DISCUSSION PAPER

January 2011 ■ RFF DP 10-66

Preliminary Empirical Assessment of Offshore Production Platforms in the Gulf of Mexico

---

Lucija Muehlenbachs, Mark A. Cohen, and Todd Gerarden

1616 P St. NW
Washington, DC 20036
202-328-5000 www.rff.org

RESOURCES
FOR THE FUTURE

Preliminary Empirical Assessment of Offshore Production Platforms in the Gulf of Mexico

Lucija Muehlenbachs, Mark A. Cohen, and Todd Gerarden

Abstract

This paper reports on a preliminary analysis of performance indicators on 3,020 platforms operating in the Gulf of Mexico between 1996 and 2010. Statistical analysis reveals that company-reported incidents (such as blowouts, fires, injuries, and pollution) increase with water depth, controlling for platform characteristics such as age, quantity of oil and gas produced, and number of producing wells. In addition to company-reported incidents, we examine government inspections and the type of enforcement action (warning, component shut-in, facility shut-in, or civil penalty review) following an inspection. Fewer incidents of noncompliance are detected during inspections on deepwater platforms compared with shallow-water platforms; however, the magnitude of the effect of depth on noncompliance is not large. We provide a preliminary analysis of the effect of prior findings of noncompliance, suggesting that noncompliance is persistent. We also find significant variability in both self-reported incidents and noncompliance across leaseholders.

Key Words: noncompliance, inspection, offshore oil and gas

JEL Classification Numbers: Q50

Contents

Preliminary Empirical Assessment of Offshore Production Platforms in the Gulf of Mexico

Lucija Muehlenbachs, Mark A. Cohen, and Todd Gerarden[*]

All findings, opinions, statements, and recommendations contained in this report are solely those of its authors. The report has been submitted to the staff of the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, but the report is not the work product of the Commission or its staff, and should not be construed in any respect as the official or unofficial findings, opinions, statements, or recommendations of the Commission or its staff.

Executive Summary

This paper reports on a preliminary analysis of performance indicators on platforms in the Gulf of Mexico between 1996 and 2010. According to data from the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), there are currently 3,020 platforms on the Outer Continental Shelf in the Gulf of Mexico. Information on platform characteristics is used to analyze differences in company-reported incidents and the enforcement actions taken following government inspections in the Gulf of Mexico. Statistical analysis reveals that company-reported incidents (such as blowouts, fires, injuries, and pollution) increase with water depth, controlling for platform characteristics such as age, quantity of oil and gas produced, and number of producing wells. For an average platform (i.e., a platform with the sample's average age, annual production, number of producing wells, and other characteristics), each 100 feet of added depth increases the probability of a company-reported incident by 8.5 percent.

In addition to self-reported incidents, we examine government inspections and the type of enforcement action (warning, component shut-in, facility shut-in, or civil penalty review)

---

[*] Muehlenbachs, Fellow; Cohen, Vice President for Research; Gerarden, Research Assistant, Resources for the Future, Washington, DC.

DISCLAIMER: This project was funded by the Department of Energy, National Energy Technology Laboratory an agency of the United States Government, through a support contract with Booz Allen Hamilton, Inc. Neither the United States Government nor any agency thereof, nor any of their employees, nor Booz Allen Hamilton, Inc., nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

following an inspection. Fewer incidents of noncompliance (INCs) are detected during inspections on deepwater platforms compared with shallow-water operations; however, the magnitude of the effect of depth on noncompliance is not large: with each 100 feet of added depth, the probability of an incident of noncompliance decreases by 0.05 percent. We also provide a preliminary analysis of the effect of prior findings of noncompliance, suggesting that noncompliance is persistent. Our results also suggest that the rate of noncompliance citation varies by inspector.

Examination of the 10 companies that produced the most oil and gas (by volume) in the Gulf of Mexico in 2009 indicates significant variation in company-reported incidents and inspector detected incidents of noncompliance across companies. The analysis suggests that the probability of a reported incident increases with BP as an operator (all else equal) compared with operators not included in the 10 largest producers. Of the 10 largest producers, BHP Billiton is the only firm with a higher probability of reporting an incident than BP. When we examine the probability of an incident of non-compliance detected during an inspection, we see that BP is less likely to have incidents of non-compliance than smaller producers. Of the 10 producers, Eni US, Apache, and Chevron have a similar (or lower) probability of an incident of non-compliance as BPBP. For an average platform, having BP as an operator increases the probability of a company-reported incident by 96 percent and decreases the probability of an enforcement action upon inspection by 9.5 percent.

Our preliminary analysis has provided some important insights as well as raised many questions that are worthy of further research using the data that we have compiled:

- The analysis is specific to offshore platforms. Data on mobile offshore drilling units are more difficult to analyze because we have data on these only when there is an incident reported. Since we do not know the location of these drilling units when they do not have an incident, it is not possible to calculate a rate of incidents. However, further data collection and refinement, as well as an analysis of mobile drilling unit inspection results, might prove useful.
- We find that if a platform if cited for an incident of noncompliance during one inspection, citation of an incident of noncompliance during the subsequent inspection is more likely. However, from this observation we are unable to determine the effect of enforcement actions, because it could be the case that had these platforms not received any enforcement action, they would be even poorer performers. Further statistical analysis of enforcement and noncompliance data should provide important insights into the causal

connections between inspections, warnings, component and facility shut-ins, civil penalty review, and subsequent reported incidents and incidents of noncompliance.

- We find significant variability in the probability of a company-reported incident by type of company. This is using a very broad definition of incidents, which include everything from a loss of well control to a fatality. It would also be interesting to examine differences in specific types of incidents as well as firm characteristics (e.g., size, financial capacity, ownership structure).
- Future research should investigate the relationship between self-reported incidents, findings of noncompliance, and actual performance. Our analysis of incidents is necessarily based on self-reporting. Although firms that self-report a higher level of incidents (e.g., accidents or spills) are generally more likely to be cited during an inspection for noncompliance, some exceptions are found. For example, both BP and Chevron had higher-than-average incident rates but were less likely to be cited for noncompliance. Without further analysis, we do not know whether this is because these firms are more likely to self-report than others or whether this is a sign of sub-optimal enforcement.

1. Introduction

In the past, high-volume oil spills have been largely associated with crude oil transport. Accordingly, the risk analysis literature focuses on accidents associated with transport (Epple and Visscher 1984; Stewart and Leschine 1986; Cohen 1986, 1987; Viladrich-Grau and Groves 1997). Conclusions from existing research on accident prevention monitoring and enforcement in the petroleum transport industry are relevant to the study of offshore oil and gas exploration and development.

However, the literature on oil offshore exploration and production, and fixed platforms specifically, remains relatively underdeveloped. As a result, findings from empirical analysis of offshore oil and gas activity conducted throughout the literature are sometimes inconsistent and even contradictory (Jablonowski 2007; Iledare et al. 1997; Shultz 1999). Furthermore, empirical analysis of oil exploration and development at current water depths is lacking. This analysis seeks to expand the existing literature on predictors of offshore oil production incidents and noncompliance with a focus on identifying and analyzing factors relevant to future regulatory decisions.

The rest of the paper summarizes the findings of this empirical assessment. The next section contains information on platform characteristics, including ownership structure. The third section employs a probit regression to analyze the effect of platform characteristics on reported incidents. The fourth section studies inspections and incidents of noncompliance, using descriptive statistics and probit regressions to study the marginal effects of past enforcement action on present compliance. The fifth section extends earlier analysis to include indicators for the top oil producers in the Gulf of Mexico in 2009. The final section summarizes findings of this analysis and draws conclusions to help guide future regulatory decisions.

2. Background Information on Offshore Platforms and Production

In this section, we provide background information on offshore platforms and production in the Gulf of Mexico. We distinguish platforms by depth, age, and measures of size and complexity. We also characterize the volume of production by lease operator.

Platform Characteristics

Two databases[1] containing platform characteristics from the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) were used to create a panel containing all offshore production facilities (platforms) in the Gulf of Mexico from the year each was first installed through 2010. The oldest platforms in the resulting data set are reported to have been installed in 1942. Overall, there are 6,056 unique platform "complexes"[2] represented in the data set. After a platform is abandoned and removed,[3] it drops out of the data set; by 2010 only 3,020 of the 6,056 platforms remain in the data.[4] The data set contains information such as the distance to shore, water depth, lease number, location (area and block), whether personnel are on board

---

[1] Platform Masters database and Platform Structures database, http://www.gomr.boemre.gov/homepg/pubinfo/freeasci/platform/freeplat.html.

[2] A platform complex is a single man-made structure or a group of structures connected by a walkway. A structure can be the fixed leg of a platform, a fixed anchor, a semisubmersible floating production system, or a mobile production unit, for example. It is not possible to determine the kind of structure where an incident occurred because the data are identified by complex; therefore, information on structures is aggregated to the complex.

[3] A platform drops out of the data set after the date when the last structure was removed (according to the removal date in the Platform Structures database) if the platform was scheduled to be abandoned (according to the Platform Masters database).

[4] This is not to say that the remaining platforms are all producing. As indicated in Table 1, 43 percent of the existing (not yet removed) platforms did not produce any oil or gas in 2009.

24 hours per day, whether a platform has a heliport, and the number of beds in the living quarters. There is also an indicator of whether the platform is considered a “major complex” (defined as a platform that has at least one structure with at least six well completions or two pieces of production equipment). Of the platforms in the data set, 21.5 percent of the platforms have personnel on board 24 hours per day. Forty-nine percent are considered major complexes (see Table 1). In the analysis here, platforms in water depths less than 1,000 feet are considered to be in shallow water; those between 1,000 and 4,999 feet are considered deepwater; and 5,000 feet or more, ultra-deep water. Table 2 shows that platform characteristics vary by water depth: unlike platforms in shallow waters, all platforms producing from waters between 1,000 and 5,000 feet are major complexes and are manned 24 hours a day. Platforms currently in deeper water are also younger: platforms are on average 3.2 years old in waters deeper than 5,000 feet, 10.03 years old in waters between 1,000 and 5,000 feet, and 22.69 years old in water less than 1,000 feet (Table 2).

