that tore up undersea pipelines. The following year, Hurricane Katrina flooded New Orleans and points east, with horrible effects. Offshore, Katrina destroyed 47 platforms and extensively damaged another 20. The 1,000-ton drilling rig on Shell's Mars platform collapsed, prompting an around-the-clock onsite recovery effort. A month later, Hurricane Rita, storming farther west, wiped out 66 platforms and broke up another 32. Rita capsized Chevron's Typhoon, an unfortunately named "mini" tension-leg platform. The majority of the platforms obliterated in these two storms were from an early generation of Gulf facilities, more than 30 years old. The two hurricanes also damaged more than 70 vessels and nearly 130 oil and natural gas pipelines, as they hit more prolific and sensitive areas than previous storms and, accordingly, caused much more extensive damages. Ominously, the short interval between the two storms exhausted the resources available for normal recovery and overwhelmed support bases.[162]

The Oil Industry and Deepwater Technology at Decade's End

As the end of the decade approached, the offshore industry in the Gulf had recovered from hurricane devastation and pressed on with deepwater and ultra-deepwater developments. Although many independent companies (such as Anadarko, Hess, BHP, Newfield, Marathon, and Mariner) had substantial deepwater leases and were actively exploring and developing them, the edge of the frontier was mainly the playground of the super-majors and firms with partial government ownership, such as Norway's Statoil and Brazil's Petrobras—long a deepwater leader.[163]

In September 2009, Transocean's *Deepwater Horizon* semi-submersible made a historic discovery for BP at the company's Tiber prospect in the Keathley Canyon. Drilling in 4,000 feet of water and to a world-record total depth of 35,055 feet, the *Deepwater Horizon* tapped in a vast pool of crude estimated to contain 4 to 6 billion barrels of oil equivalent in place, one of the largest discoveries in U.S. history. Six months later, in March 2010, Shell (with partners Chevron and BP) started up production at its Perdido spar in 8,000 feet of water in the Alaminos Canyon. A hub for the development of three fields, Perdido was the world's deepest offshore platform, besting the distinction claimed by Anadarko at its Independence Hub in 2007, and it became the first project to pump oil and gas from the Lower Tertiary. Other Lower Tertiary developments were coming onto the horizon. Later in the year, Petrobras planned to develop the Gulf of Mexico's first floating, production, offloading, and storage facility to produce from Lower Tertiary reservoirs at its Cascade and Chinook prospects in the Walker Ridge. By 2010, the industry had announced 19 discoveries in the Lower Tertiary trend, 14 of them containing more 100 million barrels of recoverable oil and gas.[164]

The fanfare around these discoveries and developments still could not disguise the fact that the technical hurdles of ultra-deepwater and the subsalt remained unique and formidable. Water depths are extreme, down to 10,000 feet. Total well depths, as Tiber demonstrated, can go beyond 30,000 feet. Well shut-in pressures can surpass 10,000 pounds per square inch. Bottom-hole temperatures can exceed 350 degrees Fahrenheit. Salt- and tar-zone formations can be problematic. The sandstone reservoirs are tightly packed, and ensuring hydrocarbon flow through risers and pipelines can be difficult. According to a 2008 report from Chevron engineers for the Society of Petroleum Engineers, all these factors "separate many GoM deepwater and ultra deepwater wells from deepwater and ultra deepwater wells in other parts of the world."[165]

Drilling in extreme water depths poses special challenges. Risers connecting a drilling vessel to the blowout preventer on the seafloor have to be greatly lengthened, and they are exposed to strong ocean currents encountered in the central Gulf. Managing higher volumes of mud and drilling fluid in these long risers makes drillers' jobs more demanding. Connecting and maintaining blowout preventers thousands of feet beneath the surface can only be preformed by remote-operating vehicles. A 2007 article in *Drilling Contractor* described how blowout preventer requirements got tougher as drilling went deeper, because of low temperatures and high pressures at the ocean bottom. The author discussed taking advantage of advances in metallurgy to use higher-strength materials in the blowout preventers' ram connecting rods or ram-shafts. More generally, he suggested "some fundamental paradigm shifts" were needed across a broad range of blowout-preventer technologies to deal with deepwater conditions.[166]

Under such conditions, methane hydrates raised a host of serious problems. Methane gas locked in ice ("fire ice") forms at low temperature and high pressure, and can often be found in seafloor sediments. Temperature and pressure changes caused by drilling, or even by natural conditions, can activate the release of 160 cubic feet of gas from one cubic foot of methane, collapsing surrounding sediment, and thus destabilizing the drilling foundation. Hydrates can also present well-control problems. As hydrocarbons are produced and transported in cold temperatures and high pressures, hydrates can form and block the flow through deep pipelines and other conduits. Government, academic, and industry research programs on hydrates and associated flow problems begun in the 1990s are continuing.[167]

Knowledge about localized geology, types of hydrocarbons, and pressure profiles in ultra-deepwater wells is still not thoroughly developed. Geological conditions are complicated and vary from prospect to prospect, and from well to well. Each well, indeed, has its own “personality” that requires maintaining an extremely delicate balance between the counteracting pressures of the subsurface formation and the drilling operation. Targets are extremely deep. Unforeseen circumstances arise, such as in 2002, when Shell was forced to abandon drilling an $80 million well at a prospect called Deep Mensa in the Mississippi Canyon after the drill bit got stuck at nearly 28,000 feet attempting to drill through fractured rock.[168] Beneath the salt, pressures in the pores of the sediment are difficult to predict. Imaging under the salt and maintaining well control in drilling through it continue to present complex problems. Hydrocarbons in the Lower Tertiary are biodegraded, and thus thicker and with higher viscosity than the fluids found in younger rocks. Finally, ultra-deepwater developments are a long distance from shore and far from established infrastructure. As a BP technical paper prepared for the May 2010 Offshore Technology Conference noted, “The trend of deepwater discoveries in the [Gulf of Mexico] is shifting toward one with greater challenges across many disciplines represented by the conditions of Lower Tertiary discoveries.”[169]

