Chapter 2

The Significance of Oil in the Gulf of Mexico

It was 9:15 p.m. on April 20, 2010, and the captain of the Deepwater Horizon was entertaining heavyweights from British Petroleum (BP) and Transocean, by showing off the computers and software at his disposal. After the Captain welcomed his visitors on the bridge, Yancy Keplinger, one of two dynamic-positioning officers, began a tour while the second officer, Andrea Fleytas, was at the desk station. The officers explained how the rig's thrusters kept the Deepwater Horizon in place above the well, showed off the radars and current meters, and offered to let the visitors try their hands at the rig's dynamic-positioning video simulator. One of the visitors, a man named Winslow, watched as the crew programmed-in 70-knot winds and 30-foot seas, and hypothetically put two of the rig's six thrusters out of commission. Then they set the simulator to manual mode and let another visitor work the hand controls to maintain the rig's location. While Keplinger was advising about how much thrust to use, Winslow decided to grab a quick cup of coffee and a smoke. He walked down to the rig's smoking area, poured some coffee, and lit his cigarette.[1]

Most readers will be familiar and comfortable with this narrative. There was nothing extraordinary about it, as thousands of similar scenes of human–computer and human–machinery interactions play out every day in industrial, medical, military, banking, security, or TV news settings. Everything seemed to be under control, with the computers in charge, and their sensors humming. The people assigned to watch these computers, and

[1] All of these events are documented in the President's Commission Report, Chap. 1, p. 7.

J.A. Tainter and T.W. Patzek, *Drilling Down: The Gulf Oil Debacle and Our Energy Dilemma*, DOI 10.1007/978-1-4419-7677-2_2,

act on their advice, were content and getting ready to go to sleep. This is who we have become, and this is the environment in which most of us exist.

Suddenly, all hell broke loose, and it became clear that the people watching the computer screens did not understand what the computers were telling them. It took just a few seconds for their false sense of security to go up in the same flames that consumed the Deepwater Horizon in two days.

Although the outcome was extraordinary, the circumstances were not. Thousands of computer screens and messages are misinterpreted or misunderstood every day, but only occasionally does a mine cave in, a nuclear reactor melt down, a well blow out, a plane crash, a refinery explode, or soldiers die from friendly fire as a result. Each time we are reassured that the incidents were isolated and could have been avoided if people were just more thoughtful, better trained, or better supervised, managed, and regulated. Is this sense of security justified, a sort of divide-and-conquer mentality where isolated events appear small and amenable to familiar solutions, or are these events the result of societal processes over which we have little control?

Why would a company like BP build such a monument to technology and ingenuity as the Macondo well in the first place? Why was it necessary to drill for oil one mile beneath the surface of the Gulf of Mexico? Hubris among top management may have minimized the perception of risk, but well-informed employees throughout the organization understood the perils as well as the benefits of deep offshore operations. You may think that the need and motivation for these operations are obvious, but any rationale for drilling in these inhospitable environments must take into account the amount of oil (or energy in some form) that is needed to build and maintain an offshore drilling rig such as the Deepwater Horizon, extract the oil, and transport, store, and bring the precious liquid to market. In other words, large offshore platforms are built and operated using vast quantities of energy in order to find and recover even more. The cost is still higher when you consider the complex management and regulatory structures needed to complement the technology, however poorly you may feel that the responsible people performed in the case of the Deepwater Horizon.

Let us begin with fundamentals. First we need to know how much recoverable oil is waiting for us down there, how this amount of oil measures up against demand and total oil use in the United States, and how big the energy profit is after so much energy is expended in exploration, drilling, recovery, refining, and transportation to your local gas station or power plant. In other words, do the benefits outweigh the risks, for whom, and for how long?

We also need to know something about energy itself. Everybody talks about energy, but do we really understand its omnipresent role in society?

How does our insatiable appetite for energy fuel the growth of technological and organizational complexity, with all of their attendant benefits and costs? In this book, you will learn the technological and organizational factors that led to the disastrous oil spill in the Gulf. We call these factors the proximate causes. You will also see how energy and complexity can enter a positive feedback loop and spiral out of control in human societies, which makes catastrophes on local and regional scales increasingly likely, and can even threaten the future of our civilization.

How Important Is Oil Production in the Gulf?

Oil production in the Gulf of Mexico is considered vital to meeting U.S. energy needs, and thus world energy requirements. We present here some data on the Gulf oil reservoirs that we know about, those we expect are yet to be discovered, and those that we think exist but will always be too small to exploit because the potential economic or energy profit is too small. Oil or gas reserves are the quantities of crude oil or natural gas (total hydrocarbons) we are sure can be recovered profitably from known accumulations of hydrocarbons. The concept of reserves implies that oil companies can use "off-the-shelf" technology to get at the hydrocarbons. In other words, to count as reserves, the hydrocarbons must be discovered, commercially recoverable, and still remaining. Usually, only 1/3–1/2 of the oil and 3/4 of the gas in place can be recovered economically.

