OCS Study
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Coastal Marine Institute

Forecasting the Number of Offshore Platforms on th

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ABSTRACT

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EXECUTIVE SUMMARY

The forecasts in this report predict the number of new offshore structures to be installed, removed, and operated on the Gulf of Mexico OCS over the next twenty-five years–1999 to 2023. The forecasts were made by using econometric modeling techniques on historical data from1947 through 1996. The historical record and predicted path (under the reference forecast) of the number of platforms operating in the Gulf over the 1947 to 2023 time period are illustrated in Figure E.1.

The principal trends and implications of the reference forecast are:

- A decline in the number of operating offshore structures from 3,687 to 2,612: a decline of about 29 percent over the 1999 to 2023 period.
- An annual average rate for installation of new platforms of not quite 142 per year: a total of 3,543 platforms installed over the 25-year period.
- Removal of old platforms at an annual rate of about 186 per year: a total of 4,645 structures removed over the period.

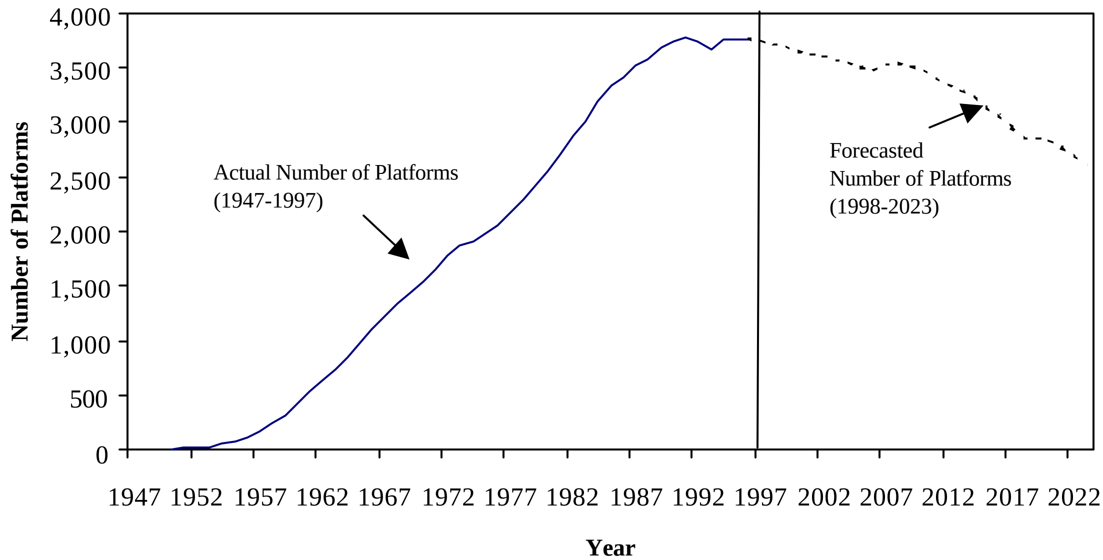


Figure E.1. Platforms operating on the Gulf of Mexico OCS.

A numerical forecast of offshore structures is relevant and useful for various purposes. For example, an important aspect of offshore platforms in the Gulf of Mexico is that they provide habitat for highly valued reef fish such as snappers and groupers. Such habitat is scarce in the Gulf. Offshore platforms have increased the total amount of reef habitat available by as much as 10 to 25 percent, depending on the definition and estimate of natural reef habitat, and have become important destinations for recreational fishermen and party boats. A forecast of the number of platforms operating over the next twenty-five years will be useful to those responsible for planning, managing, and preserving fish habitat and fish stocks through artificial reefs and other management programs.

The internal content and mechanics of the forecast also are important. For example, the economies of coastal areas adjacent to offshore petroleum producing areas are affected in important ways by offshore oil or gas development. In the reference forecast the decline in the number of operating platforms takes place because the number of platforms removed each year increases significantly above historical levels. The annual number of platforms installed, on the other hand, increases as well, but very slowly.

Since many of the platforms installed are expected to be larger platforms located in deeper water further from shore while more of the platforms forecast to be removed are smaller platforms located in shallower waters, expenditures on installing and operating new platforms and pipelines (as well as on removing old platforms) will dwarf expenditures lost as smaller platforms cease operating. Thus, the net effect on the economies of adjacent coastal areas may be quite positive despite the overall decline in the number of platforms operating. In contrast, if the same decline in the operating platforms as in the reference forecast were to come about largely because of a decline in the number of platforms installed, with a more modest decline relative to the reference forecast in the number of platforms removed, such a decline would likely have a very significant negative effect on adjacent coastal areas.

The report also reviewed the history of offshore development as a background and context for the forecast. The principal findings and generalizations from this review are:

- Since 1942, 5,561 platforms or structures have been installed on the OCS subject to federal jurisdiction.

- As of 1997, 1,645 of these structures had been removed leaving 3,916 operating platforms on the federal OCS.

- About 50 percent of the operating platforms are classified as "non-major" structures– defined as having fewer than six wells and no more than two pieces of equipment. The other 50 percent are classified as "major structures."

- About 68 percent of the structures that have been removed were non-major structures, and about 86 percent of the structures that have been removed were located in less than 400 feet of water.

- Conversely, proportionately more larger platforms, located in deeper water, have been installed as time has passed.

- The number of operating structures has grown steadily since the initial installations in the 1940s because the number of installations has been greater than the number of removals.

- The growth of the number of operating platforms has slowed in the 1990s as yields from fields have declined and the platforms installed in the 1960s and 1970s to produce them have become uneconomic to operate and have been removed.

- The average age of operating platforms has steadily increased; in 1997 it was about 18 years for major structures and 16 years for non-major structures.

- The average age of platforms that have been removed was 14.5 years for major structures and 15.8 years for non-major structures.

- Many external factors are involved in the decision to install a platform, but the determining factor is the expected productivity and profitability of the field the platform is intended to produce. When production falls below profitable levels, the platform will be shut down and removed.

- When new fields are discovered, new structures will be installed if expected revenues exceed expected costs sufficiently to compensate the operator for the risk, uncertainty, and opportunity cost of capital inherent in the installation decision. Factors that increase expected revenues or decrease uncertainty and risk will accelerate installations; factors having the opposite effects will decrease installations.

- The decision to remove a platform is more tightly constrained. Economic and cash flow considerations may influence the timing of decisions at the margin, but regulations require structures to be removed within one year after production on the lease has stopped. Structures may be removed before that time if economic or technical factors so dictate, and operators may ask that removal be postponed, but the range of managerial discretion is much narrower than it is for installations.

* * * * *

Technological change is often divided into two broad categories: 1) evolutionary technological change– the steady refinement of techniques and equipment, and 2) revolutionary technological change– the sudden, sharp change brought about by completely new techniques and equipment. The first is always present to some degree as firms and their employees gain experience, but the second is by definition difficult if not impossible to predict and incorporate into long-

4.25 TD -0.4399 Tc

2. THE NUMBER OF OFFSHORE PLATFORMS ON THE GULF OCS

2.1 Installations

Since the first offshore structure was located in the OCS Gulf in 1942, 5,561 fixed structures[2] had been installed as of December 31, 1997. Over the same time period about 1,645 platforms had been removed leaving about 3,916 fixed structures that are currently operating**.** Approximately 77 percent of platforms were installed in water depth of less than 150 feet. In aggregate since 1942, 53 percent of fixed offshore structures installed on the OCS were non-major offshore structures. Thus, 47 percent of all OCS structures installed since 1942 are major oil and gas drilling and production platforms. The number of platforms installed annually on the OCS averaged about 101 between 1942 and 1997.

Data on the number of fixed offshore structures installed in the Gulf of Mexico OCS region are presented in Table 2.1 both by water depth and type of structure. Structures are classified as either major or non-major. Structures with at least six completions and two pieces of production equipment are major structures; all others are classified as non-major.