Table 1. Platform Characteristics

	mean	sd	min	max	count
Age (years)	22.47	14.83	0	67	3016
Distance to Shore (miles)	34.05	30.57	2	195	3014
Water Depth (feet)	157.1	503.9	8	8000	3016
Major Complex (Indicator)	.492	.5	0	1	3016
Manned 24 Hours (Indicator)	.2152	.411	0	1	3016
Beds in Living Quarters	16.67	23.8	0	281	762
Heliport Present (Indicator)	.6963	.4599	0	1	3016
Cranes	.8033	.7431	0	5	2761
Annual Oil Production (mbbl)	378.2	2882	0	68302	1503
Annual Gas Production (mmcf)	1431	8130	0	292462	1706
Inactive (Indicator)	.432	.4954	0	1	3016
Producing Wells	1.981	3.434	0	47	2610
Wells Drilled (2009)	.5556	.8755	0	4	90
Cumulative Wells Drilled	4.65	7.518	0	89	3016
No. Well Operations (2009)	1.567	1.171	1	7	90
Cumulative Well Operations	6.817	12.49	0	234	3016
Avg. Depth of Wells Drilled (2009) (feet)	12148	5743	1706	26956	30
Avg. Time to Drill Wells (2009) (days)	35.89	28.7	5	149	37
Observations	3016				

Notes: Data on all offshore platforms in the Gulf of Mexico, 2009. A total of 3,016 nonremoved platforms in 2009 are represented in the data set, with the earliest platform having been installed in 1942. Well operations are separate operations in a single borehole (e.g., reentry, recompletion, horizontal drilling, or directional drilling).

Table 2. Platform Characteristics, by Water Depth

	Shallow		Deep		Ultra-deep	
	mean	sd	mean	sd	mean	sd
Age (years)	22.69	14.82	10.03	6.687	3.2	2.53
Distance to Shore (miles)	33.02	29.09	91.97	45.15	130.4	42.35
Water Depth (feet)	102.8	103.5	2900	1230	6427	945.2
Major Complex (Indicator)	.4845	.4998	1	0	.9	.3162
Manned 24 Hours (Indicator)	.2034	.4026	1	0	.9	.3162
Beds in Living Quarters	13.08	13.49	75.21	48.38	90.88	87.1
Heliport Present (Indicator)	.6919	.4618	1	0	.9	.3162
Cranes	.7784	.7155	2.361	.7983	2.25	.8864
Annual Oil Production (mbbl)	86.19	264.5	7682	9781	20758	22844
Annual Gas Production (mmcf)	906.3	2286	11716	11419	64170	95398
Inactive (Indicator)	.438	.4962	0	0	.2	.4216
Producing Wells	1.8	3.023	13.31	7.577	7.8	5.731
Wells Drilled (2009)	.4783	.7398	.4118	.6183	2.5	1.732
Cumulative Wells Drilled	4.589	7.343	10.47	16.04	1.8	1.932
Well Operations (2009)	1.478	1.023	1.588	1.228	3	2.449
Cumulative Well Operations	6.607	11.86	25.19	33.95	3.1	3.315
Avg. Depth of Wells Drilled (2009) (feet)	9672	3280	19145	6573	18399	2792
Avg. Time to Drill Wells (2009) (days)	26.35	16.16	44.25	22.98	87.81	46.75
Observations	2970		36		10	

Note: Data from 2009.

Annual Production

Monthly well-level production data for all wells in the Gulf of Mexico from 1996 to 2010 was obtained through BOEMRE's website.[5] This data set contains a unique well identifier, (the API well number), monthly gas volume, monthly oil volume, and days on production. Another data set available online through BOERME,[6] for boreholes, is used to assign a platform identifier to the API well numbers, linking monthly production data to platform characteristics. This data set was also used to count the cumulative number of wells drilled at a platform, the number of wells drilled in a given year for each platform, the average length of time to drill the wells at a platform, and the average depth of the wells drilled at a platform. The API number identifying the wellbore contains an "event sequence code" indicating different drilling or completion operations of a wellbore (e.g., reworking a well to a deeper formation or drilling horizontally

---

[5] Monthly Production Data, http://www.gomr.boemre.gov/homepg/pubinfo/freeasci/product/freeprod_ogora.html.

[6] Borehole Data, http://www.gomr.boemre.gov/homepg/pubinfo/freeasci/well/freewell.html.

from the wellbore would receive a separate event sequence code). We created a variable to indicate the number of event sequence codes per platform to obtain the annual number of well operations as well as the cumulative well operations per platform. We also calculated the annual platform-level production and the number of wells producing in each year.

Lease Owners and Designated Lease Operators

A single lease can have many owners with different percentages of ownership (working interests). A lease may also be divided into different aliquots, or portions, and each aliquot may have multiple working interests. Data on the lease ownership and designated operator of a lease were obtained from BOEMRE's website.[7] These data contain the working interests of all owners of offshore leases in the Gulf of Mexico, including all ownership changes from the assignment date of the lease to present. From this, the working interest of the designated operator is extracted, as well as the number of companies that had an interest in the lease and the minimum, mean, and maximum working interest in the lease for every year from the lease assignment date to 2010. On average, ownership of a lease is divided among 1.919 companies, ranging from sole ownership to 32 companies (Table 3). At any point in time, however, there will be only one designated operator of the aliquot. The working interest of the lease operator ranges from 0 to 100 percent and is 69.4 percent on average (Table 3). According to these data, there are 25,461 leases assigned in the Gulf of Mexico; however, only 2,757 of these leases are associated with platforms (see *N* in Table 4). The leases associated with platforms have more owners and lower working interests by the owners, on average, than leases without platforms. As water depth increases, the working interest of the average owner decreases (Table 4).

---

[7] Lease Ownership & Operator Data, http://www.gomr.mms.gov/homepg/pubinfo/freeasci/leasing/freeleas.html.

Table 3. Lease Ownership and Designated Lease Operators for All Leases

	mean	sd	min	max
No. Owners	1.789	1.365	1	27
No. Aliquot Portions	1.009	.1126	1	7
Mean Working Interest (%)	75.42	30.41	3.571	100
Min Working Interest (%)	70.35	37.01	.0001	100
Max Working Interest (%)	81.72	24.08	7.551	100
Lease Operator's Working Interest	72.71	35.6	0	100
N	25,461			

Note: Data on all leases in the Gulf of Mexico, 2010. Min (Lease Working Interest) is the lowest ownership assignment of a lease in 2010. Max (Lease Working Interest) is the highest ownership assignment of a lease in 2010.

Table 4. Lease Ownership and Designated Lease Operators, by Water Depth

	Shallow		Deep		Ultra-deep	
	mean	sd	mean	sd	mean	sd
No. Owners	2.46	2.194	2.256	1.428	2.5	.8367
No. Aliquot Portions	1.049	.2792	1	0	1	0
Mean Working Interest (%)	63.99	33.63	57.76	28.45	43.06	11.08
Min Working Interest (%)	55.09	41.55	48.52	34.99	29.86	12.48
Max Working Interest (%)	76.14	25.46	69.07	22.48	56.25	18.59
Lease Operators Working Interest	62.49	38.37	50.17	35.57	35.42	31.82
N	2712		39		6	

Note: Data on leases with one or more platforms, 2010.

Platform Operators

A platform operator is typically the responsible party in event of an oil spill. However, there are occasions where a platform ties in production from a well miles away leased to a different operator. The subsea lease operator would be financially responsible in the case that a spill occurred at the subsea lease, and the surface platform operator would not be. If the spill originated from the pipeline, the pipeline right-of-way holder would be responsible. All three parties (the surface platform operator, the subsea lessee, and the pipeline right-of-way holder) are required to show oil spill financial responsibility. The platform operator, as defined by BOEMRE, is either the lease holder or the party designated (and approved) to operate a portion of a given lease. The history of platform operators, received from BOEMRE, was used to determine the operator of a platform in time *t*. Each subsidiary of a company is given its own "company number." For example, Shell Offshore Inc. has 10 subsidiaries in the Gulf of Mexico (e.g., Shell Consolidated Energy Resources Inc., Shell Deepwater Development Inc., Shell Oil Company), each of which has a unique company number. An unofficial list of parent-subsidiaries was obtained from BOEMRE so that we could match subsidiaries to their parents.

For the remainder of unmatched observations, the parent company found in BOEMRE's operator safety summaries was used. If the platform operator was missing five years before the assignment date, the designated operator at the time of the assignment was used.

Thirty-two firms have been deepwater lease operators in the Gulf of Mexico from 1996 to 2010 (Appendix, Table A1). Of them, 12 hold only the subsea lease and partner with other firms which operate platforms tied into these wells (Table A1). Of the 20 firms that are platform operators, all but three are publicly traded. The market capitalization of these 17 companies ranges from less than $1 billion to more than $300 billion. Including the three privately held companies, fewer than half (9 of 20) have market capitalizations exceeding $40 billion.

In 2010, 15 companies were platform operators in deep waters. Table 5 lists these companies with the number of shallow, deep, and ultra-deep platforms they operated in 2010, as well as the most recent market capitalization estimate available. These 15 companies, out of a total of 132 companies, operated 29.6 percent of the platforms in the Gulf of Mexico in 2010.