To estimate oil and gas reserves in the Gulf (see Fig. 2.1), we first have to define the physical extent of the oil-producing areas in what is known as the Outer Continental Shelf (OCS). In the U.S. Interior Department's lingo, OCS consists of the submerged lands, subsoil, and seabed lying between the seaward extent of the states' jurisdiction and the seaward extent of federal jurisdiction. The continental shelf is the gently sloping undersea plain between a continent and the deep ocean. The U.S. OCS has been divided into four leasing regions, one of which is the Gulf of Mexico (GOM) OCS Region.

In 1953, Congress designated the Secretary of the Interior to administer mineral exploration and development of the entire OCS through the Outer Continental Shelf Lands Act (OCSLA). The OCSLA was amended in 1978 directing the secretary to:

- Conserve the Nation's natural resources.
- Develop natural gas and oil reserves in an orderly and timely manner.
- Meet the energy needs of the country.

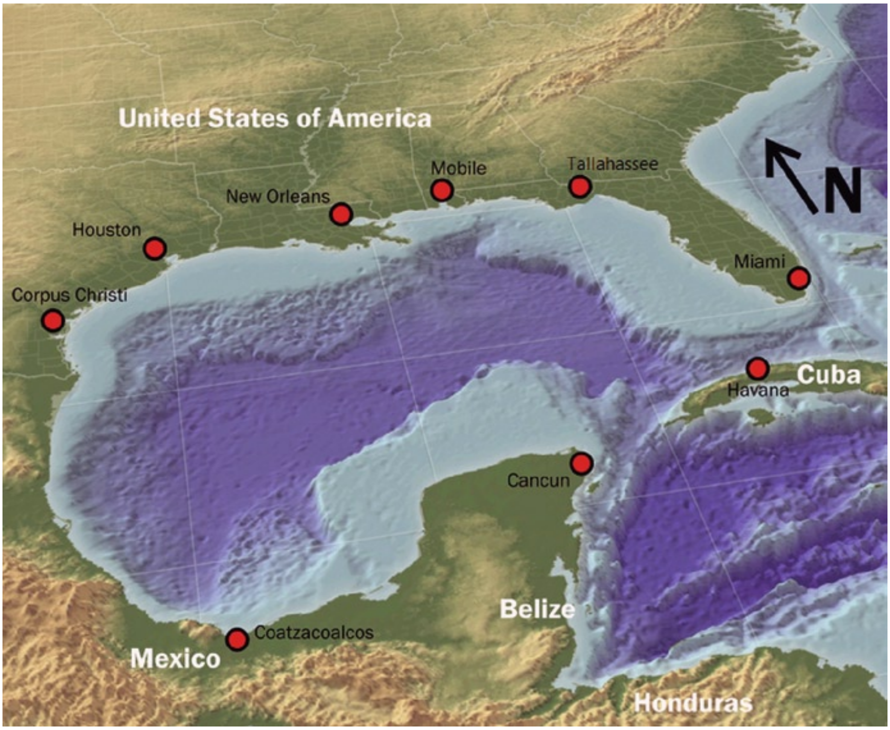

Fig. 2.1 The continental shelf of the Gulf of Mexico is topographically diverse, and includes slopes, escarpments, knolls, basins, and submarine canyons. Ocean water enters from the Yucatan channel and exits from the straits of Florida, creating the loop current associated with the upwelling and the high level of nutrient flow of this large marine ecosystem. Large quantities of freshwater are delivered from rivers in the United States and Mexico. The Gulf of Mexico is North America's most productive sea. Its shallow waters, especially river estuaries, teem with marine life. The region of the Mississippi River outflow sustains the highest level of marine life in the Gulf of Mexico. Chemical water pollution, coastal erosion, and overfishing are major threats to the health of this most important marine ecosystem in North and Central America. The Gulf of Mexico region is also a major oil and gas province that delivered 1.5 million barrels of oil per day for the United States in 2009. (Sources: NOAA, Minerals Management Service (MMS))

- Protect the human, marine, and coastal environments.
- Receive a fair and equitable return on the resources of the OCS.

State jurisdiction is defined as follows.

- Texas and the Gulf coast of Florida are extended three marine leagues (approximately nine nautical miles) seaward from the baseline from which the breadth of the territorial sea is measured.

- Louisiana is extended three imperial nautical miles (imperial nautical mile = 6,080.2 feet) seaward of the baseline from which the breadth of the territorial sea is measured.
- All other states' seaward limits are extended three nautical miles (approximately 3.3 statute miles) seaward of the baseline from which the breadth of the territorial seaward is measured.

As you can see, Texas got a much better deal than all other states, but Texas is bigger and – some people think – better. For our purposes, suffice it to say that federal jurisdiction is defined under accepted principles of international law. Thus, the GOM OCS covers an area of over 600,000 square kilometers, a little less than the area of Texas and twice the size of Poland.