Table 2.1

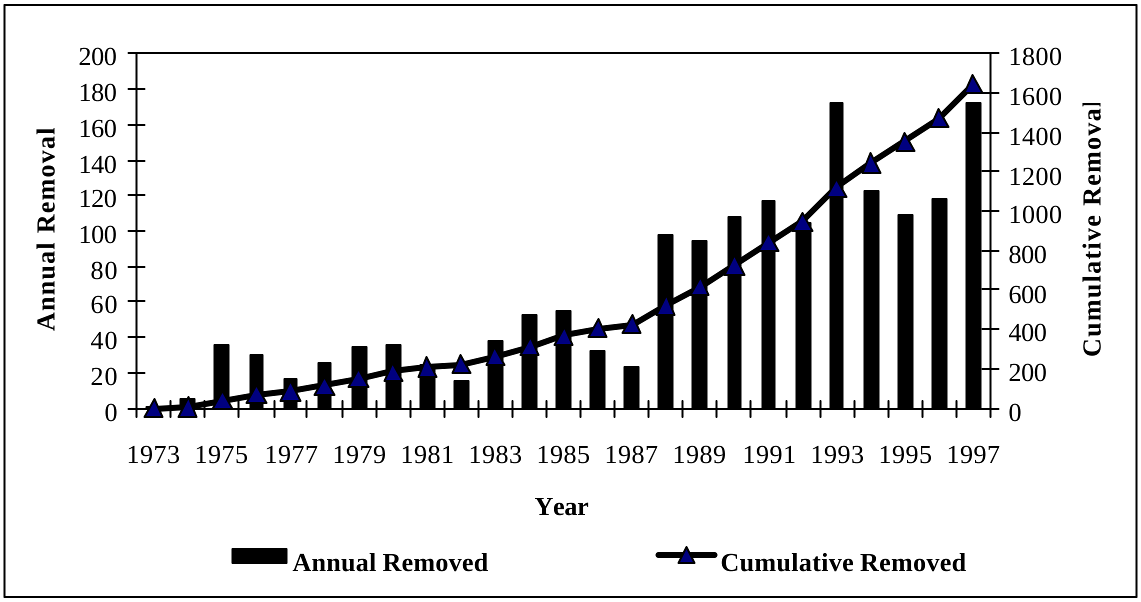
Number of Offshore Structures Installed by Water Depth and Type: Gulf OCS as of December 31, 1997

Depth Ranges	Major Structures	Non-Major Structures	All Structures
0 - 20	103	512	615
21-50	523	1,427	1,950
51-100	698	774	1,472
101-150	393	176	569
151-200	311	107	418
201-300	338	48	386
301-400	86	7	93
401-500	22	0	22
501-900	18	2	20
> 900	14	2	16
Total	2,506	3,055	5,561

[2] There are an additional 272 structures in the MMS data file. However, these are not included in the analysis because no installation date is indicated for these structures.

postponing removal include damage to the platform, services performed for other platforms such as pumping or processing, or planning or considering work overs or drilling at a new depth.

According to available data on platform removals, the first offshore structure was removed from the Gulf of Mexico OCS in 1973. To date (through 1997), 1,645 structures have been removed at an annual average rate of 65 removals. Figure 2.2 shows total platforms removed per year and the cumulative number of platforms removed in the Gulf of Mexico OCS region from 1973 through 1997. An unusually high number of offshore structures were removed in 1993 because of damage caused by Hurr 86c 0n udredwe removed in 1993



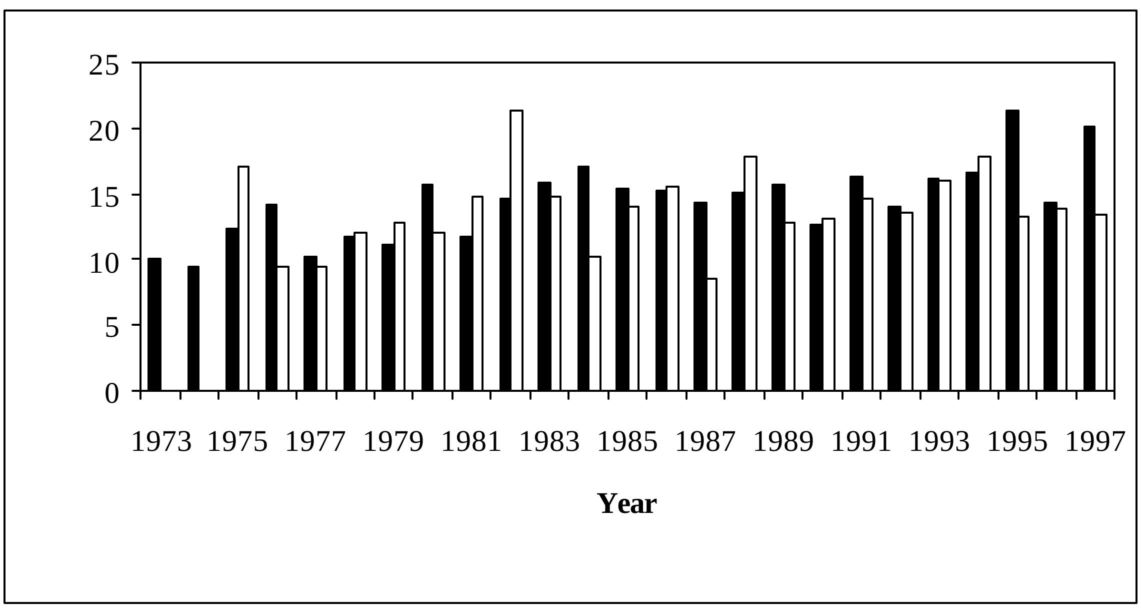


Figure 2.3. Average age of fixed offshore structures removed on the OCS, 1973-1997.

Table 2.2

Water Depth of Fixed Offshore Structures Removed on the Gulf of Mexico OCS 1973-1997

Depth Ranges	Non-Major Structures	Major Structures	All Structures
0-20	240	25	265
21-50	513	124	637
51-100	274	174	448
101-150	52	87	139
151-200	29	66	95
201-300	4	40	44
301-400	1	15	16
401-500	0	0	0
501-900	0	0	0
> 900	0	1	1
Total	1,113	532	1,645

2.3 Platforms in Operation

As of December 31, 199 0,6 nu0 TDof p95 Tw (AgrewAs oevery year e

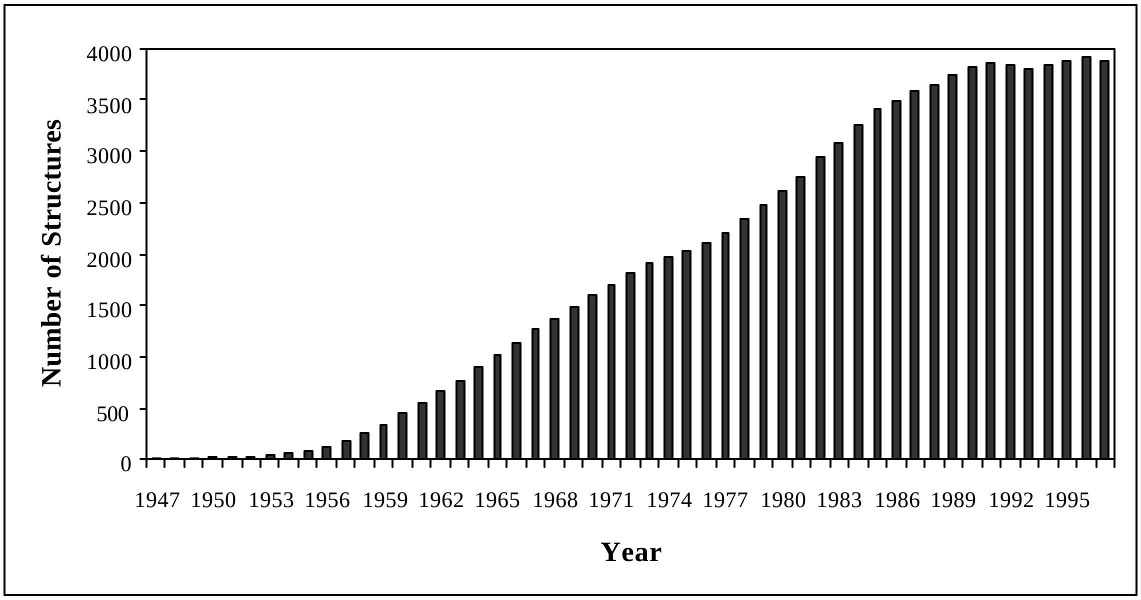


Figure 2.4. Existing offshore structures on the Gulf of Mexico OCS, 1947-1997.