Table 5. Number of Platforms for Firms with Deepwater Operations, 2010

Parent company	Platforms Shallow	 Deep	 Ultra-deep	Market cap. ($million)
ATP Oil & Gas Corporation	37	2	0	762
Anadarko Petroleum Corporation	5	5	2	29,100
BHP Billiton Petroleum (Americas) Inc.	3	3	0	135,690
BP Corporation North America Inc.	27	5	4	127,320
Chevron Corporation	352	3	1	169,390
ConocoPhillips Company	0	1	0	90,660
Dynamic Offshore Resources NS, LLC	46	1	0	—
Eni US Operating Co. Inc.	24	2	1	81,980
Exxon Mobil Corporation	54	1	0	337,690
Helix Energy (Energy Resource Technology GOM, Inc.)	99	1	0	1,392
Hess Corporation	0	1	0	20,730
Murphy Exploration & Production Company	0	2	1	12,510
Pisces Energy LLC	45	1	0	—*
Shell Offshore Inc.	12	6	1	110,750
W & T Offshore, Inc.	142	2	0	820

Notes: Market capitalization figures are in million USD using most recent data available. * Pisces Energy LLC filed for Chapter 11 bankruptcy protection on September 1, 2009 (Reuters).

3. Reported Incidents

Information on company-reported incidents was obtained from BOEMRE. Operators and other permit holders are required to report all "incidents" to BOEMRE. Prior to 2006, incidents were defined to include all serious accidents, fatalities, injuries, explosions, and fires. The incident reporting regulations were made more stringent in 2006,[8] requiring companies to report not only serious incidents but also incidents that had the potential to be serious (e.g., any incident involving structural damage to a facility, injury that led to an evacuation or days away from work, or property damage exceeding $25,000). The resulting increase in incident reporting illustrates the challenge noted by Cohen (2010) of differentiating between changes in the actual number of incidents and the *appearance* of changes in the number of incidents due to developments in monitoring and enforcement. The increase in incident reporting due to this change in regulations is apparent in Figure 1, which tracks nonweather-related[9] incidents on offshore facilities. Jablonowski (2007) analyzes the probability of incidents on offshore drilling rigs, taking imperfect reporting of incidents into consideration through use of a detection-controlled estimation model. In this paper we examine reported incidents and do not try to disentangle the probability that an incident occurred from the probability that an incident was reported.

Between 1995 and August 2010, there were 6,372 company-reported incidents. Data on the incidents include an indicator for whether the incident involved a blowout, vessel collision, fire, explosion, collision, injury, fatality, or pollution; whether it was caused by completion equipment, equipment failure, development or production operations, exploration operations, human error, a slip or a trip or a fall, or weather; and whether it involved cranes, structural damage, or overboard drilling fluid.

Of these incidents, 4,703 have a platform identifier, 1,105 have a rig number instead of a platform identifier, and 564 have neither identifier. If there was only one platform on a lease area or block in a year, that platform's identifier was assigned to incidents that occurred there, to fill in missing platform identifiers. This approach added only 14 incidents to our data set. The resulting 4,717 incident observations are then merged onto the platform characteristics (24 incidents do not merge). If there was more than one incident in a year, the platform-year is

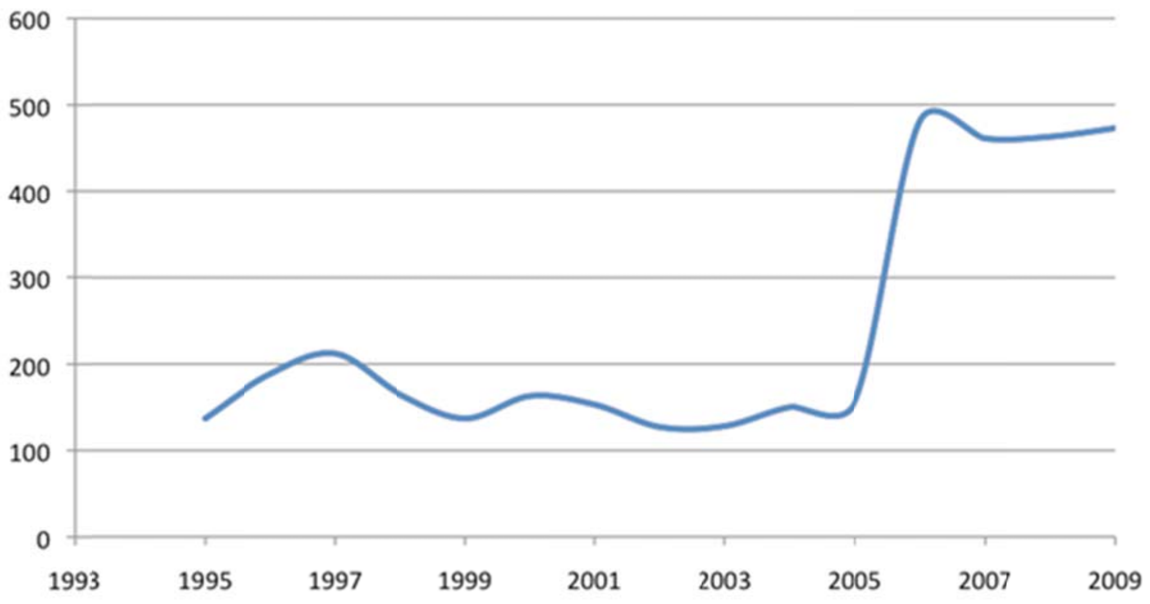
---

[8] 30 CFR Part 250, Final Rule (FR 19640), Minerals Management Service, U.S. Department of Interior.

[9] Including weather-related incidents in this figure obscures the increase in reporting in 2006, because 2008, a year with an active hurricane season, had an overwhelming number of weather-related incidents (576 of 1,041).

repeated in the master data to match the incident observations. Incidents that occurred on mobile drilling rigs (such as the *Deepwater Horizon*) are not included here because only fixed equipment can be uniquely identified in the inspection and platform data.

Figure 1. Total Nonweather-Related Incidents Reported on Offshore Production Facilities



Incidents are common: there was an incident in 8.48 percent of the platform-year observations from 1995 to 2010 (Table 6). The majority of the incidents are deemed “accidents” (Table 6). Forty-eight percent of platforms in shallow water are categorized as major complexes and 20 percent are manned 24 hours a day, whereas all deep and ultra-deep platforms are both major complexes and manned 24 hours a day. Therefore, only major complexes that are manned 24 hours a day are used when comparing the shallow, deep, and ultra-deep platforms using summary statistics (Table 7). The average number of incidents substantially increases for operations in deeper water: compared with depths less than 1,000 feet, the average number of incidents increases more than threefold for depths greater than 1,000 feet. Platform incident data include exploration activity in addition to production and development. In the statistics below, the probability of an incident from exploration appears very low because the majority of exploration-related incidents are attributed to drilling rigs (not fixed platforms), which are excluded from this analysis.

Table 6. Incidents on Offshore Platforms

	mean	sd	min	max	count
Incident Indicator	.0848	.2786	0	1	54137
No. Incidents	.1276	.5487	0	14	54137
No. Injuries	.00761	.1273	0	12	54137
No. Fatalities	.001348	.04231	0	3	54137
Explosion	.00109	.03299	0	1	54137
Blowout	.0005357	.02314	0	1	54137
Equipment Fail	.02237	.1479	0	1	54137
Human Error	.02074	.1425	0	1	54137
Accident	.07636	.2656	0	1	54137
Spill	.01119	.1052	0	1	54137
Spill Volume (bbl)	31.92	243.1	0	4834	564
Weather	.01613	.126	0	1	54137
Structural Damage	.0004803	.02191	0	1	54137
Crane	.007038	.0836	0	1	54137
Collision	.00205	.04523	0	1	54137
Well Control (Surface)	.00003694	.006078	0	1	54137
Well Control (Diverter)	.00001847	.004298	0	1	54137
Slip, Trip, Fall	.003547	.05945	0	1	54137
Overboard Drill Fluid	.0001108	.01053	0	1	54137
Exploration	.00205	.04523	0	1	54137
Development, Production	.06853	.2527	0	1	54137
Observations	54137				

Note: Annual data from all platforms in the Gulf of Mexico, 1995–August 2010. Incident indicator equals 1 if there is one or more incidents on a platform in a year (this is the dependent variable in the probit regression).

Probit regressions are completed to study the variation in probability of an incident with depth, age, distance from shore, and other factors. Because the data are not complete for 2010 and production data are available starting in 1996, the regression includes only the years 1996 to 2009. Table 8 presents the marginal effects from probit regressions for the probability that an incident is reported. The dependent variable *(Incident)* is 1 if one or more incidents are reported in year *t* on platform *i* and 0 otherwise. We display four specifications, each with an increasing number of explanatory variables. The first specification includes characteristics of platforms, including age, distance to shore, year, and whether the platform is considered a major complex; the second specification adds indicators for production activity levels. The third and fourth specifications add information on lease ownership. The results reiterate that the probability of an incident's being reported increases with water depth. An increase in the water depth of 100 feet increases reported incidents by 0.108 to 0.166 percentage points (as seen in the coefficient on *Water Depth* in Table 8). The predicted increase applies to the average platform—that is, a platform with the same age, annual production, number of producing wells, and number of completions as the average platform in the Gulf. The predicted baseline probability of an incident's being reported on the average platform is 1.4 percent; therefore, an increase of 0.12 percentage points is equivalent to an 8.5 percent increase of the baseline probability. In analyzing reported incidents on offshore drilling rigs, Jablonowski (2007) finds that an indicator for water depths deeper than 400 feet is statistically insignificant in determining the likelihood of an incident. Our findings also differ from Shultz (1999), who finds for the period of 1986 to 1995 (10 years before the period we are studying) that water depth had a negative effect on the likelihood of accidents. As illustrated in Figure 2, our study period experienced a dramatic increase in drilling at the deepest water depths, compared with the study period of Shultz (1999).