As Figs. 2.2 and 2.3 show, most of the large oil and gas fields were discovered more than 30 years ago and the future "reserve" growth will have little effect on the ultimate hydrocarbon recovery from the Gulf's OCS. The sizes of reservoirs are important for understanding ultimate oil recovery from the GOM. It turns out[2] that over the entire range of reservoir sizes, hydrocarbon reservoirs follow a "parabolic-fractal" law that says there is an increasing proportion of the smaller reservoirs relative to the larger ones. In other words, the reservoir size drops off faster than a simple power law would predict. Leaving aside the mathematics of fractals, if this law of reservoir sizes holds true, our current estimate of ultimate oil recovery in the Gulf might prove to be highly accurate, because most, if not all, of the largest oilfields have already been discovered, and the smaller ones will not add much new oil to the total regardless of how many new oilfields are discovered. On the other hand, the probability of finding another very large reservoir (a new "king," "viceroy," or at least an "elephant") is much higher than a normal or "Gaussian" probability distribution would predict. We can refer to this possibility as "fractal optimism."

Finding new oil in the deep Gulf of Mexico has not been easy. Historically, "dry holes," wells that never produced commercial hydrocarbons, have been numerous. In water depths greater than 1,000 feet (305 meters), 1,677 dry hole wells were drilled, with 331 dry hole wells in water depth greater than 5,000 feet (1,520 meters). To put the last number in perspective, 72% of all wells drilled in water depths greater than 5,000 feet were dry holes! The BP Macondo well was an exploration well that definitely was a success of sorts.

[2] Jean Laherrère, Distribution of field sizes in a petroleum system: Parabolic-fractal, lognormal, or stretched exponential?, *Marine and Petroleum Geology*, **17** (2000), 539–546.

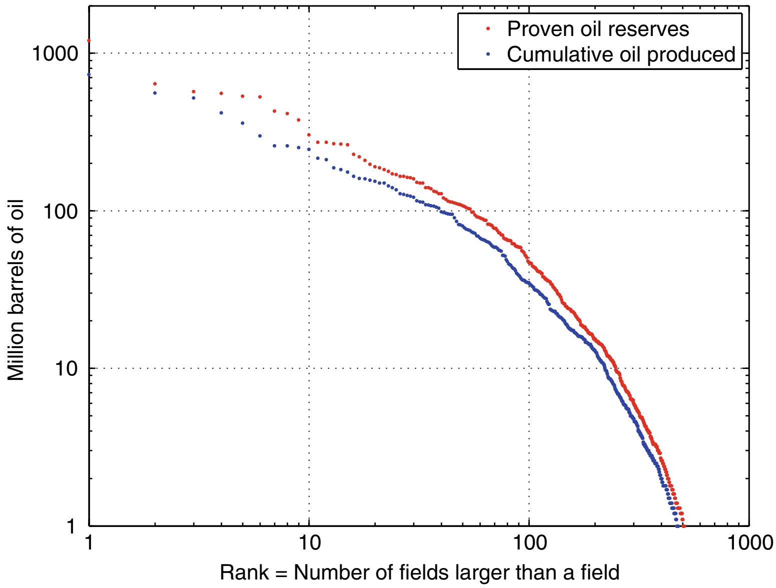

Fig. 2.2 This is the complete ranking of oil deposit volumes in the Gulf of Mexico reported to the Minerals Management Service by 2006, the latest complete statistic. The cutoff for production is one million barrels of cumulative oil produced. Thus the nonproducing oil reservoirs are excluded from the lower curve. The upper curve ranks the "proven oil reserves," (the oil we can produce for sure) with a cutoff of one million barrels of oil as well. The upper curve has 32 more points (oil fields) than the lower one, and the same ranks do not correspond to the same reservoirs. The plot has the logarithmic x-and y-axes. A simple power law, $\text{Rank} \times \text{Volume}^a = \text{Constant}$, would be "fractal" and plot as a straight line of log Volume versus log Rank, just like this plot. The fact that both curves bend down means that reservoir size decreases faster than a simple fractal would predict. Such a distribution is a "parabolic-fractal" or a "stretched exponential." Note that the reservoir volumes do not follow a bell curve, and their distribution is not Gaussian. Mother Nature operates very differently from finance and statistics that use the Gaussian distributions *ad nauseam*, whether they are justified or not. The largest reservoirs are discovered and produced first, therefore adding new discoveries of small reservoirs is unlikely to change significantly how much oil will be ultimately produced from the Gulf of Mexico. Since 2006, however, there have been several major new discoveries by Shell and others. It is hoped these discoveries will add to the reservoir volume in the largest fields, where it counts the most

Since 1995, the overall fraction of dry holes in the Gulf of Mexico was close to 25% of all wells drilled.