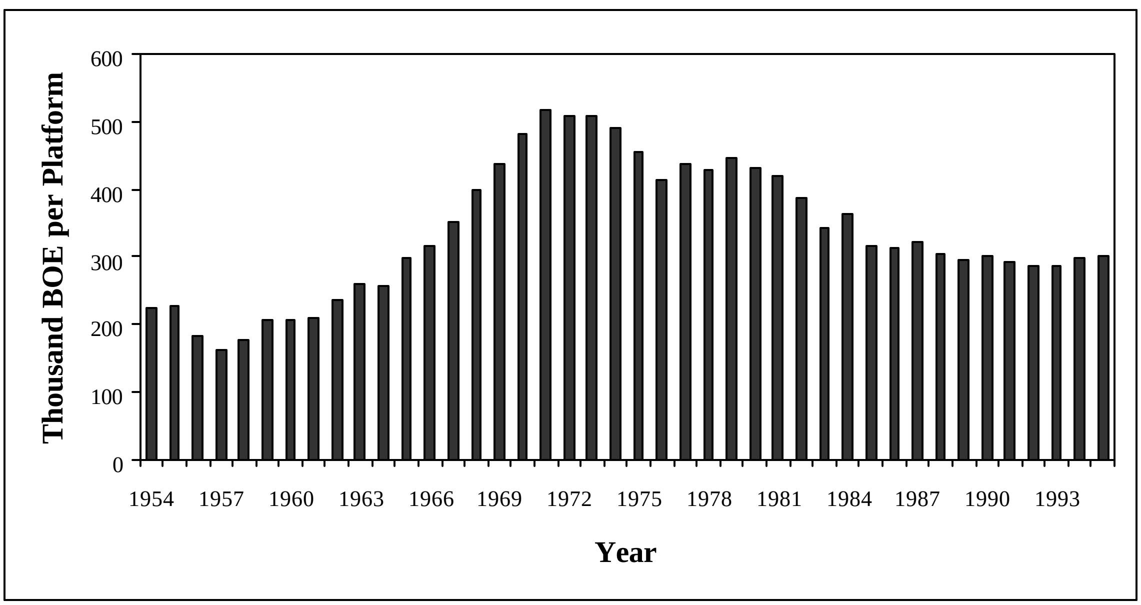


Figure 2.5. Production per operating platform on the OCS, 1954-1995.

Table 2.3

Figure 2.6. Average age of fixed non-major offshore structures operating on the OCS.

Figure 2.7. Average age of fixed major offshore structures operating on the OCS.

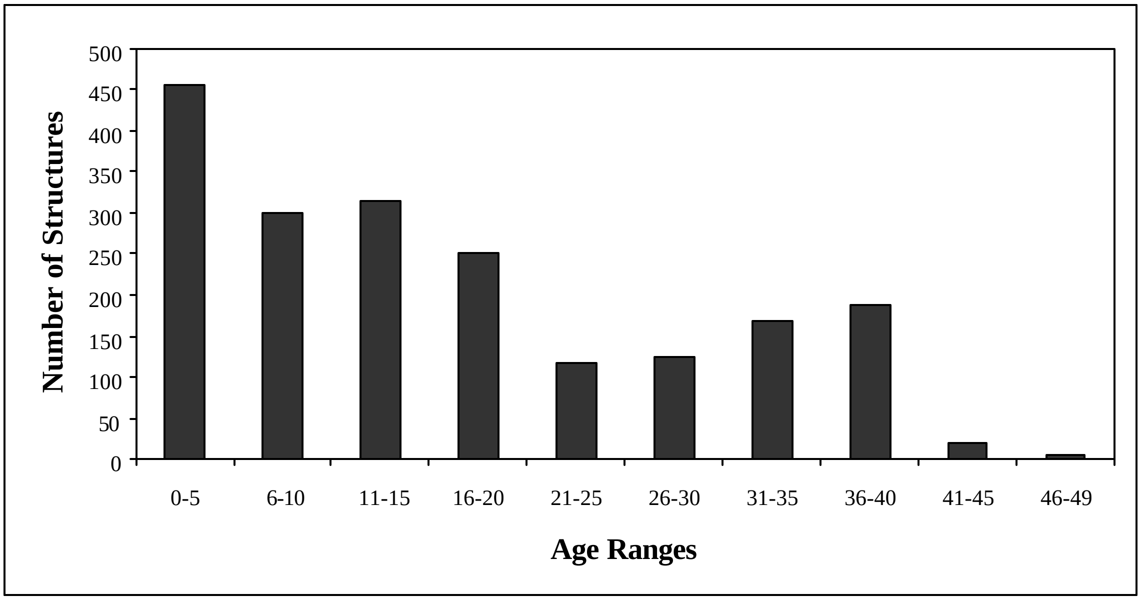


Figure 2.8. Age distributions of fixed non-major structures operating on the OCS in 1997.

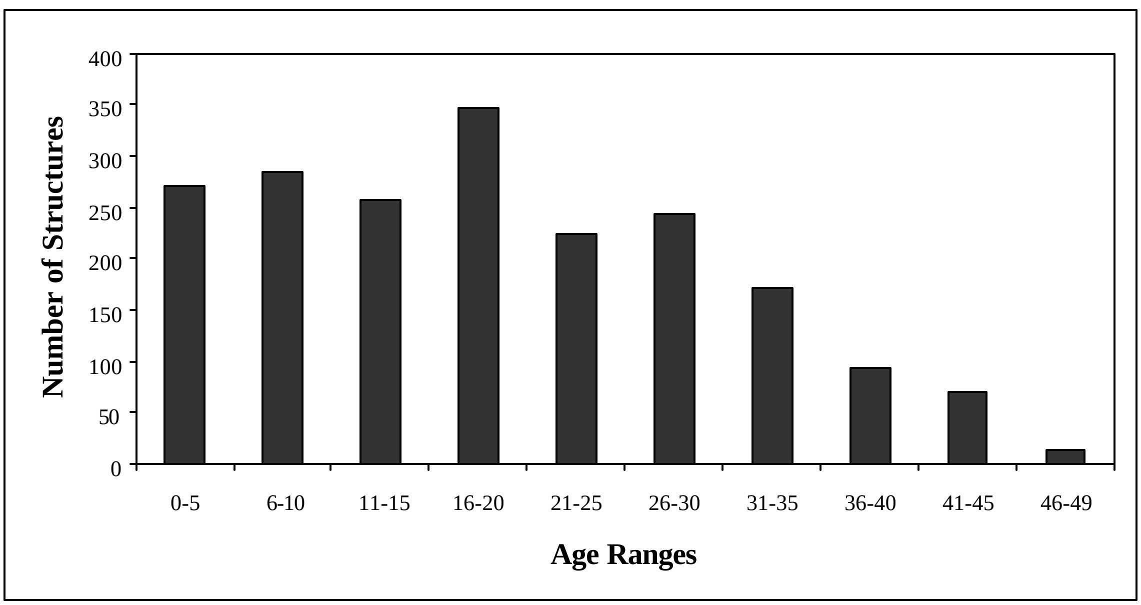


Figure 2.9. Age distribution of fixed major structures operating on the OCS in 1997.

2.4 Conclusions and Implications

- Since 1942, 5,561 platforms or structures had been installed on the OCS subject to federal jurisdiction.

- As of 1997, 1,645 of these structures had been removed leaving 3,916 operating platforms on the federal OCS.