Nevertheless, the challenges seemed manageable and the rewards appeared worth the perceived risk. The offshore industry had enjoyed a long run in the Gulf without an environmental catastrophe. The hurricanes of mid-decade had caused widespread damage, but not a major offshore spill. In recent years, the industry had touted its relatively clean record in the Gulf as a justification to allow exploration elsewhere. As oil prices climbed from 2003 to 2008, peaking at over $140 per barrel, so did the industry’s interest in exploring other frontier areas, especially offshore Alaska. In 2007, Shell and Total bid aggressively for federal leases offered in the Beaufort Sea, and in 2008, Shell spent $2.1 billion for oil leases in the Chukchi Sea. The following year, however, a lawsuit in a federal appeals court challenging the Minerals Management Service’s environmental studies preceding the sale held up applications for permits to drill on these leases.[170]

Still, from 2008 through early 2010, both government and industry were largely bullish about the potential of offshore drilling for the nation's future. Not incidentally, both were earning even greater revenues from ever-more ambitious exploration. Despite the impasse in Alaska, long-standing political opposition to offshore drilling along the U.S. coastline outside of the Gulf of Mexico, in places like Virginia, Florida, and Alaska, appeared to be weakening. In July 2008, as the U.S. presidential campaign was heating up, sitting president George W. Bush lifted the presidential moratorium on offshore drilling, a policy initiated by his father George H.W. Bush and renewed by President Bill Clinton. Crowds chanted "Drill, Baby, Drill!" at the Republican convention, and Republican nominee John McCain adopted former House speak Newt Gingrich's slogan, "Drill Here, Drill Now, Pay Less," as the basis for his energy policy. Democratic nominee, Barack Obama, and House speaker, Nancy Pelosi, initially resisted any talk of lifting the congressional moratorium, but softened their positions in hopes of achieving a compromise that would lead to broader energy policy reform. In September 2008, as national attention turned to the dire financial crisis, the House let the moratorium expire and then passed an appropriations bill that did not include Department of the Interior funding bans, with an exception for the existing moratorium on leasing in the Eastern Gulf of Mexico enacted by Congress in 2007.

The political process moved forward to loosen restrictions on offshore drilling. On his last day in office, President Bush released for public comment a Draft Proposed 5-Year OCS Oil and Gas Leasing Program that included lease sales in four areas off Alaska, two areas off the Pacific coast, three areas in the Gulf of Mexico, and three areas in the Atlantic. Shortly after taking office, Obama's secretary of the Interior, Ken Salazar, announced his offshore energy strategy, which included an extension of the comment period on Bush's Draft Proposed Program. On March 30, 2010, President Obama, as part of "expanded energy development," scaled back the Bush administration's proposal, including the cancellation of five Alaska lease sales (but not existing leases), the postponement of a lease sale offshore Virginia, and the removal from consideration of leasing in the Pacific. But Obama also gave the go-ahead for studies of potential development in the Eastern Gulf, the Chukchi and Beaufort Seas, and the Mid- and South-Atlantic.   With the exception of Eastern Gulf, the "new areas" were "opened" by President Bush's draft five-year plan. Nevertheless, Obama's announcement signaled a shift toward reconsidering the expansion of offshore drilling for the first time in at least two decades.   The president defended his position by observing, "oil rigs today generally don't cause spills."[171]

As President Obama spoke, Transocean's *Deepwater Horizon*—fresh from completing BP's spectacular find at Tiber a few months earlier—was busy drilling on BP's Mississippi Canyon 252 lease, in approximately 5,000 feet of water. BP had named the prospect Macondo, after the fictional town in Gabriel Garcia Marquez's 1970 novel, *One Hundred Years of Solitude*. The fate of the town of the Macondo, as described in a memorable passage by Marquez, presaged the fate of the Macondo well and summed up the challenges facing the industry as a whole as it plumbed the depths of the Gulf:

> It was as if God had decided to put to the test every capacity for surprise and was keeping the inhabitants of Macondo in a permanent alternation between excitement and disappointment, doubt and revelation, to such an extreme that no one knew for certain where the limits of reality lay.[172]

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[2] Richard Nehring, "Oil and Gas Resources," in *The Gulf of Mexico Basin*, ed. Amos Salvador (Boulder, CO: Geological Society of America, 1991), 445-494.

[3] J. Burney Courtney quoted in Tom Zoellner, "Oil and Water: The Adventure of Getting One from Deep Beneath the Other," *Invention and Technology* (Fall 2000): 48.

[4] Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power* (New York: Simon and Schuster, 1992), 409.

[5] Joseph Pratt, Tyler Priest, and Christopher Castaneda, *Offshore Pioneers: Brown & Root and the History of Offshore Oil and Gas* (Houston: Gulf Publishing, 1997), 15-52, 137-157; Lauren Penney, "In the Wake of War: World War II and the Offshore Oil and Gas Industry," *History of the Offshore Oil and Gas Industry in Southern Louisiana: Vol. 1*: *Papers on the Evolving Offshore Industry*, MMS OCS Study 2004-049 (2008), 37-65. Available at https://www.gomr.mms.gov/homepg/espis/espisfront.asp.

[6] Pratt, Priest, and Castaneda, *Offshore Pioneers*, 21-25.

[7] See Tyler Priest, "Claiming the Coastal Sea: The Battle for the Tidelands, 1937-1953," *History of the Offshore Oil and Gas Industry in Southern Louisiana: Vol. 1*, 11-32.

[8] Quoted in D.B. Hardeman and D.C. Bacon, *Rayburn: A Biography* (Austin: Texas Monthly Press, 1987), 381.

[9] *Thunder Bay* film trailer, 1953.

[11] On the early federal regulatory program, see Tyler Priest, "Auctioning the Ocean: The Creation of the Federal Offshore Leasing Program, 1954-1962," *History of the Offshore Oil and Gas Industry in Southern Louisiana: Vol. 1,* 93-113.

[12] Tyler Priest, "Extraction Not Creation: The History of Offshore Petroleum in the Gulf of Mexico," *Enterprise & Society* Vol. 8, No. 2 (June 2007): 240-241.

[13] Quoted in Alden J. LaBorde, *My Life and Times* (New Orleans: LaBorde Printing Company, 1996), 174.

[14] James W. Calvert, "Gulf Offshore Activity Booming," *World Petroleum* (January 1957): 48.

[15] Ben C. Belt, "Louisiana and Texas Offshore Prospects," *Drilling* (March 1956): 119; "Special Offshore Report," *World Oil* (May 1957): 118.

[16] Calvert, "Gulf Offshore Activity Booming," 48.

[17] Tyler Priest, *The Offshore Imperative: Shell Oil's Search for Petroleum in Postwar America* (College Station: Texas A&M Press, 2007), 69-71.