The U.S. federal government has kept records of oil and gas production in the Gulf of Mexico since 1947. According to the Minerals Management Service, between January 1947 and September 2010, 46,221 wells were

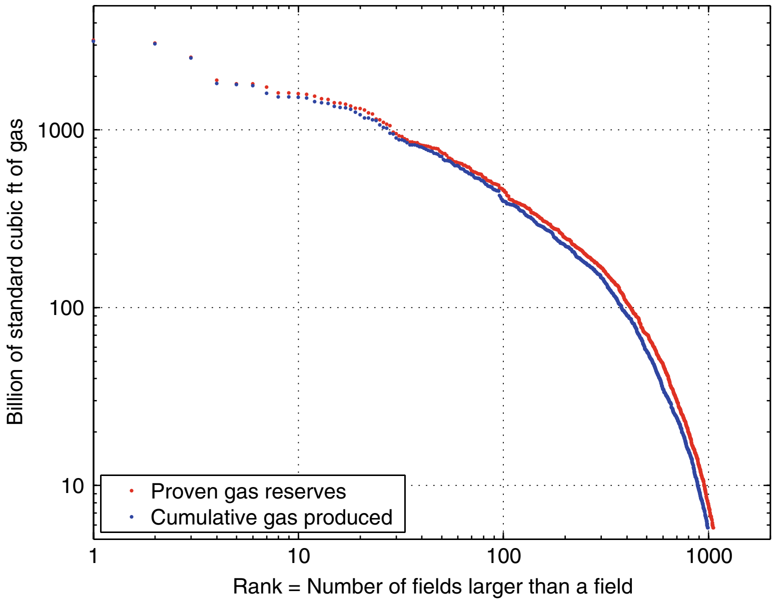

Fig. 2.3 This is the complete ranking of gas deposit volumes in the Gulf of Mexico reported to MMS by 2006, the latest complete statistic. The cutoff for production is 5.8 billion standard cubic feet of cumulative gas produced. Upon combustion, this volume of gas generates the same heat as roughly one million barrels of oil (one barrel of oil is energy-equivalent to 5,800 standard cubic feet of natural gas). The nonproducing gas reservoirs are excluded from the *lower curve*. The *upper curve* ranks the "proven gas reserves," also with a cutoff of 5.8 billion standard cubic feet of gas, equivalent in energy to one million barrels of oil. There are 62 more points on the *upper curve* than on the *lower* one, the same ranks do not correspond to the same reservoirs, and the seeming coincidence of the two curves is an optical illusion. Note that with the same lower cutoff, there are twice as many gas deposits as oil deposits, reflecting the dominance of natural gas in the Gulf. Also note the rapid proliferation of the ever smaller gas reservoirs (*the curves bend down very steeply*)

drilled in shallow Gulf water at depths of up to 1,000 feet (305 meters), and 19,888 wells are still producing. Some 3,500 platforms were activated in the shallow GOM. Between January 1975 and September 2010, 3,757 wells were drilled in deep GOM, and 1,077 wells are still producing in water depths greater than 1,000 feet (305 meters). Forty-seven platforms were activated in the deep Gulf. In water depths greater than 5,000 feet (1,524 meters), 645 wells were drilled and 115 are still producing from ten platforms. Thus, over the last 60 years, some 60,000 wells were drilled in the GOM and produced from 3,550 platforms, which is a gigantic investment

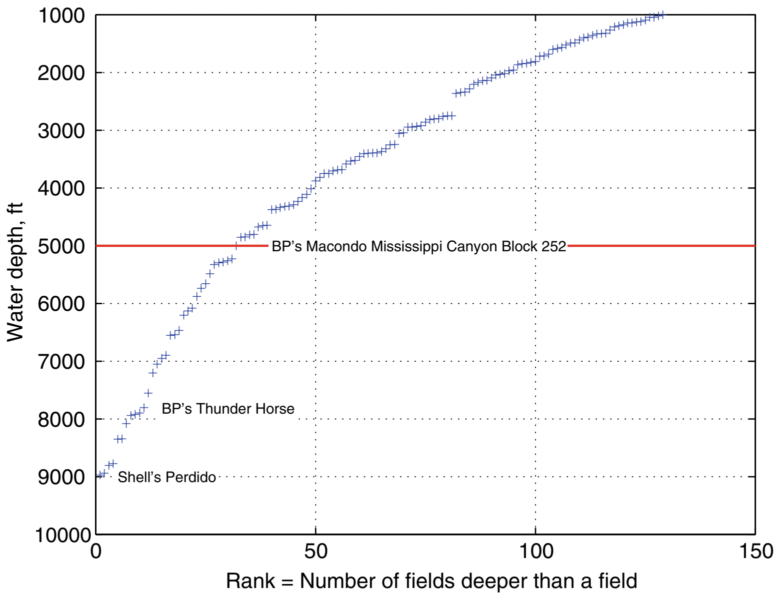

Fig. 2.4 The majority of oil production in the Gulf of Mexico comes from platforms in water deeper than 1,000 feet. There were 129 oil and gas deposits (*reservoirs*) reported by the Minerals Management Service in 2006 in water depths greater that 1,000 feet, 29 of them in water depths greater than 5,000 feet. Note that the water depth of BP's Macondo well is really 5,067 − 75 = 4,992 feet below the water surface. Its depth was measured from the derrick floor of the Deepwater Horizon rig, 75 feet above the sea. Some 1,073 wells are producing in water depths greater than 1,000 feet, 115 of them in water depths greater than 5,000 feet

of material and human resources. Figure 2.4 summarizes the distribution of known oil and gas deposits in the Gulf of Mexico in water depths greater than 1,000 feet.