- About 50 percent of the operating platforms are classified as "non-major" structures– defined as having fewer than six wells and no more than two pieces of equipment. The other 50 percent are classified as "major structures."

- About 68 percent of the structures that have been removed were non-major structures, and about 86 percent of the structures that have been removed were located in less than 400 feet of water

- Conversely, proportionately more larger platforms, located in deeper water, have been installed as time has passed.

- The number of operating structures has grown steadily since the i

- The decision to remove a platform is more tightly constrained. Economic and cash flow considerations may influence decisions at the margin, but regulations require structures to be removed by the end of one year after production on the lease has stopped. Structures may be removed before that time if economic or technical factors so dictate, and operators may ask that removal be postponed, but the range of managerial discretion is much narrower than it is for installations.

3. MODELING THE NUMBER OF OFFSHORE PLATFORMS ON THE OCS

To forecast the number of offshore structures to be operated on the Gulf of Mexico OCS over the next two decades, we make use of the arithmetic identity that the stock of operating platforms on the OCS in a given period can be estimated as cumulative platforms installed less cumulative platforms removed.

Symbolically, the above definition translates to an identity equation of the form:

$$OPP_t = OPP_{t-1} + INS_t - REM_t \qquad (3\text{-}1)$$

where:

OPP(t) is the number of operated platforms in time *t*
INS(t) equals number of installed platforms in time *t*
REM(t) represents the number of platforms removed in time *t*.

The definition set forth in equation (3-1) forms the basis for the modeling approach to forecasting the number of platform installed, removed, and operated on the OCS in this report.

3.1 Model Specification

According to equation (3-1), the number of platforms operated in a given period depends on the number of platforms removed and installed during the period, *ceteris paribus*. To use this identity to forecast, we have to be able to model and forecast those factors that explain platform installations and platform removals. For the sake of simplicity it is assumed that a platform installed in a given period on the OCS becomes operational during that period. Also assumed is that the number of removed platforms in a given year is some function of the stock of operating platforms at the end of the previous year as well as the age of the platform.

The number of platforms removed in year *t* can be expressed the sum of the proportion of platforms installed in previous periods that were removed in the current period.

Symbolically we may represent this proposition as follows:

$$REM_t = \Sigma (\alpha_j * INS_{t-j}) \qquad (3\text{-}2)$$

where:

α_j represents the proportion of platforms removed in year *t* that was installed in year *t-j* such that 0 # α_j # 1 and *j* represents the age of removed platform.

Platforms are installed for the purpose of developing and producing discovered oil and gas reserves. As firms explore for and discover new fields they will install new platforms to produce oil or gas from them, *ceteris paribus*. This relationship would not be questioned by oil industry veterans, but skeptics might argue that the two are merely associated with a third factor that the analysts has missed, or, perhaps, that the association is in some strange way the reverse of that postulated, i.e., installing platforms may cause new oil and gas fields to be found rather than the reverse.

Fortunately, an econometrician has developed statistical tests of causation, termed "Granger causality," to clarify such situations. Causality defines a condition of feedback or the presence of a feedback of one variable to another, and by implication Granger non-causality defines the absence of such a feedback. In our case, our hypothesized relationship between the discovery of new fields and the installation of platforms passes the "Granger causality" tests.[4]

However, because of short-run changes in the petroleum economy and political environment, and perhaps other determinants such as structural changes in the industry, the number of planned platforms or offshore structures to be installed in the Gulf of Mexico OCS region may not be fully accomplished in a given period.

Thus, to include such factors, the functional equation describing platform installation behavior is specified as follows:

$$INS^*_t = \beta_0 + \beta_1 \log(CFZ_t) + \beta_2 CPR_t + \beta_3 TEK_t + \beta_4 D86 + \varepsilon_t \quad (3\text{-}3)$$

where:

β_i (i=0,1,2,3,4) are constant parameters to be estimated
INS^*_t = desired or planned number of installations in period *t*.
CFZ_t = cumulative total field size at the beginning of period *t*
CPR_t = the average current crude oil price on the Gulf OCS
TEK_t = time trend as a proxy for technical progress
D86 = dummy variable, such that, D86 = 1 for time period after 1986 and zero otherwise
ϵ_t = independent random error term

The dummy variable D86 is included to capture the effects of changes in expectations and behavior of the oil and gas industry in the Gulf of Mexico OCS subsequent to the collapse of the world crude oil market in the summer of 1986.

The short run adjustment process can be measured using the following partial adjustment model specification:

$$INS_t - INS_{t-1} = \lambda(INS^*_t - INS_{t-1}) + \omega_t \quad (3\text{-}4)$$

[4] A pair-wise Granger causality test showed that cumulative field size measured in million barrels of oil equivalent does seem to Granger-cause the number of platforms installed to vary as postulated at the 90 percent significance or confidence level. The test also showed that, at nearly the 99 percent level of significance, the natural logarithm of cumulative field size does Granger-cause the number of platforms installed to vary. Having failed to reject the null hypothesis that the number of platforms does not Granger-cause either cumulative field size or the logarithm of cumulative field size, it is very plausible that past values of the logarithm of cumulative field size should be able to help predict future values of the number of platforms installed. See, Kennedy (1992)

where:

λ represents the rate of response of the change in installed platforms to the difference between the desired installations and past value of installed platforms such that 0 # λ $ 1, and ω = independent random error term.

Conceptually, equation (3-4) measures the proportion of adjustment to the desired number of platforms achieved within a year. The error term ω measures the failure of the adjustment process to accomplish the desired number of platforms.

Substituting equation (3-4) into equation (3-3) and simplifying the new equation yields an equation describing the relationship between the number of platforms installed (or to be installed) and its determinants.

$$INS_t = \lambda\beta_0 + \lambda\beta_1 \log(CFZ_t) + \lambda\beta_2 CPR_t + \lambda\beta_3 TEK_t + \lambda\beta_4 D86 + (1-\lambda)INS_{t-1} + \lambda\varepsilon_t + \varpi_t \quad (3\text{-}5)$$

If $\pi_i=\lambda\beta_i$, then −5)2 $\lambda\beta_4$ 236Φ 0.375 TΩ (236Φ 0.375 1.5 TΔ /Φ0 12 238 0.119 Tχ (XΠ5) Tφ 22.5 −1.5TfN the importance of independent operators, an increase in reliance on contract services, and the adoption of less hierarchical decision-making as well as technological innovations (Bohi, 1997). The likely effect of these changes on platform installation on the OCS is examined by including an interaction between the 1986 dummy variable and time trend such that the interactive dummy equals 1 from 1986 forward and 0 otherwise.

Econometric models were also estimated for platform removals, but in our view these did not result in as credible forecasts as the statistical technique used in our reference forecast. These econometric forecasts predicted near equality between installations and removals and, thus, little change in the number of operating platforms. One reason for this may have been the much shorter and more variable data series on removals compared with installations. However in our view these “constant-platform" forecasts did not seem consistent with industry trends**.**

3.2 Estimated Platform Installation Equation

The Ordinary Least Square (OLS) estimation results for equation (3-6) are presented in Table 3.1[5]. Equation (3-6) is a linear-log model. The general expectation from our model specification using the linear log function is that the greater the size of new fields, the larger the number of platforms to be installed, but the increase in platform installation occurs at a declining rate with cumulative size of new field additions.

Overall, the model results explain nearly 80 percent of the variation in the values of the dependent variables. The point estimate of the coefficient of the lagged value of the dependent variable is 0.463, making the adjustment coefficient 0.537. Thus we expect that firms, on average, achieve about 54 percent of their desired or planned number of platforms to be installed within a given year according to our results.

The parameter estimate for the variable representing the economic environment– the average current price of OCS crude oil– is positive as expected. Therefore, we conclude that a favorable economic environment, according to our model, leads to a statistically significant increase in the number of installed platforms. The short run price elasticity of platform installation on the OCS is estimated as 0.25; and since the adjustment coefficient is 0.537, the long-run price elasticity of platform installation by our model estimate is approximately 0.46. This means that a 10 percent increase in the current average price of OCS crude oil will lead to about 4.6 percent increase in cumula5 0 TD -0.3694 TTc 4.8222 Tw5 0 Tlts.