[18] Pratt, Priest, and Castaneda, *Offshore Pioneers*, 36-48; Priest, *The Offshore Imperative,* 74-81.

[19] Priest, *The Offshore Imperative,* 81-91.

[20] Ibid., 99.

[21] The average depths of federal leases were 67 feet in 1954-1955 and 89 feet in 1960. Tract sizes in the Gulf of Mexico were typically 5,760 acres. Initial federal OCS leasing maps were extensions of the leasing maps of Texas and Louisiana. A regular block offshore Louisiana consisted of 5,000 acres and those offshore Texas were 5,760 acres, the maximum allowed by the OCSLA. Priest, "Auctioning the Ocean," 96, 112.

[22] Ibid., 113.

[23] Diane Austin, "Coastal Exploitation, Land Loss, and Hurricanes: A Recipe for Disaster," *American Anthropologist* Vol. 108, No. 4 (December 2006): 681.

[24] U.S. Department of the Interior, "Petroleum and Sulfur on the U.S. Continental Shelf," internal study, August 1969, box 134, Central Classified Files, 1969-1972, Record Group 48, Records of the Secretary of Interior, National Archives and Records Administration (NARA), College Park, MD.

[25] John Rankin, Offshore Energy Center Hall of Fame Interview by Tyler Priest, Houston, TX, September 30, 2000.

[26] Priest, "Auctioning the Ocean," 113.

[27] On Project Mohole and JOIDES, see David K. van Keuren, "Breaking New Ground: The Origins of Scientific Ocean Drilling," in Helen M. Rozwadowski and David K. van Keuren, eds., *The Machine in Neptune's Garden: Historical Perspectives on Technology and the Marine Environment* (Sagamore Beach, MA: Science History Publications, 2004), 183-210. On Shell's *Eureka* project, see Priest, *The Offshore Imperative*, 97, 218.

[28] F. P. Dunn, "Deepwater Production: 1950-2000," Offshore Technology Conference (OTC) Paper 7627, (1994), 922-924.

[29] Priest, *The Offshore Imperative*, 127-130.

[30] "Oil Majors Wonder," *Financial Times* (April 25, 2002): 29.

[31] Dunn, "Deepwater Production: 1950-2000," 923.

[32] Cliff Hernandez interview by Andrew Gardner, May 1, 2001, New Iberia, LA, Houston History Archives, M.D. Anderson Library Special Collections, University of Houston, Houston, TX. This interview is one of approximately 450 oral histories conducted for MMS OCS Study 2004-049 (2008). Many oral histories in the collection describe working conditions offshore from the 1920 to the 1970s. A guide to the interviews can be found at http://archon.lib.uh.edu/?p=collections/findingaid&id=231&q=&rootcontentid=67211#id67211. Volumes II, III, and IV of the study contain detailed oral history narratives of the southern Louisiana communities of Bayou Lafourche, Morgan City, and Terrebonne Parish. These volumes are available at https://www.gomr.mms.gov/homepg/espis/espisfront.asp.

Personal injury lawsuits beginning in the 1960s contributed to increasing attention to safety in offshore operations. Initially, the Longshoreman and Harbor Workers' Compensation Act (LHWC) of 1927 covered most offshore workers. This act was designed to fill a gap between the

Jones Act (1920), which protects seaman, and state workers' compensation, which covers injuries incurred in a particular state. LHWC provides medical and disability benefits, rehabilitation services, and wrongful death benefits to survivors for injuries, illness, or death sustained during maritime employment on navigable waters of the United States. Maritime employment includes loading/unloading, building, and repairing vessels and offshore structures. In 1959, however, the United States Fifth Circuit Court of Appeals ruled (Offshore Co., v. Robison, 266 F.2d) that workers regularly assigned to "special purpose vessels" such as mobile offshore drilling units could be treated as seamen under the Jones Act. The significance of this decision was that the Jones Act not only entitled seaman to "transportation, wages maintenance and cure," which was equivalent to workers' compensation for seaman, but allowed injured seaman to obtain damages for pain and suffering from their employers if it could be determined that the injuries resulted from negligence by the shipowner, captain, or crew. After the Robison decision, a steady stream of personal injury lawsuits hit offshore operators, drillers, and construction companies. For information on the legal history of the Jones Act and the LHWCA, see The Steinberg Law Firm, Offshore Injury Litigation, http://www.offshoreinjury.net/.

[33] Ken Arnold interview with Tyler Priest, May 10, 2004, Houston, TX, Houston History Archives, M.D. Anderson Library Special Collections, University of Houston, Houston, TX.

[34] Don E. Kash, et. al., *Energy Under the Oceans: A Technology Assessment of Outer Continental Shelf Oil and Gas Operations* (Norman: University of Oklahoma Press, 1973), 104.

[35] U.S.G.S., "Monthly Engineering Reports," Volume 128, December 1958 and Volume 144, February 1960, RG 57, Records of the U.S. Geological Survey, NARA.

[36] Kash, et. al., *Energy Under the Oceans*, 105.

[37]Neil R. Etson to President Nixon, March 18, 1970, Central Classified Files, 1968-1974, Box 71, RG 57, Records of the U.S. Geological Survey, NARA.

[38]Kash, et. al., *Energy Under the Oceans,* 104.

[39] Robert E. Kallman and Eugene D. Wheeler, *Coastal Crude in a Sea of Conflict* (San Luis Obispo: Blake Printery and Pulbishing, 1984), 63.

[40] Riley E. Dunlap and Angela G. Mertig, *American Environmentalism: The U.S. Environmental Movement, 1970-1990* (Philadelphia: Taylor and Francis, 1992).

[41] All Presidential statements can be found at John T. Woolley and Gerhard Peters, *The American Presidency Project* [online], Santa Barbara, CA, available at http://www.presidency.ucsb.edu/.

[42] Russell Wayland, "The New Federal OCS Regulations in the Light of Santa Barbara," Society of Petroleum Engineers (SPE) Paper, 2780 (1969); Richard B. Krahl and David W. Moody, "Gulf Coast Lease Management Inspection Program," OTC Paper 1714 (1972), 846.