The rates of oil production from the shallow (less than 1,000 feet deep) and deep (above 1,000 feet of depth, and mostly above 4,000 feet) Gulf water are shown in Fig. 2.5. The shallow water production peaked in 1973, and the deepwater production might have peaked in 2009. Our forecast is based solely on the historical production and its future decline; when completely new oilfields are brought online, our estimate may go up. The cumulative oil produced from the deepwater Gulf is shown in Fig. 2.6. The industry forecasts up to nine billion barrels of ultimate production from the deepwater Gulf, whereas Patzek forecasts only eight billion barrels. Either way, the total oil produced from the deep Gulf water will be less than the 11 billion barrels of oil already produced from the Prudhoe Bay field in Alaska, with another

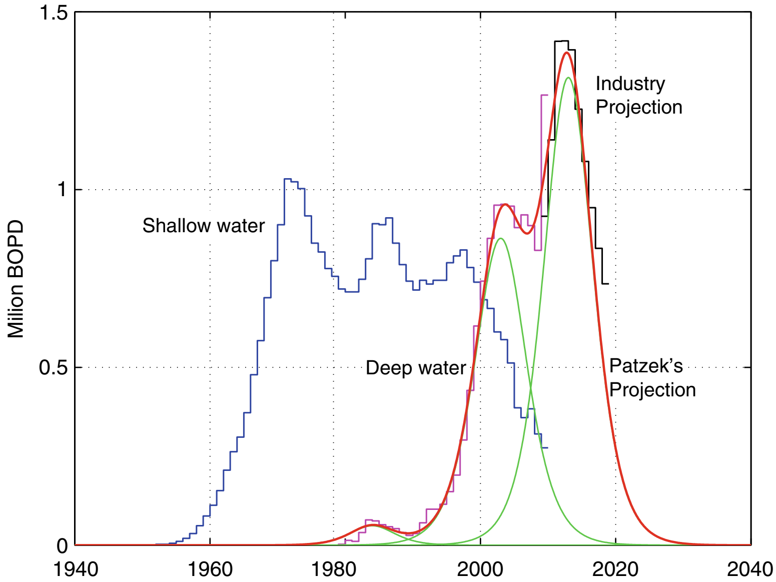

Fig. 2.5 The rate of oil production from the offshore Gulf of Mexico in millions of barrels of oil per day (BOPD). In 2010, the United States used about 19 million BOPD, and produced five million BOPD. Note that the shallow water development occurred in three stages. The highest peak of shallow oil production occurred in 1971, and the production rate has been declining rapidly since 1997. Deepwater oil production became noticeable in 1979, reached the first peak in 2003, and jumped to a new all-time high in 2009, mostly because of BP's Thunder Horse. The industry forecasts the new large oilfields coming online soon, and peaking in 2012–2013. Because we have no knowledge of the production capacity of the new finds in the GOM (these finds are closely held secrets), we project a faster decline based on the Hubbert curves that fit historical production data and predict the future decline of the oilfields in the dataset. The right Hubbert curve is related mostly to ultra-deepwater. This curve will probably grow as the future oilfields start producing. (Sources: U.S. DOE Energy Information Administration (EIA), Minerals Management Service (MMS), and Patzek's calculations)

one billion barrels to go at Prudhoe. The Gulf oil production will also be roughly one third of the oil produced by Norway in the North Sea. There is only one Prudhoe Bay in North America and there are some 400 producing oil reservoirs in the U.S. Gulf, with an estimated 900 small reservoirs yet to be produced. Such is the fundamental injustice of Mother Nature: one supergiant oil field can produce more oil than a large geographical region of a continent, the Gulf Coast. To add insult to injury, it is also much cheaper to produce oil from Prudhoe Bay than from deepwater.

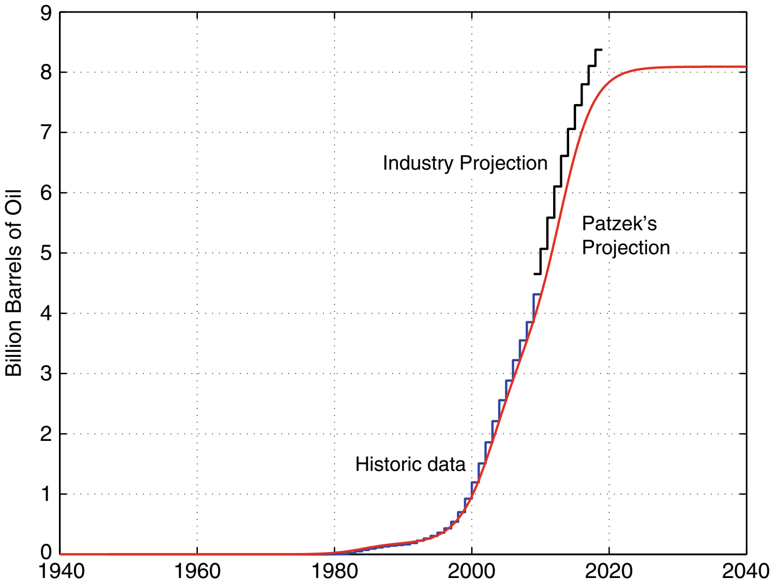

Fig. 2.6 Cumulative oil production from the deep offshore Gulf of Mexico in billions of barrels of oil. Based on the historical data, we estimate that the deep Gulf will produce about eight billion barrels, whereas the industry projects about nine billion barrels. We will adjust our prediction upward as the new production data become available. Even nine billion barrels of oil is less than the 12 billion barrels of ultimate oil production from Prudhoe Bay in Alaska, the largest oilfield in North America. Thus far, Prudhoe Bay has produced 10.8 billion BO. Ultimately, the deep GOM will produce about a third of the oil produced by Norway in the North Sea. (Sources: U.S. DOE EIA, MMS, and Patzek's calculations)