Table 7. Incidents on Major Complexes Manned 24 Hours a Day, by Water Depth

	Shallow		Deep		Ultra-Deep	
	mean	sd	mean	sd	mean	sd
Incident Indicator	.2282	.4197	.7453	.436	.8095	.3946
No. Incidents	.3372	.7772	1.963	2.289	2.467	2.446
No. Injuries	.02035	.2102	.04173	.2886	.009524	.09759
No. Fatalities	.00401	.07209	.004317	.06561	0	0
Explosion	.00421	.06475	.002878	.05361	0	0
Blowout	.001403	.03744	.001439	.03793	0	0
Equipment Fail	.06766	.2512	.223	.4166	.181	.3868
Human Error	.05704	.2319	.1842	.3879	.181	.3868
Accident	.2034	.4025	.7209	.4489	.7905	.4089
Spill	.03087	.173	.04604	.2097	.0381	.1923
Spill Volume (bbl)	26.51	159.8	17.54	30.76	.9541	.355
Weather	.03198	.1759	.05324	.2247	.04762	.214
Structural Damage	.0006014	.02452	0	0	0	0
Crane	.01704	.1294	.1511	.3584	.2095	.4089
Collision	.002406	.04899	.004317	.06561	0	0
Well Control (Surface)	.0001002	.01001	0	0	0	0
Well Control (Diverter)	.0001002	.01001	0	0	0	0
Slip, Trip, Fall	.009924	.09913	.01151	.1067	.009524	.09759
Overboard Drill Fluid	.0003007	.01734	.001439	.03793	0	0
Exploration	.003709	.06079	.0259	.1589	.05714	.2332
Development, Production	.1812	.3852	.6576	.4749	.7524	.4337
Observations	9976		695		105	

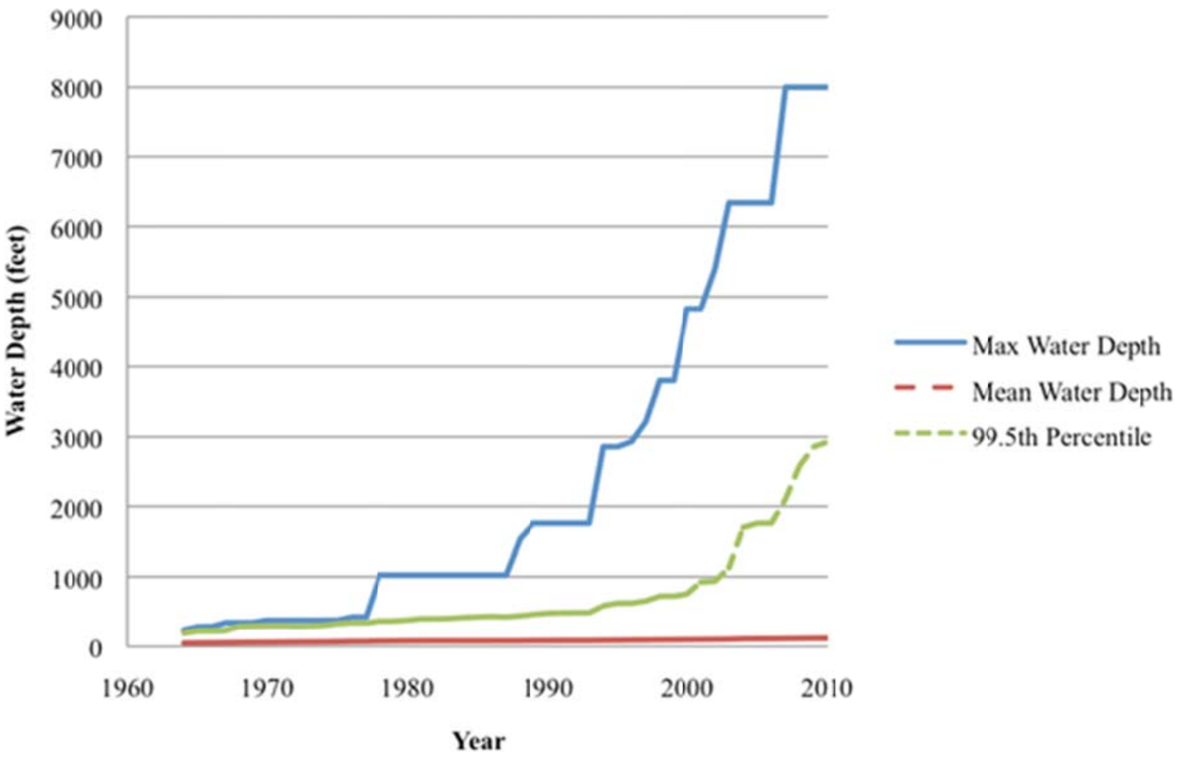
Note: Annual data from all major complexes manned 24 hours a day, 1995–August 2010. Incident indicator equals 1 if there is one or more incidents on a platform in a year (this is the dependent variable in the probit regression).

It is possible that our finding regarding water depth is driven by a lack of industry and operator experience at these new depths. To investigate the temporal effect of learning, we created an indicator for platforms that were installed in water 500 feet deeper than all other existing platforms at that time. We find that indicators for the first, second, third, fourth and fifth year of platforms that were once at the leading edge of water depth were statistically insignificant as predictors of company-reported incidents (this specification is not reported in Table 8). The results imply that, compared with the average platform, “pioneer” platforms in deeper waters do not report more incidents in the first five years after being installed.

We tried several specifications of pioneering platforms to see whether there was any experience effect. For example, we created an indicator for any platform that was in the 99.5th percentile of water depth in a given year (Figure 2). This indicator also results in no statistically significant findings when water depth is included as a covariate in the regression. We also confirm that if water depth is not included in the regression, this indicator is statistically significantly positive—that is, if this was the only measure of water depth, then we find that the platforms in the 99.5th percentile water depth are more likely to have incidents than those below the 99.5th percentile.

Platform-level production in deep water is on average much higher than production in shallow water (Table 2). Therefore, it is plausible that the increase in incidents with water depth could in fact be correlated with increased production. Including production volume in the regression for reported incidents shows that higher production does increase the probability of an incident report (in specifications (3) and (4)); however, as when production is not accounted for, the marginal effect of increasing water depth is still significant. The marginal effect of water depth also does not change substantially when accounting for drilling activity that year at the platform *(Drilling Activity (Indicator)).* On average platforms in deeper water are more complex: they have had more boreholes drilled and more well operations (such as well reentries and horizontal drills) than platforms in shallow water. However, even after accounting for the cumulative number of well operations and the current number of producing wells at a platform, water depth still plays a statistically significant role in determining the probability of an incident.

Figure 2. Maximum and Mean Platform Water Depth over Time



The predicted annual probability of a reported incident at different water depths is displayed in Figure 3. The predicted probability was obtained using estimates from Specification 4 in Table 8, holding all other variables in the model at their mean.

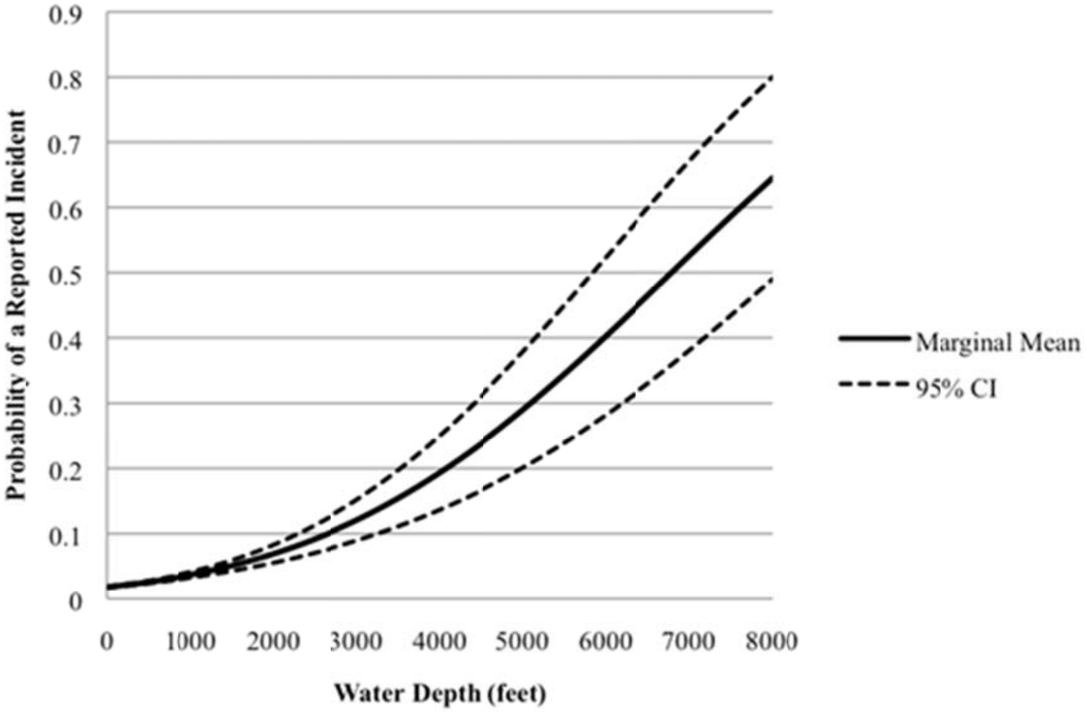
The effects of other variables included in the regression are as expected. Site complexity, approximated by “major complex” status in this analysis, is positively correlated with the probability of an incident, as suggested by Jablonowski (2007) and Iledare et al. (1997). Reported incidents increase as platforms are farther from the shore or manned 24 hours a day. Age also increases the likelihood of a reported incident, supporting the findings of Iledare et al. (1997); however, Shultz (1999) finds platform age to be insignificant.