[43] M.D. Reifel, "Offshore Blowouts and Fires," in ETA Offshore Seminars, Inc., *The Technology of Offshore Drilling, Completion and Production* (Tulsa: The Petroleum Publishing Company, 1976),

239-257; "The Wicked Witch is Dead," *Shell News* No. 2 (1978): 2-8; and R.C. Visser, "Offshore Platform Accidents, Regulations, and Industry Standards," OTC Paper 7118 (1993). Shell managed to keep most of the wells burning above the platform, thus minimizing the spill in the water. However, there is some expert opinion that oil companies greatly underestimated the volumes of these spills, and the leaked oil may have been much greater than reported. See Steve Mufson, "Federal Records Show Steady Stream of Oil Spills in Gulf since 1964," *Washington Post* (July 24, 2010).

[44] Krahl and Moody, "Gulf Coast Lease Management Program;" Donald Solanas, "Update – OCS Lease Management Program," OTC Paper 1754 (1973); E.W. Standley, Interior Liaison Representative, to Jack W. Boller, Assistant Executive Secretary, Marine Board, National Academy of Engineering, February 15, 1972, Central Classified Files, 1969-1972, Box 136, Part 13, RG 48, Records of the Secretary of Interior, NARA.

[45] K.E. Arnold, P.S. Koszela and J.C. Viles, "Improving Safety of Production Operations in the U.S. OCS," OTC Paper 6079 (1989), 349-350.

[46] Dunn, "Deepwater Production," 923-924.

[47] Peter Lovie, "Classification and Certification of Offshore Drilling Units," in ETA Offshore Seminars, *The Technology of Offshore Drilling, Completion and Production*, 389-413.

[48] See data in National Academy of Sciences, Committee on Assessment of Safety of OCS Activities, *Safety and Offshore Oil* (Washington D.C.: National Academy Press, 1981).

[49] The rate of fires and explosions increased steady during the 1970s, from about 12 in 1970 to more than 30 in 1978, but the number of wells completed rose from 5,584 in 1970 to 9,140 in 1979. Ralph G. McTaggart, "Offshore Mobile Drilling Units," in ETA Offshore Seminars, *The Technology of Offshore Drilling, Completion and Production,* 24-25.

[50] E.P. Danenberger, Outer Continental Shelf Drilling Blowouts, 1971-1991, OTC Paper 7248 (1993).

[51] As of 2006, the system had a total length of 46,876 miles, the largest public works project in history. It took 35 years to complete, at a cost of $114 billion (adjusted for inflation, $425 billion in 2006 dollars). U.S. Department of Transportation, Federal Highway Administration, http://www.fhwa.dot.gov/interstate/faq.htm#question3.

[52] U.S. Energy Information Administration (EIA), Annual Energy Review, Petroleum, Table 5.13.c, http://www.eia.gov/emeu/aer/petro.html. On the forgotten victory of energy conservation and efficiency, see Jay Hakes, *A Declaration of Energy Independence: How Freedom from Foreign Oil Can Improve National Security, Our Economy, and the Environment* (Hoboken: John Wiley & Sons, 2008), 41-71.

[53] "Bidders Snub Most Deepwater Tracts," *The Oil and Gas Journal* (April 8, 1974): 36.

[54] Priest, *The Offshore Imperative*, 191-195.

[55] Stephen P.J. Cossey, "Celebrations Began with Cognac," *AAPG Explorer* (September 2004), http://www.aapg.org/explorer/2004/09sep/gom_history.cfm.

[56] Priest, *The Offshore Imperative*, 196-201.

[57] Pratt, Priest, and Castaneda, *Offshore Pioneers*, 83-90.

[58] Austin, "Coastal Exploitation," 682; Woody Falgoux, *Cajun Mariners: The Race for Big Oil* (Thibodaux, LA: Stockard James, 2007).

[59] "Gulf Lease Sale Shatters Two Records," *Oil & Gas Journal* (October 6, 1980): 34; Charlie Blackburn quoted in Priest, *The Offshore Imperative*, 216; D.A. Holmes, "1970-1986 Lookback of Offshore Lease Sales in the Gulf of Mexico Cenozoic," Interoffice Memorandum, Shell Offshore Inc. (August 24, 1987).

[60] Priest, *The Offshore Imperative*, 209-215.

[61] Get Oil Out! website, http://www.getoilout.org/about.htm.

[62] Kallman and Wheeler, *Coastal Crude in a Sea of Conflict*, 72.

[63] The Coastal Zone Management Act of 1972 gave coastal states the authority to ensure that OCS development was "consistent" with state plans for managing their coasts, but this was not a powerful enough tool to influence the location and amount of leases offered, so political actors still demanded greater voice. On post-Santa Barbara environmental policy developments, see Charles Frederick Lester, "The Search for Dialogue in the Administrative State: The Politics, Policy, and Law of Offshore Development" (Ph.D. Dissertation, UC-Berkeley, 1992).

[64] Robert Gramling, *Oil on the Edge: Offshore Development, Conflict, Gridlock* (Albany: SUNY Press, 1996), 199-123.

[65] Richard Charter, "People Power: How Citizen Action Works in California," in Dwight Holing, *Coastal Alert: Ecosystems, Energy, and Offshore Oil Drilling* (Washington DC: Island Press, 1990), 55.

[66] "Problems with Government," *Ocean Industry* (April 1982): 21.

[67] Exxon's Lena, for example, achieved a peak well rate of only 500 to 2,200 barrels per day. Cossey, "Celebrations Began with Cognac."

[68] Juan Carlos Boué with Edgar Jones, *A Question of Rigs, of Rules, or of Rigging the Rules? Upstream Profits and Taxes in U.S. Gulf Offshore Oil and Gas* (Oxford: Oxford University Press, 2007), 17.

[69] Rich Sears, "A Brief History of Deepwater," draft prepared for the National Oil Spill Commission, August 2010.

[70] Paul Voosen, "Gulf of Mexico's Deepwater Oil Industry Is Built on Pillars of Salt," *New York Times* (July 28, 2010); Gary Steffens and Neil Braunsdorf, Shell Exploration and Production Technology Company, "The Gulf of Mexico Deepwater Play: 50 Years from Concept to Commercial Reality," AAPG Distinguished Lecture, 1997-1998.

[71] "New MMS Setup Aims to Smooth OCS Leasing," *Oil & Gas Journal* (June 7, 1982): 66-67. The DOI created the MMS after the Linowes Commission – an independent panel charged with allegations of revenue theft – issued a report taking the federal government to task for gross mismanagement of mineral royalties. A copy of the report can be found at the Project On Government Oversight website, http://pogoblog.typepad.com/pogo/2010/07/is-interior-relying-on-mms-to-reform-itself.html.