An average well in the GOM is not very productive. Gas wells account for 60–70% of new wells, and only 30% are oil wells. The mean gas production rate is 1.5 million standard cubic feet per well per day (CFPD) with the current maximum of over 100 million CFPD. The mean oil production rate is 450 stock tank barrels of oil per day (STBOPD) per well, with the current maximum of 41,000 STBOPD. Since January 2008, only 10% of GOM wells have been producing in excess of 2,000 STBOPD or 11 million CFPD.

Nevertheless, in inflation-adjusted dollars (see Fig. 2.7), the total revenue produced from the Gulf has been a little less than $700 billion. Seven hundred billion dollars is as much as the Troubled Asset Relief Program (TARP) that allowed the U.S. Department of the Treasury to purchase or insure up to

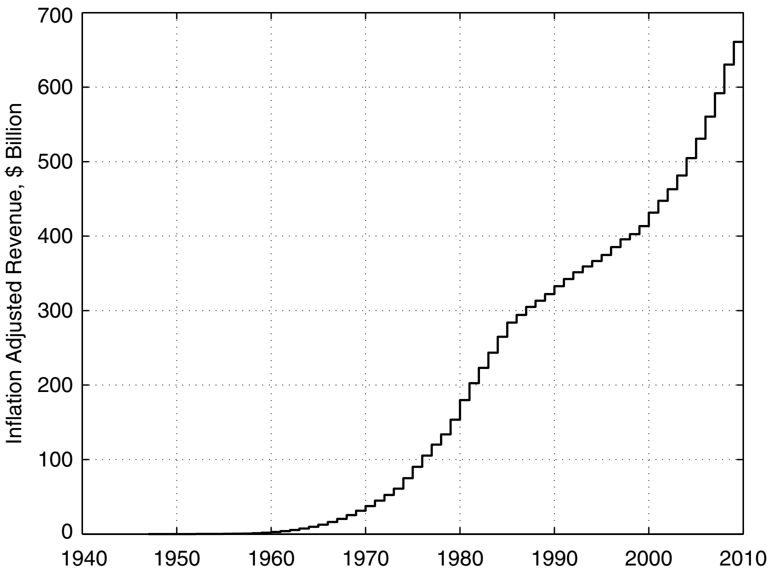

Fig. 2.7 Cumulative gross revenue generated by the offshore Gulf of Mexico oil. The average oil prices have been adjusted for inflation to June 2010 prices using the Consumer Price Index (CPI-U) as presented by the Bureau of Labor Statistics. (Sources: U.S. DOE EIA, MMS, BLS, and Patzek's calculations)

$700 billion of "troubled assets[3]". It took the hard work of three generations and tens of thousands of people to produce this *real* oil wealth in the Gulf over 70 years, but an equal amount of wealth was annihilated by a few hundred speculators, peddling bets rather than real assets, over just a few years.

Figure 2.8 illustrates the bottom line. The ratio of oil production from the Gulf to production from all other oilfields in the United States outside of the Gulf was increasing until 2003, when it was equal to 37%. Since then this ratio decreased to about 30% in 2008, and jumped back to 40% in 2009, with oil production elsewhere in the United States decreasing slowly.

[3] Defined as "(A) residential or commercial mortgages and any securities, obligations, or other instruments that are based on or related to such mortgages, that in each case was originated or issued on or before March 14, 2008, the purchase of which the Secretary determines promotes financial market stability; and (B) any other financial instrument that the Secretary, after consultation with the Chairman of the Board of Governors of the Federal Reserve System, determines the purchase of which is necessary to promote financial market stability, but only upon transmittal of such determination, in writing, to the appropriate committees of Congress." Source: *CBO Report, The Troubled Asset Relief Program: Report on Transactions Through December* 31, 2008.