The results show that cumulative field size is an important determinant of the number of platforms installed. As expected, the coefficient is positive and statistically significant at the 99 percent significant level. However, the short run and long run elasticity of cumulative reserves is on average significantly less than unity.

The empirical result is consistent with our expectation that since 1986, platform installation did decrease as a result of structural changes in the industry, deep water drilling techniques and completion technology. However, the point estimate of the interactive dummy included in the regression to capture the effects of technology and institutional changes, although negative as expected, is not statistically different from zero.

Figure 3.1 shows that the prediction using equation (3-6) presented in Table 3.1 tracks the actual trend in platform installation very closely.

Table 3.1

OLS Estimates of the Platform Installation Model (t-statistics in parenthesis)

Variable	Coefficient
Intercepts	-113.931
	(-2.847)
Cumulative New Fields (CFZ)	16.618
	(3.118)

3.3 Platform Removal Equation

The statistical equation applied in this paper for predicting platform removals is a reduced form of equation (3-2) reproduced below in an estimated form as equation (3-7):

$$REM_t = 0.953INS_{t-33} + 0.351INS_{t-21} \qquad (3\text{-}7)$$

Of the several alternative forms of equation (3-2) that we examined, equation (3-7) yields the best statistical fit to the available historical data on removed platforms.[6]

In order to model the physical reality in which only installed platforms can be removed, we selected a specification with a suppressed intercept. Thus, when values for both independent

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[6] For every observation in the series (1947-1997), new variables were created. These variables represented consecutive lags for the installed platforms. For example, lag_1 for 1948 contains platforms installed in 1947; lag_2 for 1950 contains platforms installed in 1948, and so forth. In certain cases, statistical software created missing values. For example, lag_2 for 1948 is a missing value, because there were no platforms installed in 1946. All missing values were substituted with zeroes. Then, a step-wise OLS regression were performed with the annual number of removed platfoms as a dependent variable and 40 lags (lag_1, lag_2,..., lag_40) of installed platforms as independent variables. Out of the 40 independent variables, the step-wise regression procedure selected, based on the resulting R square, ten be TQepall ical for

variables are set to zero, the value for the dependent variable is also equal to zero. The final relationships estimated in the equation state that 95.3 percent and 35.1 percent of platforms installed in year (t-33) and (t-21), respectively, are removed in year *t*.

The above estimated removal equation is obtained using statistical method that lacks the conceptual foundation that the forecasting equation for platform installations enjoys. But, the model explains more than 95 percent of the observed variation in platform removal. Parameter estimates of the independent variables are also statistically significant. However, the mean absolute percent error and the root mean square percent error of the predicted values are a high 22 and 21 percent, respectively. Figure 3.2 plots the actual and predicted number of removed platforms for the period 1947 - 1997.

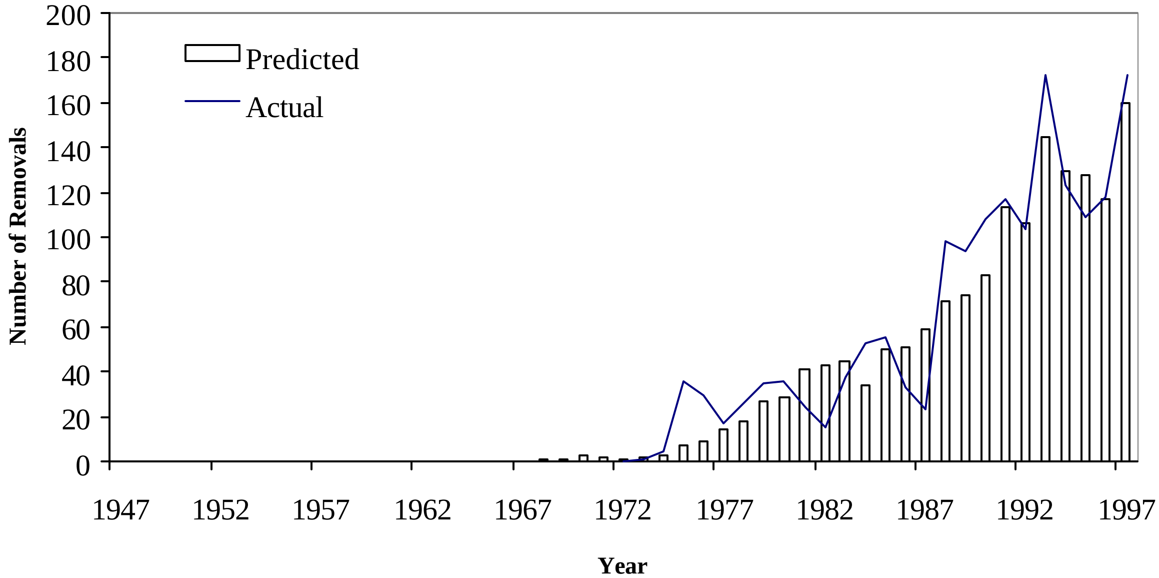
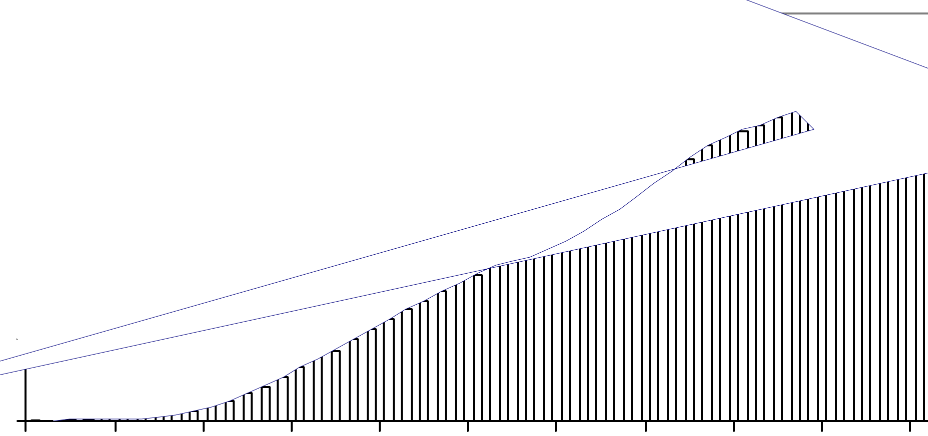


Figure 3.2. Actual and predicted number of platform removals.

ting Operating Platforms

quations (3-6) and (3-7) in combination with the identity equation (3-1), predicted platforms can be calculated. Figure 3.3 shows a pictorial view of the ting platforms over the period for which we have data. The predicted uite well, with the moving average percent error (MAPE) for nt while the root mean square is approximately 4.48



4. FORECASTING THE NUMBER OF OPERATING PLATFORMS

The model results presented in Table 3.1 were used to generate annual forecasts of the number of platforms installed for the period 1999-2023. The values assumed for all the parameters and variables used to forecast platform installations are reported in Table A.1 in Appendix A. Equations (3-6) and (3-7) were subsequently applied to calculate future removals and installations, and the corresponding number of platforms operating annually was estimated using familiar precept that the largest fields in a region tend to be found first, with smaller fields discovered later (Arps and Roberts, 1958, and Attanasi and Haynes, 1983).

Maximizing equation (4-1) with respect to WELLS yields a drilling plan:

$$\text{WELLS}^* = \text{fn}(\text{NOP, SUCC, SIZE, NTLL}) = \text{fn}(\text{NOP, NTLL, WILDT}) \qquad (4\text{-}2)$$

where:

WELLS* = optimal number of new wild cat wells drilled;
NTLL = number of tracts leased in the previous period.