[72] Sale 53 was held, but leases were not awarded. "Offshore Leasing Wins in High Court," *Oil & Gas Journal* (January 16, 1984): 60-61.

[73] Committee on Marine Area Governance and Management, National Research Council, *Striking a Balance: Improving Stewardship of Marine Areas* (National Academy of Sciences, 1997), 37.

[74] The historical causes of the destruction of the state's coastal wetlands are complex. Sugar and timber barons in the late 19th and early 20th centuries amassed large landholdings and transformed the landscape's hydrology with levees, drainage ditches, and canals. Decades of extractive activity and manipulation of waterways had gradual but cumulative impacts on coastal wetlands. Their erosion accelerated after World War II with the dredging of pipeline canals to service the proliferation of offshore platforms. These canals provided conduits for salt-water intrusion, while their spoil banks created ponds that drowned sections of the marsh. After years of debate, scientific opinion has moved against the argument that oil field canals are primarily responsible for wetlands destruction. The leading factors are regional subsidence and the prevention of sediment replenishment by levees on the Mississippi River. Still, credible scientific estimates find oil field canals responsible for at least 10 to 30 percent of the 1,900 square miles of coastal land loss in Louisiana between 1932 and 2000. Austin, "Coastal Exploitation," 671-691; Tyler Priest and Jason P. Theriot, "Who Destroyed the Marsh? Oil Field Canals, Coastal Ecology, and the Debate over Louisiana's Shrinking Wetlands," *Economic History Yearbook* 2 (2009): 69-80.

[75] "Critical Issues in OCS Activity Could Be Resolved This Summer," *Oil & Gas Journal* (July 2, 1984): 19-24. An obscure provision in the 1978 OCSLA amendments, labeled section 8g, had directed the federal government to share a "fair and equitable" portion of revenue derived from oil and gas fields that crossed into state territory and set up an escrow fund to collect revenues from the boundary section. Political fighting and litigation ensued over determining what was "fair and equitable." The settlement gave coastal states 27 percent of rents, bonuses, and royalties accumulated since 1978, along with a share of future royalty revenues. Donald W. Davis and Rodney E. Emmer, "8g – 'Oil on the Line,'" Paper Presented at Coastal Zone 87, Fifth Symposium on Coastal and Ocean Management, Seattle, WA, May 26-29, 1987.

[76] "A Show of Faith in the Oil Industry," *Newsweek* (June 6, 1983): 77.

[77] Bureau of Ocean Energy Management, Regulation, and Enforcement, Gulf of Mexico Oil and Gas Leasing Offerings, http://www.gomr.boemre.gov/homepg/lsesale/swiler/swiler.html.

[78] Priest, *The Offshore Imperative*, 221-222.

[79] During 1983-1986, Shell Oil won 252 of the 327 (77 percent) of all tracts awarded in the Gulf of Mexico. Priest, *The Offshore Imperative*, 221-226, 242-243.

[80] "The Time to Start Looking is Now," *Shell News* 4 (1984): 16.

[81] By 1990, Americans consumed less gasoline on a per capita basis (437 gallons per year) than they did in 1979. U.S. Energy Information Administration (EIA), Annual Energy Review, Petroleum, Table 5.13.c, http://www.eia.gov/emeu/aer/petro.html.

[82] Gramling, *Oil on the Edge*, 118.

[83] Steffens and Braunsdorf, "The Gulf of Mexico Deepwater Play."

[84] "Bullwinkle Takes Shape," *Shell News* 6 (1987): 2-7; "Rising Above the Crowd," *Shell News* 6 (1988): 28-34.

[85] "How Conoco Developed the Tension-Leg Platform," *Ocean Industry* (August 1984): 35-46.

[86] Tom Curtis, "Lifestyles of the Rich and Bankrupt," *Texas Monthly* (March 1988): 90.

[87] Congress of the United States, Office of Technology Assessment, *Oil and Gas Technologies for the Arctic and Deepwater: Summary* (Washington: GPO, 1985), 22-23.

[88] On the struggle over Bristol Bay, see Lester, "The Search for Dialogue in the Administrative State," 113-146.

[89] Quoted in Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power* (New York: Simon and Schuster, 1992), 733. On failed exploration ventures in Alaska, see Priest, *The Offshore Imperative*, 212-215.

[90] Priest, *The Offshore Imperative*, 209-215.

[91] Steffens and Braunsdorf, "The Gulf of Mexico Deepwater Play."

[92] BOEMRE, Gulf of Mexico Oil and Gas Leasing Offerings, http://www.gomr.boemre.gov/homepg/lsesale/swiler/swiler.html.

[93] Auger was not Shell's first deepwater discovery beyond the shelf. Discoveries at Tahoe (1984), Popeye (1985), Powell (1985), Mensa (1986) preceded Auger. On the history of Bullwinkle and Auger, see Priest, *The Offshore Imperative*, 237-251. Also see *Auger: Moving into the Future* (Houston: Hart Publications, 2001).

[94] On the history of Mars, see Priest, *The Offshore Imperative*, 253-261; *Shell's Mars Mission: A Deepwater Odyssey* (Houston: Hart Publications, 1999); and "Launch Pad into the Deep," *Houston Chronicle* (August 17, 1997).

[95] Bob Horton quoted in Tom Bower, *Oil: Money, Politics, and Power in the 21st Century* (New York: Grand Central Publishing, 2009), 19.

[96] "U.S. E&P Surge Hinges on Technology, Not Oil Price," *Oil & Gas Journal* (January 13, 1997).

[97] On the development of 3-D seismic, see William A. Schneider, "3-D Seismic: A Historical Note," *The Leading Edge* (March 1998): 375. On its impact in the Gulf of Mexico, see "Looking Ahead in Marine and Land Geophysics – A Conversation with Woody Nestvold and Ian Jack," *The Leading Edge* (October 1995): 1061-1067.

[98] "Exploring the Ocean's Frontiers," *Time* (December 17, 1990): 98; "Offshore Oil: How Deep Can They Go?" *Popular Science* (January 1992): 80-97.

[99] "Exploring the Ocean's Frontiers," 98.

[100] "Oil and Gas Technology Development," Topic Paper #26, National Petroleum Council Global Oil & Gas Study, November 22, 2006, 16. This topic paper was one of 38 working documents used to produce the 2007 NPC study, *Facing the Hard Truths About Energy* http://www.npchardtruthsreport.org/.