Table 8. Probit Estimates of Nonweather-Related Incidents

	Specifications			
	(1)	(2)	(3)	(4)
Water Depth (100 feet)	.00166*** (.000108)	.00108*** (.000103)	.0012*** (.000112)	.00121*** (.000111)
Age	.0000479 (.0000359)	.0000904*** (.0000336)	.000105*** (.0000335)	.000119*** (.0000332)
Manned 24 Hours (Indicator)	.0798*** (.00352)	.0434*** (.00264)	.0422*** (.00266)	.0421*** (.00266)
Major Complex (Indicator)	.0306*** (.00149)	.0178*** (.00124)	.0171*** (.00124)	.0167*** (.00122)
Distance to Shore (miles)	.000142*** (.0000172)	.0000695*** (.000015)	.000065*** (.000015)	.0000665*** (.0000147)
Year>=2006 (Indicator)	.0261*** (.00134)	.0296*** (.00136)	.0302*** (.00139)	.0202*** (.00283)
Inactive (Indicator)		-.0207*** (.00122)	-.0214*** (.00124)	-.021*** (.00122)
Production (mBOE)		2.17e-07 (1.38e-07)	2.84e-07* (1.46e-07)	3.03e-07** (1.44e-07)
Drilling Activity (Indicator)		.0317*** (.00278)	.0312*** (.00279)	.0297*** (.00272)
No. Well Operations		.000432*** (.0000383)	.000412*** (.0000377)	.000412*** (.0000372)
No. Producing Wells		1.25e-06 (.000118)	-4.21e-06 (.000116)	-.0000413 (.000114)
Lease Operator’s % Ownership			-.0000158 (9.94e-06)	-.0000117 (9.81e-06)
No. Lessees			.000225 (.00019)	.000165 (.000188)
District Effects	Yes	Yes	Yes	Yes
Year Effects	No	No	No	Yes
N	76,595	76,595	74,438	74,438
Pseudo R-squared	0.28314	0.33149	0.33476	0.33724

Notes: *** significant at the 1% level. Dependent variable: whether a nonweather-related incident occurred on platform i in year t. Data on nonweather-related incidents, 1996–2009. Probit slope derivatives (marginal effects) are reported. Specification includes a constant term (marginal effect not reported). Standard errors are shown in parenthesis. All specifications contain an indicator for the district of jurisdiction, and the last specification contains an indicator for the year. Production is the annual production of oil and gas (where gas is converted to thousand barrels of oil equivalent (mBOE) with 0.178 bbl per thousand cubic feet (mcf).

Figure 3. Predicted Probability of a Reported Incident, by Water Depth



Lake Jackson, and Lake Charles) have a lower probability of reported incidents. This is in conformity with Jablonowski (2007), who found that location affected the probability of reporting and suggested that spatial variation in inspection characteristics may be the cause. Finally, to account for variation in the platforms over time, a year indicator is included in the final specification. When taking time into consideration, we find that the working interest of the lease operator and the number of firms that have ownership in the lease are not significant in determining incident occurrence.

This data set includes platforms that are not actively producing but have not yet been removed. Including an indicator for these inactive platforms *(Inactive (Indicator))* shows that, as expected, incidents are less likely to be reported for inactive platforms.

4. Facility Inspections and Incidents of Noncompliance

Pursuant to the OCS Lands Act of 1953 (as amended), all fixed production facilities are to be inspected by BOEMRE at least once annually for compliance with safety regulations, accurate recordkeeping, and proper maintenance. In addition to this annual inspection, unannounced risk-based inspections are conducted on an irregular basis. According to BOEMRE inspection data, each year 90.1 percent of active platforms were inspected at least once from 1986 through 2009. Other inspections are tailored to the current use of each facility, which can range from exploratory activities through production to abandonment.

Annual and risk-based production inspections both follow similar guidelines (OEMM, 2009). They are scheduled in advance to enable inspection of platforms in close proximity on the same date. Within a given group of facilities, the lead inspector assigns individual inspectors based on their inspection records to ensure that an inspector does not visit the same facilities in successive years. On the date of inspection, the inspector group, which can range from one to seven inspectors, conducts a visual inspection during the helicopter approach and an initial walk around the facility to check its general condition. Next, one inspector begins a paperwork review while any other inspectors present examine and test the safety equipment designed to prevent blowouts, fires, spills, and other major accidents. General violations and specific safety equipment failures are documented, and the inspector group issues "Incidents of Noncompliance" (INCs) as appropriate. These INCs are classified into three broad categories: (1) a warning, in which the operator is ordered to address the problem; (2) a component shut-in, which requires the operator to suspend the operation of a piece of equipment that is not functioning properly, which may or may not hinder production; and (3) a facility shut-in, which requires cessation of all production until the problem is mitigated and verified during a follow-up inspection. In addition, INCs can be referred for a civil penalty review. Later, the supervisory inspector for each district checks the inspection documentation for accuracy.

Information on these inspections and the detected INCs were obtained from BOEMRE. Between 1986 and August 2010 there were 138,197 inspections on pipelines, meter facilities, mobile offshore drilling units, and offshore facilities; 91,775 of these inspections were on offshore facilities alone, and these were used for statistical analysis.[10] The descriptive statistics below show that fewer than 10 percent of historical inspections were unannounced (Table 9). Twenty-seven percent of inspections led to the issuance of at least one INC, with an average of 0.91 INCs issued per inspection (the maximum issued during one inspection was 67, and standard deviation is 2.38). As with the incident data, these descriptive statistics reveal variation with water depth; however, the trend was reversed: on average, fewer INCs were issued to

---

[10] Because the date the platform was recorded to have been installed is after the date of the inspection, 369 of these inspections do not match.

platforms in deeper water (Table 10).

Table 9. Descriptive Statistics of Platform Inspections

	mean	sd	min	max	count
No. Inspectors	1.424	.6321	1	7	91775
Unannounced (Indicator)	.09293	.2903	0	1	91775
Inspection Time (hours)	3.323	6.548	0	702	91774
Components Inspected	19.08	27.39	0	356	82570
INC Issued (Indicator)	.2748	.4464	0	1	91775
No. INCs Issued	.91	2.383	0	67	91775
INCs per Unit Time	.3846	1.278	0	67	89900
INCs per Component	.1115	.4426	0	23	77251
Rescinded INCs	.006974	.1415	0	14	91775
No. Warnings	.3526	1.19	0	41	91775
No. Component Shut-ins	.3927	1.374	0	66	91775
INCs toward Facility Shut-in	.02441	.2105	0	15	91775
INCs to Civil Penalty Review	.01366	.2357	0	34	91775
Cum. Inspections (t-1)	11.47	9.903	0	82	91775
Cum. INCs (t-1)	14.22	25.64	0	278	91775
Cum. Civil Penalty Reviews (t-1)	.1258	.852	0	35	91775

Note: Data on all offshore platform facilities, 1986–2010.

Table 10. Descriptive Statistics of Platform Inspections, by Water Depth

	Shallow		Deep		Ultra-deep	
	mean	sd	mean	sd	mean	sd
No. Inspectors	1.497	.711	1.843	.9242	2.011	.9777
Unannounced (Indicator)	.2001	.4001	.1306	.3372	0	0
Inspection Time (hours)	6.93	10.26	17.2	21.76	19.02	24.66
Components Inspected	41.39	37.99	78.68	78.45	95.82	101.9
INC Issued (Indicator)	.4056	.491	.2588	.4382	.08696	.2833
No. INCs Issued	1.616	3.332	.873	2.34	.2065	.8713
INCs per Unit Time	.2879	.8269	.08915	.3377	.01667	.08817
INCs per Component	.1096	.4899	.0498	.2359	.005032	.01678
Rescinded INCs	.01321	.1964	.03144	.4579	.02174	.1466
No. Warnings	.6092	1.69	.3676	1.215	.07609	.3987
No. Component Shut-ins	.7558	1.981	.4728	1.443	.1304	.539
INCs toward Facility Shut-in	.04496	.3038	.01209	.1628	0	0
INCs to Civil Penalty Review	.02894	.3084	.01935	.1764	0	0
Cum. Inspections (t-1)	18.15	13.23	14.71	11.85	6.13	4.82
Cum. INCs (t-1)	33.55	37.6	14.32	18.41	1.62	2.343
Cum. Civil Penalty Reviews (t-1)	.3338	1.382	.1415	.3974	0	0
Observations	20664		827		92	

Note: Data on all offshore platform facilities classified as major complexes that are manned 24 hours a day, 1986–2010.

Inspectors

The inspection data obtained from BOEMRE include unique identifying information for up to four inspectors for each inspection (of a maximum of seven inspectors).[11] This additional information allows for study of individual inspectors' characteristics, predictive capabilities using historical data, and any evidence of relationship-building between inspectors and operators or platforms. The data were reorganized to link inspection characteristics with individual inspectors. Specific variables were created for each inspection by each inspector with a time lag to exclude the current inspection information (e.g., cumulative number of INCs before the current inspection). These variables were condensed to the level of the inspection group. For example, for each inspection, the average over the inspector group of the average time for all of the past inspections by each inspector was created. Table 11 summarizes inspector variables, averaged across the inspection group. For example, the average inspector had completed 1,013 inspections at any point in time between 1986 and 2010 and had issued a total of 416.7 warnings and 30.1 facility shut-ins.