This is called the drilling model and can be made operational by recursively predicting the next period's drilling activity from the previous period's cumulative wild cat wells drilled, discovery size, and discovery probability, *i.e.*, the success rate from the previous period's drilling. Firms operating in the Gulf of Mexico are not entirely free to drill anywhere, however, so the number of tracts leased in the previous period is also included in the model. This is also assumed to be exogenous in each lease sale.

Following Arps and Roberts (1958), it is assumed that for any given size class of field, the probability of field discovery is directly proportional to the number of undiscovered fields remaining in that class in the region and to the ratio of the average surface area of fields in that class to the overall area of the region. Attanasi and Haynes (1983) achieved good predictive results for estimating the number of undiscovered fields remaining in a size class by using the following analytical form as an estimating equation for fields (the discovery model):

$$\text{Fi(WILDT)} = \text{Fi}(4)(1-\text{EXP}(-(\text{Ci.Ai.WELLS})/\text{B})) \qquad (4\text{-}3)$$

where:

Fi(WILDT) = the cumulative number of fields in size class *i* expected to have been discovered after drilling WILDT exploratory wells;
Fi(4) = the ultimate (unknown) number of fields in size class i;
B = the area of the region;
A = the average area of the fields in size class i;
Ci = a parameter representing the efficiency of discovery of fields in size class i;
Fi(4) and Ci are parameters to be estimated using observations on the other variables.

There is a factor that complicates the implementation of equation (4-3). Generally, only those fields large enough to be economically viable are reported. Smaller fields may have been found but not reported, hence they would not be included in the data used to estimate equation (4-3). Attanasi and Haynes referred to this problem as economic truncation and noted that it could cause biased estimates of Fi(4) and Ci for those size classes in which economic truncation occurs.

The work of Drew, et al. (1982) is useful in addressing this problem. Based on observations of highly developed regions, they proposed that field sizes are distributed log-normally. They determined the largest size class which exhibits economic truncation as the class for which discovery rates did not significantly decline with time in the study region. They use as the estimate of Fi(4) for that size class the estimated ultimate number of fields of the next larger size class, Fi(4), multiplied by 1.65 (Drew, et al., 1982, pp. 17-22).

For size classes that exhibit economic truncation, it is only necessary to estimate the efficiency of

Table 4.1

Drilling Model Results (t- statistic in parenthesis)

Variable	Coefficient
Intercept	-14.473
	(-0.74)
Size (SIZE)	0.3342
	(1.830)
Success Rate (SUCC)	236.80
	(3.940)
Number of Tracts Leased (NTL)	0.0812
	(6.920)
Net Operating Profit (NOP)	4.7866
	(5.740)

Observations	49
AIC	213.470
SBC	221.419

Table 4.2

Discovery Model Results

Class	Size Range (MMBOE)		Known Fields	Estimated Total	C, (95% CI)
	Upper	Lower			
18	777.2	388.6	9	9	1.97 (0.1 - 6.4)
17	388.6	194.3	31	35	2.00 (0.3 - 3.7)
16	194.3	97.2	75	80	1.00 (0.6 - 1.4)
15	97.2	48.6	84	118	1.00 (0.6 - 1.4)
14	48.6	24.3	117	169	1.00 (0.6 - 1.4)
13	24.3	12.14	143	213	1.00 (0.5 - 1.5)
12	12.14	6.07	121	188	1.00 (0.1 - 2.2)
11*	6.07	3.04	127	200	1.00**
10	3.04	1.52	96	329	1.00
9	1.52	0.76	44	544	1.00
8	0.76	0.38	33	897	1.00
7	0.38	0.19	19	1480	1.00

* Truncation begins at Class 11
** lower bound

4.2 Forecasting Model Variables

4.2.1 New Fields: Forecasting results for the base case, assuming that NOP is constant and that the number of tracts leased is constant, are reported in Table 4.3. The results are consistent with *a priori* expectations that the average size of new discoveries will decline as drilling proceeds. The success rates may seem somewhat low, but this is a result of using data from 1970 to 1993. Higher success rates are a relatively recent phenomenon, thus are not heavily weighted in the data.[7] The drilling and discovery sub-models yield estimates of new fields rather than our objective, new platforms.

4.2.2 Wellhead Price: The U.S. Department of Energy's Energy Information Administration (EIA) forecasts wellhead prices for crude oil in the lower 48 states under three scenarios: reference, high, and low prices (Annual Energy Outlook,1997, p 57). Based on EIA's forecasts of a declining (but positive) growth rate for both oil prices and economic growth (AEO, 1997, p 76), the reference price growth rates we calculated for the periods 2000-2005, 2006-2010, and 2011-2023 are 1.34%, 0.69%, and 0.55%, respectively.

To capture the uncertainties in the oil prices so as to examine the price impact on the number of operating platforms correspondingly, we used EIA's projection of high and low prices to calculate the high and low boundaries of expected prices. This is done in a similar manner to the method used to calculate the variations for new field size, *i.e.*, take the standard error of the EIA low price forecast and subtract two standard errors from the low forecast and add two standard errors to the high price forecast.

4.3 Operating Platform Forecasts and Analysis

4.3.1 The Reference Case Forecast: The reference forecast, or the forecast that in our view is the most likely, is summarized in Table 4.4.

During the forecast period the forecast calls for new platforms to be installed at an annual rate of about 142 platforms per year. Over the 25-year period, 3,543 platforms would be installed. Figure 4.1 illustrates the installation forecast and compares it to the historical record.

The number of platforms forecast to be removed is illustrated in Figure 4.2. A total of 4,645 platforms are forecast to be removed, which is an approximate annual rate of about 186 over the forecast period.

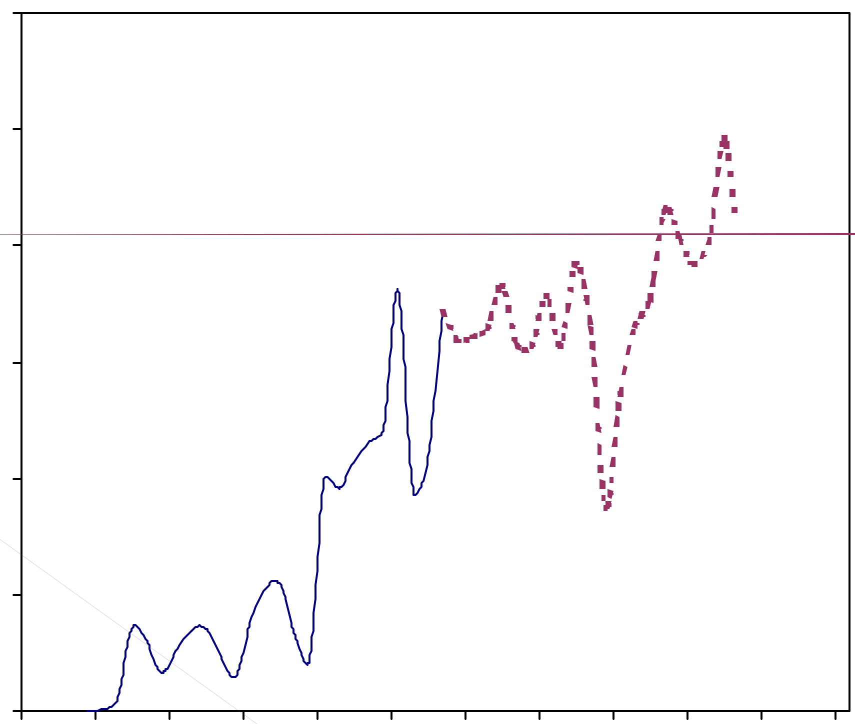
The number of platforms forecast to be operating in each year is shown in Figure 4.3. Operating platforms are predicted to decrease in number from 3,687 in 1999 to 2,612 in the year 2023. This is a decline of 1,075 or about 29 percent.

[7] The consequences of higher success rates are discussed in the following section.