[101] S.A. Wheeler, W.F. Wallace, J.P Wilbourn, "The Deep Star Project: An Overview of Industry Cooperation," OTC Paper 7264 (1993).

[102] Susanne S. Pagano, "Offshore Drilling, Production – New Waves of Technology, *Sea Technology* (April 1991): 19-21; "There's Oil Down There . . . Way Down There," *Texas Shores* Vol. 31, No. 1 (Spring 1998): 14-15.

[103] Shell's engineers received strong indication that this was possible when, in 1992, they increased production from Bullwinkle's wells to 7,000 barrels per day without any loss of bottom-hole, draw-down pressure. Priest, *The Offshore Imperative*, 243-251.

[104] "Shell Marks Progress in Deepwater Gulf," *Oil & Gas Journal* (November 13, 1995); "Debottlenecking Removes Auger Production Constraints," *Oil & Gas Journal* (November 11, 1996).

[105] Priest, *The Offshore Imperative*, 251-252.

[106] MMS, "Shell to Pay $49 Million in Settlement Agreement with Minerals Management Service," News Release, August 5, 2003.

[107] Boué and Jones, *A Question of Rigs*, 130.

[108] F. Jay Schempf, "New Study Finds Port Fourchon 'Vital' to U.S. Economy," *Offshore* (March 1, 2008).

[109] Quoted in Helen Thorpe, "Oil and Water," *Texas Monthly* (February 1996): 144.

[110] D.G. Godfrey, J.P. Haney, A.E. Pippin, C.R. Stuart, D.D. Johnston, and R.H. Orlean, "The Mars Project Overview," OTC Paper 8368 (1997).

[111] But, as a 1997 McKinsey study also warned, alliance networks could create problems. "When more than two join the dance," the authors write, "the challenges multiply: managing communications, tailoring financial arrangements to reflect each partner's contribution and ability to absorb risk, and managing the risk that proprietary capabilities may be transferred inadvertently." David Ernst and Andrew M.J. Steinhubl, "Alliances in Upstream Oil and Gas," *McKinsey Quarterly* 2 (1997): 153.

[112] Jeff Ryser, "Hot Play in the Gulf," *Texas Business* (August 1995): 33.

[113] "The Cloning of Mars," *Shell News* 64, No. 1 (1996): 8-13; "Shell Oil Goes Deep in Gulf," *Houston Chronicle* (April 9, 1999): 1c, 8c; Priest, *The Offshore Imperative*, 260-262.

[114] Charles Conn and David White, *Revolution in Upstream Oil and Gas* (Sydney and Melbourne: McKinsey & Company Asia-Pacific Energy Practice, 1994), 64.

[115] For example, Shell's West Delta 13 platform served Popeye and Mensa subsea gas production; Cardamom, Oregano, Macaroni, and Habanero all tied into Auger; Troika was the first of several fields to be tied into Bullwinkle; and Europa and Princess linked into Mars.

[116] Located in 115 feet of water about 18 miles off the Louisiana coast, LOOP was the nation's only deepwater oil port. It was built in the late 1970s to accommodate the Very Large Crude Carriers (VLCCs) importing oil into to the United States. In the early 1990s, LOOP began to suffer from the changing global oil market. Rising imports from South America and Canada to the United States meant fewer big tankers calling to port at LOOP. In order to diversify its operations and stay financially competitive, LOOP obtained approval from federal regulators to modify its existing underground storage at the Clovelly salt dome, about 48 miles south of New Orleans, to take on new sources of domestic production from the emerging deepwater operations. John Kingston, "Moody's Reviews LOOP, Cites S. American Imports," *Platt's Oilgram News* (July 26, 1995): 3; A. D. Koen, "Shifting pattern of U.S. oil import sources tests viability of deepwater port projects," *Oil & Gas Journal* (August 21, 1995): 22; Mary Judice, "Out of the LOOP," *Times Picayune* (September 17, 1995): F-1, F-3. The passage of Deepwater Port Modernization Act of 1996 confirmed LOOP's statutory authority to receive oil from the deepwater OCS.

[117] C.G. Steube, "Addressing Transportation Needs for Deepwater Gulf of Mexico," OTC Paper 13169 (2001); Boué and Jones, *A Question of Rigs, of Rules, or of Rigging the Rules?* 324-327. The three corridors are the Eastern Pipeline, service by the Delta Pipeline System; the Central Pipeline, serviced by the Amberjack, Mars, Eugene Island, and Poseidon systems, and the Western Pipeline, serviced by the Ship Shoal system. Maps of Shell's systems can be found at: http://www.shell.us/home/content/usa/products_services/solutions_for_businesses/pipeline/crude_system_maps_spec/#subtitle_3.

[118] Boué and Jones, *A Question of Rigs*, 17.

[119] Installations, Removals, and Cumulative Totals of Offshore Production Facilities in Federal Waters: 1959-2010, www.boemre.gov/stats/PDFs/OCSPlatformActivity.pdf.

[120] Dolly Jorgenson, "An Oasis in a Watery Desert: Discourses on an Industrial Ecosystem in the Gulf of Mexico Rigs-to-Reefs Program," *History and Technology* Vol. 25, No. 4 (November 2009): 343-364.

[121] Carolita Kallaur, Associate Director, MMS, "The Deepwater Gulf of Mexico – Lessons Learned," presentation to the Institute of Petroleum's International Conference on Deepwater Exploration and Production, London, UK, February 22, 2001.

[122] Analysts have long debated whether the GOM Federal OSC fiscal regime is overly generous. Defending royalty relief in 1999 and 2000, Andrew Derman and Daniel Johnston argued that most government "take" statistics are based upon "the division of profits from an undiscounted (nominal) and unrisked point of view," which ignores that cost and lead times are greater in deepwater than elsewhere, and that threshold field size for development is greater because of lack of infrastructure. They objected to the fact that bonuses paid on blocks where no discovery is made were not incorporated into typical take statistics, and that when bonuses were included for blocks on which there is a discovery, they were not calculated on a net present value (NPV) basis. There is a lag of several years between bonus payment and discovery. On a NPV basis, bonuses can reach 20% of discounted gross revenues, and government take in the GOM (bonues, royalties, Federal income tax) then approaches 70 percent. Andrew Derman and Daniel Johnston, "Bonuses Enhance Upstream Fiscal System Analysis," *Oil & Gas Journal* (February 8, 1999); and Derman and Johnston, "Royalty Relief Vital for Continued Deepwater Development," *Oil & Gas Journal* (May 8, 2000).