Table 11. Inspector–Specific Descriptive Statistics

	mean	sd	min	max	count
Cum. Inspections by I	1013	811.9	1	4732	91775
Cum. Warnings Issued by I	416.7	508.6	1	4221	91775
Cum. Component Shut-ins Issued by I	490.6	556.4	1	4288	91775
Cum. Facility Shut-ins Issued by I	30.1	28.65	.5	200	91775
Cum. INCs Issued by I	1099	1159	1	8740	91775
Cum. INCs to Civil Penalty Review by I	17.57	23	0	162	91775
Average Inspection Time of I	4.389	1.854	0	40.25	91775

Notes: Data on all offshore platform facilities, 1986–2010. All statistics are based on the last inspection (i.e., cumulative inspections by inspector I prior to the current inspection). I = inspector. The observation is the inspection; if the inspection had more than one inspector, the variable is the average over the inspectors.

Because we are able to link each inspector to an actual inspection, we have compiled platform-specific and platform operator-specific inspector information. Tables 12 and 13 describe the historical inspection linkages between inspectors and platforms and operators. For example, from Table 12, we see that at any point in time, an inspector who is visiting a particular

---

[11] Our interest is in understanding the role of inspectors in enforcement and compliance; we are not interested in identifying any individual inspector. We have thus removed any identifying information from the data. Instead, each inspector has an anonymous but unique identifying code.

platform has previously inspected the same platform 1.2 times, with the maximum being 37 previous visits. Similarly, from Table 12, we see that at any point in time, the average inspector has inspected any platform of a platform operator 98.4 times. Later, in the regression analysis, we use these data to further investigate these relationships and determine whether past inspection characteristics predict outcomes of future inspections when linked to both the inspector and the operator or platform. Similarly, platform characteristics were analyzed to determine whether past performance influenced the likelihood of receiving an INC (Table 14).

Table 12. Inspector-Platform–Specific Descriptive Statistics

	mean	sd	min	max	count
Cum. Inspections of P by I	1.228	2.138	0	37	91775
Cum. INCs Issued to P by I	1.45	4.312	0	106	91775
Cum. Warnings Issued to P by I	.5085	1.839	0	47.5	91775
Cum. Component Shut-ins Issued to P by I	.6175	2.198	0	90	91775
Cum. Facility Shut-ins Issued to P by I	.03696	.2605	0	15	91775
Cum. Civil Penalty Reviews of P by I	.02007	.2931	0	34	91775

Notes: Data on all offshore platform facilities, 1986–2010. All statistics are based on the last inspection (i.e., cumulative inspections of platform (P) by inspector (I) prior to the current inspection). P = platform; I = inspector. The observation is the inspection; if the inspection had more than one inspector, the variable is the average over the inspectors.

Table 13. Inspector-Operator–Specific Descriptive Statistics

	mean	sd	min	max	count
Cum. Inspections of O by I	98.41	188.4	0	1825	91775
Cum. INCs Issued to O by I	73.4	147.1	0	1600	91775
Cum. Warnings Issued to O by I	24.96	59.11	0	750	91775
Cum. Component Shut-ins Issued to O by I	29.54	67.05	0	821	91775
Cum. Facility Shut-ins Issued to O by I	1.342	2.861	0	23	91775
Cum. Civil Penalty Reviews of O by I	.4431	2.513	0	54	91775

Notes: Data on all offshore platform facilities, 1986–2010. All statistics are based on the last inspection (i.e., cumulative inspections of platforms operated by operator (O) by inspector (I) prior to the current inspection). O = operator; I = inspector. The observation is the inspection; if the inspection had more than one inspector, the variable is the average over the inspectors.

Table 14. Platform–Specific Descriptive Statistics

	mean	sd	min	max	count
Cum. Inspections of P	11.47	9.903	0	82	91775
Cum. INCs Issued to P	14.22	25.64	0	278	91775
INC Issued to P	.2846	.4512	0	1	91775
Cum. Warnings Issued to P	.2194	1.15	0	32	6281
Warning Issued to P	.1565	.3633	0	1	91775
Cum. Component Shut-ins Issued to P	.2629	1.351	0	36	6281
Component Shut-in Issued to P	.157	.3638	0	1	91775
Cum. Facility Shut-ins Issued to P	.02038	.1936	0	6	6281
Facility Shut-in Issued to P	.0186	.1351	0	1	91775
Cum. Civil Penalty Reviews of P	.1258	.852	0	35	91775
Civil Penalty Review of P	.007747	.08768	0	1	91775

Notes: Data on all offshore platform facilities, 1986–2010. All statistics are based on the last inspection (i.e., cumulative inspections of platform (P) prior to the current inspection). P = platform.

Regression Analysis of Incidents of Noncompliance

Probit regression analysis is used to examine the effect of water depth on the probability of receiving an INC while controlling for other platform characteristics. Table 15 reports on an analysis of inspections of all active platforms between 1996 and 2010.[12] We estimate four probit regressions to examine (1) the probability that any INC is issued upon an inspection; (2) the probability that a component shut-in is issued upon an inspection; (3) the probability that a facility shut-in is issued upon an inspection; and (4) an ordered probit of the probability of a warning, component shut-in or facility shut-in. In all specifications we include a fixed effect for the type of inspection (if there were more than 15 observations from an inspection type), district, and year.

The majority of the inspections are complete production inspections and "sampling" production inspections (where a random sample of components is inspected), but other types include accident investigations, meter inspections, and environmental inspections. In contrast with the estimates on company-reported incidents, platforms operating in deeper waters are less likely to receive INCs of any type. Other factors, namely, age, distance to the shore, the number of well operations, and whether the platform is a major complex have similar effects as in the

---

[12] Tables 12–14 are based on the full set of data from 1986 through 2010 for both active and inactive platforms, resulting in 91,775 platform-years. Table 15 is based only on active wells during the years for which we have production data, 1996 through 2010, resulting in 30,054 platform-years.

company-reported incident regression. The quantity of oil and gas produced from a platform does not increase the probability of an enforcement action; however, the number of producing wells does. A larger number of producing wells (as measured by the number of producing boreholes) increases the likelihood of an INC. A greater number of operations (where each borehole can have more than one operation, such as horizontal drilling or reentry) results in a reduced likelihood of an INC. Older platforms are more likely to receive INCs, with the exception of component and facility shut-ins, where age does not appear to play a role. As with the estimates on incidents, major complexes that are farther from shore are more likely to receive INCs of all types. Those that are manned 24 hours a day are found to have more component shut-ins. As expected, increasing the number of inspectors or the length of inspection increases the probability that an INC of any type is issued.

Including the percentage of past inspections that resulted in an INC in the analysis suggests that poor performance is persistent. Platforms that were more likely to have been issued an INC in a past inspection (as calculated by the percentage of inspections that resulted in an INC) were also more likely to receive an INC from the current inspection. If a warning, component shut-in, or facility shut-in was issued in the inspection immediately prior, there is also an increased probability that an INC is issued during the current inspection. We cannot say whether the INCs have no effect on noncompliance; however, this last finding suggests that enforcement actions do not fully ensure future compliance. These results correspond to remarks made by the director of BOEMRE, that “sanctions that are currently available to deter and punish violations of safety and environmental standards and regulations, must be substantially strengthened” (Bromwich, 2010). Still, there is reason to believe that inspections and penalties have some effect; for example, Cohen (1986) finds that inspections have a deterrent effect on oil spills from tanker transfer operations.[13]

We obtain mixed results when we examine the frequency that inspectors visited the same platforms or platforms operated by the same company in the past. The estimates suggest that the more times an inspector (or average over the group of inspectors) has visited a platform in the past (Cum. Inspections of P by I at t-1), the less likely the inspector is to issue an INC during the current inspection. This is shown by examining the number of times that each inspector visited

---

[13] See also Cohen (2000) for a review of the empirical literature on enforcement and oil spills from tanker operations. More recently, Eckert (2004) has examined inspections and compliance of petroleum storage facilities and suggested that inspections have only a small deterrent effect on future noncompliance.

the platform in the past. However, the effect of an inspector's visiting many platforms operated by the same operator in the past (Cum. Inspections of O by I at t-1) is not found to be significant. The higher the percentage of inspections that lead to an INC for that platform by the inspector in the past (percentage Inspections of P by I with INCs in t-1), the higher the probability of an INC—suggesting that there is either persistence in noncompliance or an ongoing relationship between the inspector and the platform. However, the opposite is true when this analysis is expanded to encompass all platforms of an operator. The percentage of all the inspections performed by the inspector of an operator's platforms that resulted in an INC (percentage of O by I with INCs in t-1) is negatively correlated with the probability of an INC. Although these results are only suggestive and further research is warranted, it appears that whether a platform is found to be in noncompliance varies by inspector.