Table 4.4

Reference Case Forecasts of the Number of Platforms to be Installed, Removed, and Operated on the Gulf of Mexico OCS, 1999 - 2023

Year	Platforms Operating	Platforms Installed	Platforms Removed
1999	3,687	137	165
2000	3,642	138	183
2001	3,623	138	158
2002	3,605	139	157
2003	3,566	140	178
2004	3,550	140	157
2005	3,498	141	193
2006	3,475	141	165
2007	3,529	142	87
2008	3,534	142	136
2009	3,510	142	166
2010	3,475	142	177
2011	3,402	142	215
2012	3,342	143	203
2013	3,292	143	192
2014	3,233	143	202
2015	3,130	143	246
2016	3,064	143	208
2017	2,957	143	251
2018	2,855	143	245
2019	2,849	143	149
2020	2,834	143	158
2021	2,772	144	206
2022	2,682	144	234
2023	2,612	144	214



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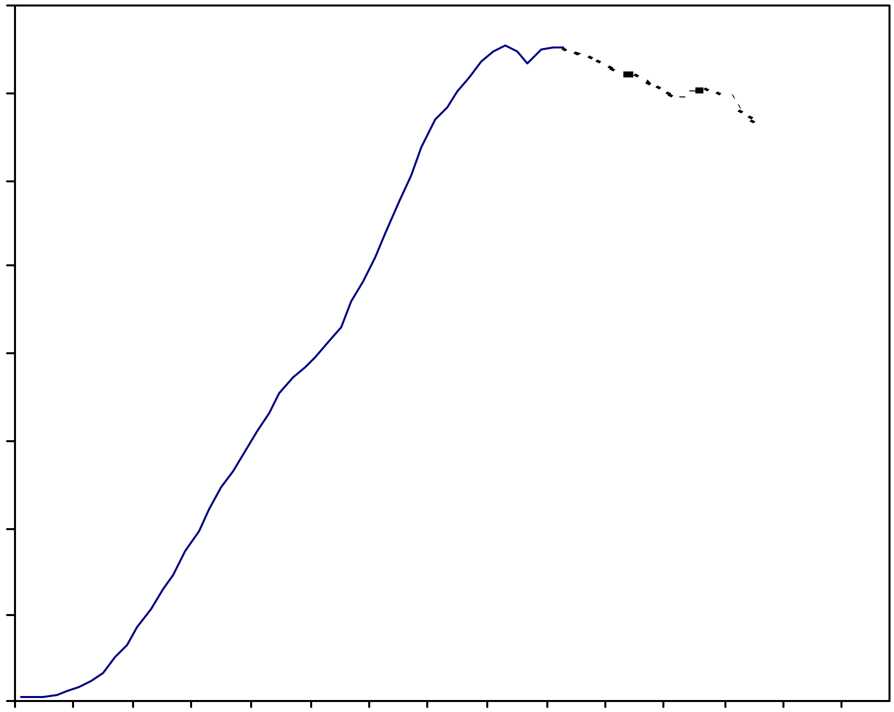


Table 4.5

Summary of Differences Among Reference and Alternative Forecasts 1999-2023

	FORECAST ASSUMPTIONS			
	Reference	EIA High & Low Prices	High New Field*	EIA & New Field Plus**
Platforms in 2023--High	18.91	16.15	15.96	15.76
Percent > Reference 2023	19.48	16.72	16.39	16.05
2023 as percent of 1999	20.38	17.62	17.05	16.51
Platforms in 2023--Low	21.12	18.36	17.64	16.92
Percent > Reference 2023	21.55	18.80	17.99	17.16
2023 as Percent of 1999	21.70	18.94	18.09	17.22

Source: See Appendix A. *High New Field is New Field plus 2 Std. Errors. **EIA and New Field Plus is EIA high price plus 2 Std. Errors and New field plus 2 std. errors. Note: Std. Errors are deviations in EIA and Field forecasts.

Conversely, high prices are unlikely to result in a major acceleration in installations of platforms. Over the past thirty years operators have repeatedly seen high prices erode as low cost producers increase production from already developed fields. Similarly, they have seen costs of installing platforms rise as day rates for drilling platforms and ships are bid up. They have learned to expect prices to increase and decrease over a cycle and are unlikely to make major changes in investment plans because of short-term price fluctuations.

As Table 4.5 shows, substituting the high new field discovery series for the reference forecast of new fields would increase the number of operating platforms in the year 2023 by 66 and reduce the decline in the number of operating platforms over the 2000 to 2023 time period from 28 percent in the reference forecast to a little less than 26 percent. The low forecast of new fields would decrease the number of platforms operating by 48 and increase the percentage drop over the time period to 29.5 percent.

Using EIA's high or low forecasts of oil prices, rather than its reference forecast, results in similar, marginal changes in the platform forecast. Comparing in the year 1999 and the year 2023, the high EIA price forecast would increase the number of platforms operating in 2023 by 60 platforms over the reference forecast. The low price forecast would predict 91 fewer operating platforms. The decline in operating platforms would be about 26 percent in EIA's high price scenario and about 30 percent in low price case–compared to a decline of 28 percent in the reference case. Figure 4.4 shows the effects of adding two standard errors to EIA's oil price forecasts. Figure 4.5 illustrates the effects of the change on the platform forecast.

The third alternative case summarized in Table 4.4 is one in which both the oil price forecasts and the new field forecast are increased by two standard errors in the high cases and decreased by two standard errors in the low cases. In simpler terms, this means the price forecast was increased enough that statisticians would be confident that ninety-five percent of the time the actual price would be below (in the high price case) or above (in the low price case) the corresponding EIA price.

Under these assumptions, the number of operating platforms in the year 2023 is about 12.5 percent higher than the reference forecast and about 10 percent lower in the low price case. The decline in the number of operating platforms over the 2000 to 2020 period is slightly less than 20 percent in the high price case and 35 percent in the low price case compared to the 28 percent drop in the reference forecast.

Figure 4.6 compares the effects of the change to the reference forecast. The year-by-year forecasts for each of the alternatives summarized in Table 4.4–giving platforms installed, operating, and removed–are in Appendix A. Also included in the appendix is a table giving the oil prices assumed in the reference and alternative forecasts.