There are several problems with Derman's and Johnston's analysis. First, they greatly underestimate discounted revenues from deepwater. In Shell's major TLP projects in the 1990s, bonus payments did not come close to 20% of the project's discounted gross revenues. Second, when estimating Federal income tax liabilities, Derman and Johnston use the marginal rate of 35 percent, instead of the average effective tax rate, which is closer to 10% or less for upstream income generated in the GOM Federal OCS, due to the fact that upstream activities are not ring-fenced for tax purposes. Aggregate dry hole expenses and the carrying costs of a lease inventory are corporate-wide costs, not project costs. So, for big companies like Shell and BP, with high exploration success in deepwater, large lease inventories, and major capital expenditures, the U.S. OCS fiscal regime can be very generous. For companies with more dry holes – and thus a higher ratio of bonuses paid for unproductive tracts -- and a small share of deepwater production, the fiscal regime may not be that favorable. See critique in Boué and Jones, *A Question of Rigs*, 236-245. Also, in 2007, a U.S. Government Accountability Office study found that the U.S. government "receives one of the lowest government takes in the world." U.S. GAO, *Oil and Gas Royalties: A Comparison of the Share of Revenue Received from Oil and Gas Production by the Federal Government and Other Resource Owners* (Washington, D.C.; U.S. GAO, 2007), 2. That same year, deepwater royalty rates increased from 1/8 (12.5%) to 1/6 (16.7%). Nevertheless, U.S. government take from offshore is still relatively small. In April 2010, right before the DH spill, DOI created a commission to study U.S. royalty rates in comparison with other countries: http://www.doi.gov/news/pressreleases/2010_04_12_release.cfm.

[123] Boué and Jones, *A Question of Rigs*, 189. The authors point out that the Deepwater Royalty Relief Act was not a politically popular measure and that it passed only because it was appended to another bill that enjoyed broad support: the repeal of the ban on Alaska oil exports. In 2006, the Department of the Interior released a study estimating that royalty relief accounted for very small percentage of deepwater production increases, but that the vague and poorly worded law had cost the government billions of dollars. See "Incentives on Oil Barely Help U.S., Study Suggests," *New York Times* (December 22, 2006); and "Vague Law and Hard Lobbying Add Up to Billions for Big Oil," *New York* Times (March 27, 2006).

A 2008 GAO study found that Deepwater Royalty Relief granted on Gulf leases issued between 1996 and 2000 would cost the federal government between $21 and $53 billion depending on the outcome of litigation, initiated by Kerr-McGee and carried on by Anadarko, challenging the authority of Interior to place price thresholds to remove royalty relief on certain leases. U.S. GAO, *Oil and Gas Royalties: The Federal System for Collecting Oil and Gas Revenues Needs Comprehensive Reassessment* (Washington, D.C.: U.S. GAO, 2008). In January 2009, the 5th Circuit Court in New Orleans ruled in favor of Anadarko, and in October 2009 the U.S. Supreme Court refused to hear the federal government's appeal. So the ultimate cost will be closer to the higher number in the GAO study.

[124] "High Bids Total $307 Million in Central Gulf of Mexico Lease Sale 152," MMS Press Release, May 10, 1995, http://www.boemre.gov/ooc/press/1995/50037.txt.

[125] Voosen, "Gulf of Mexico's Deepwater Oil Industry Is Built on Pillars of Salt;" Thorpe, "Oil and Water," 140-141.

[126] Ten years later, Exxon developed the prospect as a subsea natural gas development called Mica.

[127] Scott L. Montgomery and Dwight Moore, "Subsalt Play, Gulf of Mexico: A Review," *AAPG Bulletin* Vol. 81, No. 6 (June 1997): 875-876.

[128] Thorpe, "Oil and Water," 141.

[129] David Brown, "Salt Stymied GOM Progress," *AAPG Explorer* (March 2008), http://www.aapg.org/explorer/2008/03mar/salt.cfm.

[130] Rhonda Duey, "Pioneering a Global Play," *Hart's E&P* (July 1, 2009); Thorpe, "Oil and Water," 142.

[131] R.R. Israel, P. D'Ambrosio, A.D. Leavitt, J.M. Shaughnessey, and J. Sanclemente, "Challenges Evolve for Directional Drilling Through Salt in Deepwater Gulf of Mexico," *Drilling Contractor* (May/June 2008), http://drillingcontractor.org/challenges-evolve-for-directional-drilling-through-salt-in-deepwater-gulf-of-mexico-1622.

[132] Steve Enger and Andy Logan, "Ultradeepwater Play Paces Gulf, North America," *Oil & Gas Journal* (November 5, 2001), http://www.ogj.com/index/article-display/125508/articles/oil-gas-journal/volume-99/issue-45/special-report/ultradeepwater-play-paces-gulf-north-america.html.

[133] David Ivanovich, "Gulf is Heart of Deepwater Drilling," *Houston Chronicle* (May 4, 1997): 4J.

[134] Brian Knowlton, "Oil Growth Boomerangs on Houston," *International Herald Tribune* (April 1, 2002).

[135] David Townshend, "Golden Triangle Dominates," *Petroleum Economist* (October 2002).

[136] Dresser separated from Halliburton in 2001, and KBR was spun off from Halliburton in 2007.

[137] Other major offshore drilling contractors include Diamond Offshore, ENSCO, Nabors Industries, Noble Drilling, Pride International, and Saipem.

[138] Tim Colton and LaVar Huntziner, *A Brief History of Shipbuilding in Recent Times*. (Alexandria, VA: CNA Corporation, 2002); Mike Hunt and Lenny Gary, "Gulf of Mexico Fabrication Yards Built 5,500 Platforms Over 50 Years," *Offshore* (January 2000).

[139] BP's official history through 1975 can be found in a three-volume series: Ronald W. Ferrier, *The History of the British Petroleum Company, Vol. 1: The Developing Years, 1901-1932* (Cambridge: Cambridge University Press, 1982); J.H. Bamberg, *The History of British Petroleum, Vol. 2: The Anglo-Iranian Years, 1928-1945* (Cambridge: Cambridge University Press, 1994); and James Bamberg, *British Petroleum and Global Oil, 1950*-1975*: The Challenge of Nationalism* (Cambridge: Cambridge University Press, 2000). In 2007, Bamberg finished a fourth volume called *Energy and Enterprise: The Transformation of BP in the Second Era of Globalisation*, which carried the history forward to 2005, only to be informed that BP would not give permission to publish it, which was the company's right under the terms established in commissioning the study. See http://www.britishscholar.org/sommarch2008.html.