Table 15. Probit Estimates of Enforcement Action (Marginal Effects)

	(1) Any INC Binary Probit	(2) Component Shut-in Binary Probit	(3) Facility Shut-in Binary Probit	(4) Ordered INC Probit
Water Depth (100 feet)	-.000142***	-.000126***	-8.50e-06**	-.000141***
	(.0000129)	(.000011)	(3.30e-06)	(.0000129)
Production (mBOE)	1.18e-06	1.50e-06	-6.90e-07	1.18e-06
	(1.19e-06)	(9.73e-07)	(4.31e-07)	(1.19e-06)
No. Producing Wells	.00352***	.00322***	.000324	.00355***
	(.00103)	(.000806)	(.000213)	(.00103)
No. Well Operations	-.000685*	-.000634**	-.0000792	-.000684*
	(.000358)	(.000286)	(.000076)	(.000358)
Age	.000787**	-.000294	.0000397	.000801***
	(.000308)	(.00025)	(.0000728)	(.000308)
Manned 24 Hours (Indicator)	.0103	.0122*	.000189	.0102
	(.00821)	(.00639)	(.00168)	(.00821)
Major Complex (Indicator)	.099***	.0909***	.0106***	.0989***
	(.00721)	(.00567)	(.00169)	(.00721)
Distance to Shore (miles)	.000791***	.000635***	.0000978***	.000794***
	(.000122)	(.0000968)	(.0000263)	(.000122)
No. Inspectors (t)	.0315***	.021***	.00626***	.0314***
	(.00418)	(.00329)	(.000884)	(.00418)
Inspection Time (hours) (t)	.0118***	.0088***	.00028***	.0118***
	(.00038)	(.000282)	(.0000493)	(.00038)
% Inspections with INCs (t-1)	.000297***	.000194***	.0000281***	.000296***
	(.0000328)	(.0000246)	(6.00e-06)	(.0000328)
No. Ps Operated by O (t)	-.0000986***	-.000024*	-9.56e-06**	-.0000993***
	(.0000164)	(.0000132)	(4.15e-06)	(.0000164)
Warning Issued to P (t-1)	.0328***	.0144**	.00226	.033***
	(.00728)	(.00575)	(.00162)	(.00728)

Component Shut-in Issued to P (t-1)	.0415***	.0392***	.00226	.0415***
	(.0076)	(.00618)	(.00167)	(.00759)
Facility Shut-in Issued to P (t-1)	.0113	.00564	.0112***	.0115
	(.0165)	(.0125)	(.00431)	(.0165)
Civil Penalty Review of P (t-1)	.0604***	.0435**	-.000698	.0607***
	(.0235)	(.0187)	(.00389)	(.0235)
Cum. Inspections of P (t-1)	.0006	.000463	.000051	.000589
	(.000471)	(.000368)	(.000102)	(.00047)
Cum. Inspections of P by I (t-1)	-.00926***	-.00481***	-.00119***	-.00927***
	(.00155)	(.00125)	(.000414)	(.00155)
% Inspections of P by I with INCs (t-1)	.0000976***	.0000688***	1.87e-06	.0000973***
	(.0000146)	(.0000106)	(2.48e-06)	(.0000146)
Cum. Inspections of O by I (t-1)	8.88e-06	-.0000182	-3.01e-06	9.05e-06
	(.0000155)	(.0000133)	(4.69e-06)	(.0000155)
% Inspections of O by I with INCs (t-1)	-.000282***	-.000131***	-.000036***	-.000282***
	(.0000144)	(.0000112)	(4.85e-06)	(.0000144)
Year Effects	Yes	Yes	Yes	Yes
District Effects	Yes	Yes	Yes	Yes
Inspection Type Effects	Yes	Yes	Yes	Yes
N	30,054	30,054	29,986	30,054
Pseudo R-squared	0.13458	0.14568	0.11659	0.13444

Notes: *** significant at the 1% level, ** 5% level, * 10% level. Specifications: (1) probit regression for whether 1 or more warnings was issued at platform during an inspection at *t;* (2) probit for whether 1 or more component shut-ins were issued; (3) probit for whether a facility shut-in was issued; (4) ordered probit for an inspection without any INCs, with a warning, component shut-in, or facility shut-in. O = operator; I = inspector; P = platform. Probit slope derivatives (marginal effects) are reported. Specification includes a constant term (marginal effect not reported). Standard errors are shown in parenthesis. Production is the annual production of oil and gas (where gas is converted to thousand barrels of oil equivalent (mBOE) with 0.178 bbl per thousand cubic feet (mcf). Data on inspections, 1996–August 2010.

5. Company Effects

The regressions of company-reported incidents (Table 8) and enforcement action (Table 15) are now re-estimated to include indicators for major oil producers. The 10 companies that produced the most oil and gas from the Gulf of Mexico in 2009 are included as separate dummy variables in the regressions, with the remaining companies left in the regression as the base case. Table 16 tabulates the number of platforms, production levels, and incident characteristics for the top 10 producers in 2009. In 2009, BP was the largest producer of oil in the Gulf, followed by Shell, Chevron, and Anadarko. Combined, the top 10 companies accounted for 75 percent of total production in the Gulf between 1996 and 2009.

Table 16. Operator Characteristics by Top-Producing Operators in 2009

Parent Operator	No. Platforms	No. Deep Platforms	Avg. Platform Prod. (mBOE)	Operator Prod. (mBOE)	Avg. No. Incidents	Avg. No. Injuries	Avg. No. Fatalities
BP	269	9	1.9740	3340	.3629	.0201	.0030
Shell	160	9	6.1497	6057	.6964	.0091	.0030
Chevron	1022	5	.3694	3108	.1222	.0075	.0013
Anadarko	276	8	.7583	1189	.0957	.0147	.0026
BHP Billiton	6	3	8.2985	340	1.0976	.0000	.0000
Apache	523	0	.2097	631	.1227	.0090	.0013
Eni US	78	3	.9115	489	.1716	.0168	.0019
Exxon Mobil	230	2	.7461	1098	.1719	.0204	.0007
W&T Offshore	205	0	.1707	181	.1210	.0085	.0019
Murphy Expl & Prod	248	3	.2228	348	.1376	.0019	.0000
Other	3445	10	.2095	5736	.1043	.0069	.0012

Data from 1996–2009. The table lists operators in order of total 2009 production volume. “No. Platforms” is the count of unique platforms ever operated from 1996 to 2009. Production data are listed by millions of barrel of oil equivalent (mmBOE). “Avg. Platform Prod.” is the average production per platform year. “Operator Prod” is the cumulative production summed over all years and platforms. “Avg. No. Incidents” is the average per platform year.

Estimates are fairly uniform across different specifications of the probit for company-reported incidents and the ordered probit of enforcement action, and therefore only the last specification from each is displayed (Table 17). The probit estimation of company-reported incidents (first column of Table 17) suggests that the probability of a reported incident increases with BP as an operator compared with operators that are not among the top 10 producers. The probability that the average platform would have a reported incident in any given year is 1.4

percent. The marginal effect of BP as an operator increases the probability of a reported incident by 1.35 percentage points—nearly doubling the probability of an incident. The marginal effect of having BP as an operator is surpassed only by BHP Billiton—an increase in 6.3 percentage points. Note that these are self-reported incidents. Hence, without further study, it is not possible to know whether the higher level of incidents for BP and BHP Billiton are the result of poorer safety records or a higher level of compliance with self-reporting requirements. Put differently, it is possible that BP and BHP Billiton simply report more incidents than the rest of the industry.

A poorly performing company is expected to be more likely to have incidents to report, and likewise more likely to receive INCs when they are inspected. The signs on the coefficients of company indicators are not always consistent across the incident probit and the ordered INC probit, including in the case of BP. That is, BP is less likely to receive an INC upon an inspection than other companies not included in the top 10 producers. However, the increase in the probability of INCs from having BP as an operator is small in proportion to the baseline probability of an INC, and statistically significant at only $p<.10$. The probability of receiving an INC for the average platform is 28 percent, and having BP as an operator would decrease that probability by only 2.67 percentage points, or roughly 9.5 percent. Without further study, it is impossible to know whether the slightly lower INC rate for BP is the result of a better compliance record or a smaller percentage of infractions culminating in enforcement actions.

Table 17. Company Effects in Probit Regressions

	(1) Incident binary probit	(2) Ordered INC probit
Covariates	Table 8, Specification 4	Table 15, Specification 4
BP	.0135***	-.0267*
	(.00309)	(.0145)
Shell	-.000746	.0555***
	(.0023)	(.0196)
Chevron	.00466***	-.0647***
	(.00124)	(.0186)
Anadarko	-.00347*	.00026
	(.00175)	(.0151)
BHP Billiton	.0631**	.00294
	(.0493)	(.14)
Apache	-.00337**	-.0328***
	(.00123)	(.0118)
Eni US	-.00601**	-.0526*
	(.0021)	(.0258)
Exxon Mobil	-.00138	-.0101
	(.00184)	(.0157)
W&T Offshore	.00052	-.0134
	(.00242)	(.0175)
Murphy Expl & Prod	-.000161	-.0206
	(.00284)	(.018)
N	74,438	30,054
Pseudo R-squared	0.33996	0.13520

*** significant at the 1% level, ** 5% level, * 10% level. Specifications include covariates from (1) Table 8 and (2) Table 15. Dependent variables: (1) whether a nonweather related incident occurred on platform i in year t, using data on nonweather related incidents; (2) ordered probit for an inspection without any INCs, with a warning, component shut-in or facility shut-in, using data on inspections. Data from 1996 to 2009, although variables such as the cumulative number of inspections were created using data back to 1986. Probit slope derivatives (marginal effects) are reported. Standard errors are shown in parenthesis.

6. Conclusions

This paper reports on a preliminary analysis of performance indicators on platforms in the Gulf of Mexico between 1996 and 2010. Although our findings are preliminary, an analysis of the data provides evidence of the value of empirical investigations of firm safety and environmental performance as well as government inspection and enforcement activities. Statistical analysis reveals that company-reported incidents (such as blowouts, fires, injuries, and pollution) increase with water depth, controlling for platform characteristics such as age, quantity of oil and gas produced, and number of producing wells. For an average platform (i.e., a platform with the sample average age, annual production, number of producing wells, and other characteristics), each 100 feet of added depth increases the probability of a company-reported incident by 8.5 percent.