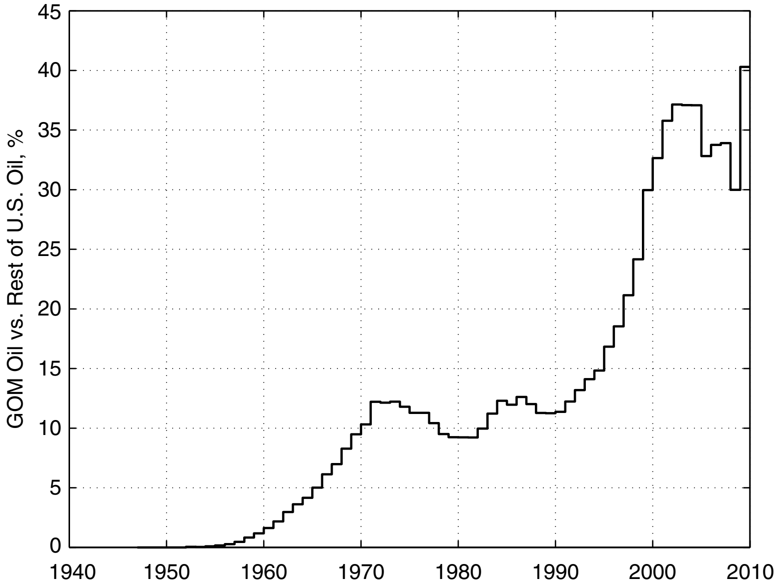

Fig. 2.8 All offshore oil production in the Gulf of Mexico as a percentage of U.S. oil production from all sources outside of the GOM. Note that the ratio of the GOM's oil production to the remaining U.S. production first peaked in 2003, at 37%, and then declined until 2009, when it jumped to 40%, in good part because of BP's Thunder Horse. (Sources: U.S. DOE EIA and MMS)

The total production in the United States has hovered around five million barrels of oil per day since 2004, and it may increase again in 2011 because of all the new drilling in Texas and North Dakota. The new production from BP's very large Thunder Horse semisubmersible platform[4] resulted in a jump of 260,000 barrels of oil per day, and the actual production in the GOM is a little ahead of the industry projection.

[4]Thunder Horse production and drilling quarters is the world's largest production semisubmersible platform ever built. The platform's topside area is the size of three football fields. It is packed with equipment and systems capable of processing and exporting a quarter of a million barrels of oil per day. Thunder Horse never hit that level of production. This semisubmersible produces oil and gas in one of the largest hydrocarbon fields in the Gulf of Mexico. The floating platform operates under extreme conditions. It pumps out oil and gas from the field which is three miles beneath mud, rock, and salt, topped by a mile of ocean. The hydrocarbon pressure is over 1,200 atmospheres (17,600 psi) and its temperature is 135°C (275°F). More information can be found at www.offshore-technology.com/projects/crazy_horse/ and www.petroleumnews.com/pntruncate/10942334.shtml.

Because of the huge flash production from Thunder Horse, and the need for more U.S. oil, the Interior Department exempted BP's plans for a nearby Macondo well from a detailed environmental impact analysis in 2009. According to government documents, after three reviews of the area it was concluded that a massive oil spill was unlikely.[5] On April 6, 2009, a fateful decision was handed down by the department's Minerals Management Service (MMS) to give BP's lease at the Mississippi Canyon Block 252 a "categorical exclusion" from the National Environmental Policy Act (NEPA). Neither the government nor BP conceived of the possibility of a Black Swan, in Taleb's memorable term for an unpredictable or unlikely event, descending upon the United States only 1 year later, almost to the day. Taleb's book, *The Black Swan – The Impact of the Highly Improbable*, should be required reading for all governmental and corporate managers.

Lessons About Technology and Oil Reserves

Unfortunately, oil production from the prolific Thunder Horse has been declining faster than most experts thought. In the words[6] of Glenn Morton, a consultant for oil exploration projects and analyst for OilDrum.com, "Thunder Horse hasn't reached anywhere near its expected potential," in oil or natural gas, a fact which "underscore[s] the point that deepwater oil drilling is a tricky process, and not always as easy or predictable as thought." Thus Lesson Number 1: the complex technology we deploy to conquer Nature interacts with the complex Earth systems in ways that are either unpredictable or very difficult to quantify.

In 2005, during Hurricane Dennis, an incorrectly plumbed, 6-inch. length of pipe allowed water to flow freely among several ballast tanks that ultimately caused the Thunder Horse platform to tip into the water; see Fig. 2.9. The platform was fully righted about a week after the hurricane, delaying commercial production initially scheduled for late 2005 by 3 years. During repairs, it was discovered that poorly welded pipes in an underwater manifold were severely cracked, and the $1 billion manifold had to be redone. Lesson Number 2: the small cheap parts of the astronomically expensive complex

[5] "U.S. Exempted BP's Gulf of Mexico Drilling from Environmental Impact Study," Juliet Eilperin, *Washington Post* staff writer, Wednesday, May 5, 2010.

[6] See www.energybulletin.net/node/52659.

Fig. 2.9 The U.S. Coast Guard reported on July 12, 2005: "Thunder Horse, a semi-submersible platform owned by BP, was found listing after the crew returned. The rig was evacuated for Hurricane Dennis." This almost $1 billion platform was nearly sunk by an incorrectly plumbed 6-inch. pipe valued at just a few dollars. Then there were problems with welds in the subsea pipes and manifolds. Their replacement cost and 3 years of production delays might have been as high as another billion USD. (Image Source: USCG photo by PA3 Robert M. Reed, displayed in Wikipedia)

structures can cause them to disintegrate. Remember the failed rubber O-ring in the right booster rocket of the space shuttle Challenger? We show how this lesson was missed at the failed BP Macondo well.