[140] "This Oil's Domestic, but It's Deep and It's Risky," *New York Times* (August 11, 2002). Beginning in 1993, BP started self-insuring for the largest risks the company was taking. This overturned the conventional practice followed by large companies to insure against large potential losses and self-insure against smaller ones. The insurance markets did not have the capacity to underwrite large and highly specialized exposures, like those encountered in deepwater. Neil A. Doherty and Clifford Smith, "Corporate Insurance Strategy: The Case of British Petroleum," *Journal of Applied Corporate Finance*, Vol. 6, No. 3 (Fall 1993): 4-15.

[141] BP's acquisition of Arco included Vastar Resources, Arco's Gulf of Mexico E&P subsidiary. During 1996-1999, Vastar acquired a large number of deepwater leases.

[142] Rainey quoted in Kathy Shirley,"Vision Led to Crazy Horse Find," *AAPG Explorer* (March 2002), http://www.aapg.org/explorer/2002/03mar/thunderhorse.cfm.

[143] Ibid.

[144] Rainey quoted in Bower, *Oil*, 24.

[145] "Resolution Undergoing Revolution," *AAPG Explorer* (March 2008): 16, http://www.aapg.org/explorer/2008/03mar/resolution.cfm.

[146] Rainey quoted in Bower, *Oil*, 23.

[147] "Vision Led to Crazy Horse Find."

[148] "Payoff Is A Long Time in Coming," *Houston Chronicle* (November 18, 2007), D1, D4.

[149] Bower, *Oil*, 25; "Vision Led to Crazy Horse Find."

[150] Peter Lehner with Bob Deans, *In Deep Water: The Anatomy of a Disaster, the Fate of the Gulf, and Ending Our Oil Addiction* (New York: The Experiment, 2010), 63.

[151] "Deepwater GOM New Focus of BP Growth Strategy," *Oil & Gas Journal* (August 19, 2002): 36.

[152] "This Oil's Domestic."

[153] "The Jack-2 Perspective," *Oil & Gas Journal* (September 11, 2006): 17.

[154] B.F. Thurmond, D.B.L. Walker, H.H. Banon, A.B. Luberski, M.W. Jones, and R.R. Peters, "Challenges and Decisions in Developing Multiple Deepwater Fields," OTC Paper 16573 (2004).

[155] K.L. Marshall and G.H. Smith, "Inspection Management Experience for a Fleet of Spars in the Gulf of Mexico," OTC Paper 17619, May 2005; C. Jim Thibodeaux, R. Don Vardeman, and Charles E. Kindel, "Nansen/Boomvang Projects: Overview and Project Management," OTC Paper 14089 (2002).

[156] Thurmond et al., "Challenges and Decisions in Developing Multiple Deepwater Fields."

[157] Bill Kirton, Gary Wulf, and Bill Henderson, "Thunder Horse Drilling Riser Break – The Road to Recovery," SPE Paper 90628 (2004).

[158] Simon Todd and Dan Replogle, "Thunder Horse and Atlantis: The Development and Operation of Twin Giants in the Deepwater Gulf of Mexico," OTC Paper 20395 (2010).

[159] "Thunder Horse Platform Payoff A Long Time Coming for BP," *Houston Chronicle* (November 17, 2007).

[160] Ibid.

[161] "BP Sued by Watchdog Group over Atlantis Platform," Bloomberg.com, September 13, 2010, http://www.bloomberg.com/news/2010-09-10/bp-sued-over-alleged-safety-gaps-at-atlantis-production-platform.html.

[162] Det Norske Veritas, Technical Report, Minerals Management Service, Pipeline Damage Assessment from Hurricane Ivan in the Gulf of Mexico, Report No. 440 38570, May 8, 2006. Includes data on damages from hurricanes through 2005.

[163] Lesley D. Nixon, Nancy K. Shepherd, Christy M. Bohannon, Tara M. Montgomery, Eric G. Kazanis, and Mike P. Gravois, *Deepwater Gulf of Mexico 2009: Interim Report of 2008 Highlights*, OCS Report, MMS 2009-016 (2009), https://www.gomr.mms.gov/homepg/espis/espisfront.asp.

[164] "BP Taps Vast Pool of Crude in Deepest Oil Well," Associated Press (September 2, 2009); "Shell's Perdido First to Produce in Key Deep Water Gulf Region," *Houston Chronicle* (March 31, 2010); "Chevron Plans New Floating City," *Houston Chronicle* Energy Watch blog, FuelFix, http://fuelfix.com/energywatch/2010/10/21/chevron-plans-new-floating-city/.

[165] Frank Close, Bob McCavitt, and Brian Smith, "Deepwater Gulf of Mexico Development Challenges Overview," SPE Paper 113011 (2008), 2.

[166] Melvyn Whitby, "Design Evolution of a Subsea BOP: Blowout Preventer Requirements Get Tougher as Drilling Goes Ever Deeper," *Drilling Contractor* (May 2007).

[167] Mary C. Boatman and Jennifer Peterson, *Oceanic Gas Hydrate Research and Activities Review*, OCS Report MMS 2000-017, U.S. Department of the Interior, MMS, Gulf of Mexico OCS Region, 2000.

[168] Bower, *Oil*, 29-30; "Market Movement," *Oil & Gas Journal* (April 15, 2002), http://www.ogj.com/index/article-display/140976/articles/oil-gas-journal/volume-100/issue-15/regular-features/ogj-newsletter/ogj-newsletter.html.

[169] Fergus Addison, Kevin Kennelley, and Fikry Botros, "Future Challenges for Deepwater Developments," OTC Paper 20404, May 2010.

[170] United States Court of Appeals, District of Columbia Circuit, *Center for Biological Diversity v. U.S. DOI*, No. 07-1247 (D.C. Cir. April 17, 2009).

[171] The White House, Office of the Press Secretary, Remarks by the President in a Discussion on Jobs and the Economy in Charlotte, North Carolina, April 2, 2010, http://www.whitehouse.gov/the-press-office/remarks-president-a-discussion-jobs-and-economy-charlotte-north-carolina.

[172] Gabriel Garcia Marquez, *One Hundred Years of Solitude*, Translated from the Spanish by Gregory Rambassa (New York: Avon Books, 1970), 212.