In addition to self-reported incidents, we have examined government inspections and enforcement actions (warning, component shut-in, facility shut-in, and civil penalty review) following an inspection. Fewer incidents of noncompliance are detected during inspections on deepwater platforms than on platforms in shallow water; however, the magnitude of the effect of depth on noncompliance is not large: with each 100 feet of added depth, the probability of an incident of noncompliance decreases by 0.05 percent. We also provide a preliminary analysis of the effect of prior findings of noncompliance and conclude that noncompliance is persistent. Our results also suggest that findings of noncompliance vary by inspector.

Examining the 10 companies that produced the most oil and gas in the Gulf of Mexico in 2009 indicates significant variation in company-reported incidents and incidents of noncompliance across companies. The analysis suggests that the probability of a reported incident increases with BP as an operator (all else equal) compared with operators not included in the 10 largest producers (by volume). Of the 10 largest producers, BHP Billiton is the only firm with a higher probability of reporting an incident than BP. When we examine the probability of receiving an enforcement action upon inspection, we find that BP is less likely to receive an enforcement action than are smaller producers. For the average platform, having BP as an operator increases the probability of a company-reported incident by 96 percent and decreases the probability of an enforcement action upon inspection by 9.5 percent.

The variables of interest for each analysis were chosen based on supporting literature and the availability of data provided by BOEMRE. The agency’s incident data reflect only those incidents that have been reported or detected; other research has demonstrated the likelihood of discrepancies between actual and recorded incidents (Jablonowski 2007). Shultz (1999) also points out reliability concerns and recommends improving “data acquisition, data entry, and database management efforts” (p. 55) as well as regularly updating and eliminating errors in the records to increase the confidence of any conclusions drawn from these data. These activities are beyond the scope of this work; as a result, the quantitative findings of this report should be taken in light of the data limitations.

In addition to providing important insights, this preliminary analysis has raised many questions that are worthy of further research using the compiled data. First, this analysis is specific to offshore platforms. Data on mobile offshore drilling units are more difficult to analyze because we have data only on reported incidents. Since we do not know where these drilling units are when they do not have an incident, it is not possible to calculate a rate of incidents. However, further data collection and refinement, with an analysis of mobile drilling unit inspection results, might prove useful.

Second, we find that if an incident of noncompliance has been detected during a prior inspection, another incident of noncompliance is more likely. A poorly performing platform is more likely to have received an incident of noncompliance in the past but also more likely to receive one in the future, so it is difficult to determine whether the enforcement action in the past changed any behavior: the platform could possibly have been an even poorer performer without the past enforcement action. Further statistical analysis of enforcement and noncompliance data should provide important insights into the causal connections between inspections, warnings, component and facility shut-ins, and civil penalty review and subsequent reported incidents and incidents of noncompliance.

Third, we find significant variability in the probability of a company-reported incident by type of company. This is using a very broad definition of incidents, which include everything from a loss of well control to a fatality. It would be interesting to examine differences in specific types of incidents as well as firm characteristics (e.g., size, financial capacity, ownership structure).

Finally, future research should investigate the relationship between self-reported incidents, findings of noncompliance, and actual performance. Our analysis of incidents is necessarily based on self-reporting. Although firms that self-report a higher level of accidents or spills are generally more likely to be cited for noncompliance during an inspection, some exceptions are found. For example, both BP and Chevron had a higher-than-average incident rate but were less likely to be cited for noncompliance. Without further analysis, we do not know whether this is because these firms are more likely to self-report than others or a sign of sub-optimal enforcement.

References

Bromwich, M.R. 2010. “Implementation Plan In Response to the Outer Continental Shelf Safety Oversight Board’s September 1, 2010 Report to the Secretary of the Interior”, September 4, 2010.

Cohen, M.A. 1986. The Costs and Benefits of Oil Spill Prevention and Enforcement. *Journal of Environmental Economics and Management* 13(2) (June): 167–88.

———. 1987. Optimal Enforcement Strategy to Prevent Oil Spills: An Application of a Principal-Agent Model with Moral Hazard. *Journal of Law and Economics* 30(1) (April): 23–51.

———. 2000. Empirical Research on the Deterrent Effect of Environmental Monitoring and Enforcement. *Environmental Law Reporter* 30: 10245–52.

———. 2010. Oil Spills: The Deterrent Effects of Monitoring, Enforcement, and Public Information. In *Issues of the Day: 100 Commentaries on Climate, Energy, the Environment, Transportation, and Public Health Policy*, 58–59. Washington, DC: Resources for the Future Press.

Eckert, H. 2004. Inspections, Warnings, and Compliance: The Case of Petroleum Storage Regulation. *Journal of Environmental Economics and Management* 47(2): 232–59.

Epple, D. and M. Visscher, 1984. Environmental Pollution: Modelling Occurrence, Detection, and Deterrence. *Journal of Law & Economics* 27: 29-60.

Iledare, O.O., et al. 1997. Oil Spills, Workplace Safety and Firm Size: Evidence from the U.S. Gulf of Mexico OCS. *Energy Journal* 18(4): 73–89.

Jablonowski, C.J. 2007. Employing Detection Controlled Models in Health and Environmental Risk Assessment: A Case in Offshore Oil Drilling. *Human & Ecological Risk Assessment* 13(5) (September): 986–1013.

Shultz, J. 1999. The Risk of Accidents and Spills at Offshore Production Platforms: A Statistical Analysis of Risk Factors and the Development of Predictive Models. Doctoral dissertation, Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh.

Stewart, T.R., and T.M. Leschine. 1986. Judgment and Analysis in Oil Spill Risk Assessment. *Risk Analysis* 6(3): 305–15.

OEMM, 2009. Offshore Energy and Minerals Management, Gulf of Mexico OCS Region, Field Operations, "eFacilities Inspections Team Report", March 2, 2009.

Viladrich-Grau, M. and T. Groves, 1997. "The Oil Spill Process: The Effect of Coast Guard Monitoring on Oil Spills" *Environmental and Resources Economics* 10(4): 315-339.

Appendix

Table A1. Deepwater Platform Operators and Lease Operators in Gulf of Mexico, 1996–2010

Operator	Public or Private	Headquarters	Employees	2009 net income ($million)	2009 sales ($million)	Market cap. ($million)	Ptfm. oper.	Des. lease oper.
Anadarko Petroleum Corporation	Public APC	The Woodlands, TX	4,300	103	9,000	29,100	Y	Y
Apache	Public APA	Houston	3,452	-292	8,574	37,560	Y	Y
ATP Oil & Gas Corporation	Public ATPG	Houston	63	49	312	762	Y	Y
BHP Billiton Limited	Public	Melbourne, Australia	39,570	5877	50,535	135,690	Y	Y
BHP Billiton Plc	Public BBL	London	39,570	5,877	50,535	76,400	Y	Y
BP p.l.c.	Public BP	London	80,300	16,578	246,138	127,320	Y	Y
Chevron	Public CVX	San Ramon, CA	95,000	10,483	171,636	169,390	Y	Y
ConocoPhillips Company	Public COP	Houston	30,000	4,858	152,840	90,660	Y	Y
Deep Gulf Energy Lp (funded by First Reserve Corporation)	Private	Houston	16	—	—	—	N	Y
Devon Energy	Public DVN	Oklahoma	5,400	-2479	8,015.	28,679	N	Y
Dynamic Offshore Resources, LLC	Private	Houston	45	—	—	—	Y	Y
Eni S. p. A.	Public ADR	Rome	78,417	6,258	120,883	81,980	Y	Y
Exxon Mobil Corporation	Public XOM	Irving, TX	80,700	19,280	310,586	337,690	Y	Y
Helix Energy Solutions Group, Inc. (Energy Resources Technology GOM, Inc.)	Public HLX	Houston	1,550	175	1,461	1,392	N	Y
Hess Corporation	Public HES	New York	13,300	740	29,569	20,730	Y	Y
Marathon Oil Company	Public MRO	Houston	28,855	1463	54,139	23,470	N	Y

Mariner Energy, Inc	Public ME	Houston	328	-319	942	2,610	N	Y
Marubeni	Public MARUY	Tokyo	5,451	1143	41,139	11,600	N	Y
Murphy Oil Company (Murphy Exploration)	Public MUR	El Dorado, AZ	8,369	837	19,012	12,510	Y	Y
Newfield Exploration Gulf Coast LLC	Public NFX	Houston	1,148	542	1,338	7,870	Y	Y
Nexen Inc.	Public NXY/PB	Calgary, AB	4,594	510	5,530	11,163	N	Y
Noble Energy, Inc.	Public NBL	Houston	1,630	131	2,313	14,426	N	Y
Palm Energy Partners LLC (Pisces Energy LLC)	Private	Metairie, LA	25	—	2.6	—	Y	Y
Petrobras Argentina S.A.	Public PZE	Buenos Aires	4,326	242	3,113	1,884	N	Y
Placid Refining Company	Private	Port Allen, LA	200	—	3,351	—	N	Y
Pyramid Petroleum Inc. (Pyramid GOM, Inc.)	Public TSX: PYR	Houston	—	2.66	—	4,051	Y	Y
Royal Dutch Shell plc	Public RDSA	The Hague	101,000	12,518	285,129	110,750	Y	Y
Statoil	Public ASA	Stavenger, Norway	29,000	3151	80,101	70,618	N	Y
Stone Energy Corporation	Public SGY	Lafayette, LA US	313	-212	714	775	Y	Y
Valero Energy Corporation (Oryx Energy)	Public VLO	San Antonio	20,920	-1982	68,144.00	10,193	N	Y
W & T Offshore	Public WTI	Houston	286	-187	611	820	Y	Y
Walter Oil & Gas Corporation	Private	Houston	—	—	41	—	Y	Y

Note: All dollars are in millions, most recent data available. Sources: public documents, including SEC filings.