We must also not forget that drilling for offshore oil has always been hard and dangerous work. Since 2001, the Gulf of Mexico workforce – 35,000 people, working on 90 big drilling rigs and 3,500 production platforms – has suffered 1,550 injuries, 60 deaths, and 948 fires and explosions.[7] Almost

[7] Bureau of Ocean Energy Management, Regulation, and Enforcement, Installations, Removals, and Cumulative Totals of Offshore Production Facilities in Federal Waters; 1959–2010, 2/2010, www.boemre.gov/stats/PDFs/OCSPlatformActivity.pdf.; Bureau of Ocean Energy Management, Regulation and Enforcement, OCS Incidents/Spills by Category: 1996–2005, 10/19/2007, www.boemre.gov/incidents/Incidents1996–2005.htm; Bureau of Ocean Energy Management, Regulation, and Enforcement, OCS Incidents/Spills by Category: 2006–2010, 7/10/2010, www.boemre.gov/incidents/IncidentStatisticsSummaries.htm.

20% of all fatalities in the GOM were caused by the BP Macondo well blowout.[8]

The Take-Home Messages

The cover photo of this book is familiar to anyone who watched television or internet news sources or read a newspaper in April, 2010, and should be sufficient to convince most people that offshore production of oil and gas is risky. Because the Gulf of Mexico currently accounts for 40% of crude oil produced in all other areas of the United States combined, drilling in the Gulf is clearly necessary in spite of the risks and the diminishing returns on investment. Ultimate oil recovery from OCS will likely exceed nine billion barrels of oil, roughly 1.5 years of the total U.S. consumption of crude oil and petroleum products in 2009. In other words, the deep and ultra-deepwater oil production in the GOM will suffice to power the United States for 1.5 years.

Most oil production in the GOM comes from water depths greater than 1,000 feet, and a good portion from depths below 4,000 feet. Although Gulf of Mexico oil accounted for about 8% of U.S. daily oil use in 2010, and this percentage is likely to decline in the next few years, stopping GOM production would have severe economic repercussions for the U.S. economy.

Exploration in the deep Gulf is financially risky, with over 70% of all new wells never producing appreciable quantities of hydrocarbons. Given the price tags of these wells, anything from $50 to $200 million apiece, deepwater drilling in the Gulf is not for the faint-hearted. After some of the current very large finds by Shell, BP, and others are produced, oil production in the deep Gulf will move to the shallower and much smaller reservoirs that have been bypassed on the way to the deep big ones. Elsewhere in the world, oil exploration and production will go deeper, even much deeper, in hopes of larger rewards. Oil production in the Gulf will continue for several more decades, albeit at a much decreased level. Currently, there are 1,073 successful producing wells in water depths greater than 1,000 feet, and 115 in water depths greater than 5,000 feet. In recent years, about 400 new gas and oil wells have been drilled in the GOM annually.

[8] If the GOM workforce had fought in Afghanistan over the same period of time, one would expect at least 520 deaths, and 3,000–4,000 injuries.

In many ways, drilling for oil and gas in one mile of seawater is more unforgiving than sending people to outer space. The total darkness and remoteness, crushing pressures, near-freezing water temperature, extremely high hydrocarbon temperatures, aggressive corrosive gases, solid hydrates and paraffins, and so on, all have made ultra-deepwater perhaps the most inhospitable environment on Earth. Yet, we will continue to explore and drill in this environment, simply because there is a lot of oil and gas down there, the low-hanging fruit of easily accessible oil has been mostly picked, and our voracious appetite for concentrated sources of energy only increases with time.

The U.S. domestic oil supply peaked in 1970, and global peak oil production may have been reached in 2005 when the highest conventional oil production rate worldwide was recorded. Therefore, it is unlikely that we can obtain supplies from elsewhere to replace oil from the Gulf. If the rate of oil consumption in the United States compels oil companies and the nation as a whole to assume the risk of drilling in deep water, whose responsibility is it to manage this risk, or at least to try? The answer to this question is complex, and requires a deeper understanding of the origins of different risk factors and drivers, from the technology, to the corporate boardroom, and ultimately to societal processes that have led us to seek energy in remote inhospitable environments. Our search for an answer will take us from the Macondo well to the Roman and Byzantine empires and back. Hold on to your seats.

Further Reading

1. Mandlebrot, B.B.: Fractals and Scaling in Finance – Discontinuity, Concentration, Risk. Springer, New York (2010)
2. Taleb, N.N.: The Black Swan – The Impact of the Highly Improbable. Random House, New York (2010)
3. Zipf, G.K.: Human Behavior and the Principle of Least Effort – An Introduction to Human Ecology. Hafner, New York (1965)

http://www.springer.com/978-1-4419-7676-5

Drilling Down
The Gulf Oil Debacle and Our Energy Dilemma
Tainter, J.A.; Patzek, T.W.
2012, IX, 242 p. 97 illus., 47 illus. in color., Softcover
ISBN: 978-1-4419-7676-5