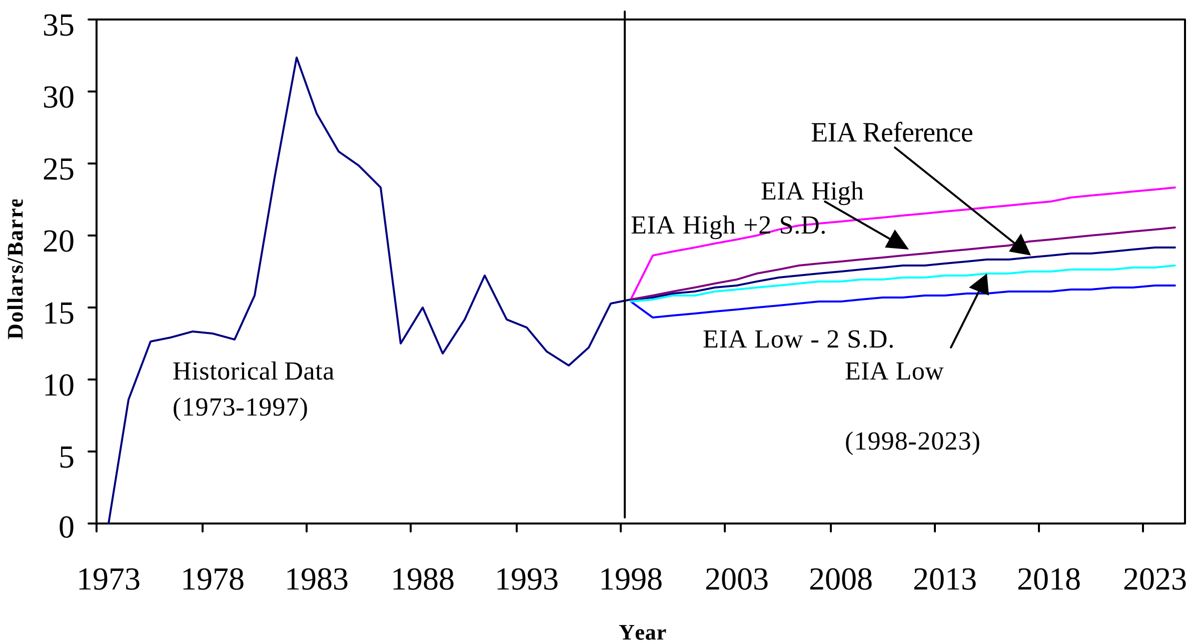
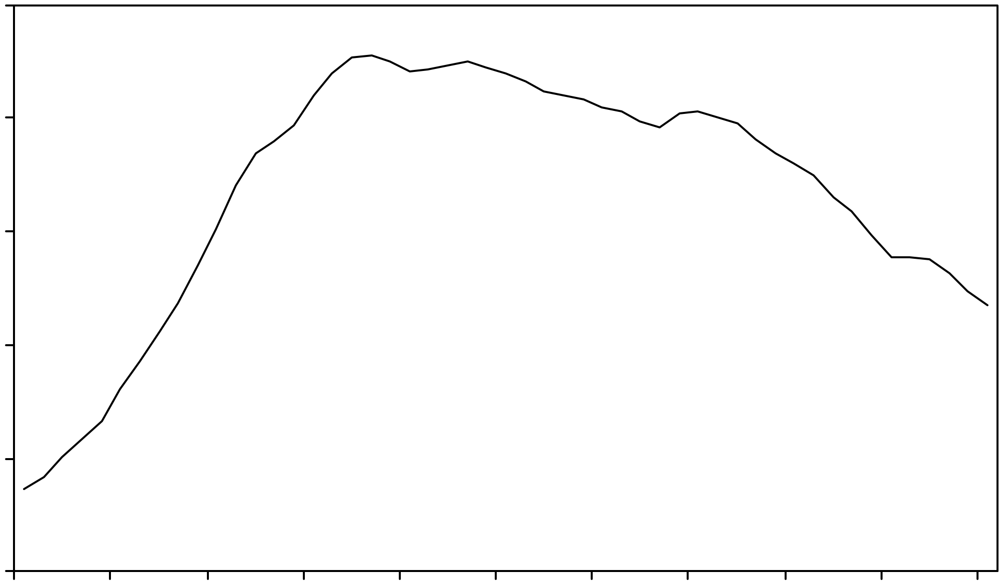


Figure 4.4. Predicted prices relative to EIA reference price.



5. SUMMARY AND CONCLUSIONS

The total number of oil and gas platforms located in the federal or OCS part of the U.S. Gulf of Mexico is forecast to begin a slow but steady decline over the first quarter of the next century. The plateau of about 3,600 structures that was reached and maintained during the 1990s is a peak, according to the forecast, and the drop-off-period for the decline.

By the year 2023 the number of platforms in the Gulf is forecast to be roughly 2,600, a drop of 1,075 platforms for a total that will be about 29 percent below the current peak. Alternative forecasts made by changing the values of the forecasting variables did not result in major differences from the reference forecast. Even spreading the range of the values used in the forecasting equations by adding two standard errors to forecasting variables did not reverse the trends in the reference forecast. Adding or subtracting two standard errors to the cumulative size of new oil and gas field developed in the Gulf and to the Energy Information Agency's forecast of oil prices resulted in forecasts in which the decline in operating platforms in high forecast was still more than 20 percent, as compared to 29 percent in the reference forecast. The decline in the corresponding low forecast was about 35 percent.

According to the reference forecast– the following predictions can be made:

- The number of platforms operating in the Gulf will decline as the result of an increase in the annual number of platforms removed over historical levels while the number of new platforms installed each year will increase very slowly. This is the reverse of the historic pattern in which removals have usually fallen short of installations, producing an increase in the number of operating platforms.

- The number of platforms installed annually will increase from an estimated 138 in the year 2000 to 144 in the year 2023, which is not much different than the average over the 1990s. The number of platforms annually removed from the Gulf OCS will move more irregularly than installations, varying from a low of 87 in 2007 to a high of 246 in the year 2015. These annual numbers are given only to indicate range–our methods and objectives are designed to forecast longer-term trends, not precise, yearly magnitudes or changes. A principal reason for the variation is that the removal forecast is driven by the number of installations in previous years. As the forecast encounters unusually high or low numbers of historical installations, the removal estimate changes accordingly. The forecasts of installations and removals were made separately with different methods.

- Installations were estimated using an econometric model driven by estimates of the rate of discovery of new petroleum fields and the size of those fields, technological trends in petroleum exploration and production, prices for crude oil, and the shock of the oil price collapse in the mid-1980s. The estimating equation had the "correct" signs , *i.e.*, was consistent with our hypotheses and explained about 79 percent of the variation in platform installations.

- Platform removals were estimated with a purely statistical approach that measured the association between the number of platforms removed and the number of platforms installed in each previous year. Doing this interactively for each year's (1947 to 1997) removals and all preceding year's installations enabled us to pick the number of years (referred to as "lags") in which the number of installations is most closely associated with the number of removals so many years in the future. The best model from a forecasting viewpoint predicted removals based on the number of platforms installed, or lags, of 32 and 21 years in the past. The estimating equation for platform removals explained about 95.2 percent of the variation in the historical data on removed platforms.

The reference forecast, despite its hybrid ancestry, fits fairly well with current industry trends and opinion, although longer term forecasting is not a topic to which the industry has paid much attention. Nevertheless, a common industry view is that as exploration and production move into the deep (and deeper) Gulf, larger and more complex platforms will be installed. This, when coupled with advanced seismic imaging and directional drilling, means that more wells can be drilled from a single platform. On the other side, these same factors also make feasible the production of smaller fields in shallow and intermediate depth waters with smaller, simpler and frequently re-used platforms. Indeed, as discussed earlier, although about 80 percent of the approximately 1,500 platforms removed from the Gulf were non-major structures (major structures having at least six completed wells and two pieces production equipment) about 25 percent of the smaller, non-major structures were less than five years old. But the net result, in our view, is that shown in the reference forecast– a slow but steady decline in the number of platforms operating in the federal OCS Gulf of Mexico.

A slow and steady decline in the number of platforms does not necessarily imply a decline in oil and gas production or less economic activity related to the development of the offshore. Indeed, production per platform has increased since the early 1990s. As more and more production comes from the very large deep Gulf wells, we expect this trend to continue. Similarly, with the number of installations increasing, albeit very slowly, and expenditures to install each platform increasing as the proportion of larger platforms located in deeper waters grows coupled with a significant increase in the number of platforms removed, economic activity associated with offshore oil and gas exploration and production is likely to increase.

6. REFERENCES

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Table A.1
Estimated Values of Model Variables and Parameters Used to Forecast the Number of Platforms Installed from 1998-2023

Year	Wildcats Wells	New Fields #	Field Size (MMBOE)*	Success Rate	Avg. Well Head Price (Dollars/Bbl)
1998	110	18	24.5	0.16	15.74
1999	114	14	15.4	0.12	15.96
2000	101	14	13.1	0.14	16.17
2001	104	12	16.9	0.12	16.38
2002	100	12	21.0	0.12	16.61
2003	103	13	34.8	0.13	16.83
2004	109	14	12.4	0.13	17.05
2005	102	11	17.6	0.11	17.28
2006	99	12	14.2	0.12	17.40
2007	101	10	15.2	0.10	17.52
2008	96	11	21.7	0.11	17.64
2009	102	11	14.6	0.11	17.77
2010	98	10	14.8	0.10	17.89
2011	96	10	38.4	0.10	17.99
2012	105	11	13.9	0.11	18.06
2013	97	8	9.3	0.08	18.19
2014	90	10	14.8	0.11	18.29
2015	98	7	5.4	0.07	18.39
2016	86	9	16.2	0.10	18.49
2017	97	9	8.8	0.09	18.59
2018	92	9	16.4	0.10	18.69
2019	96	8	4.9	0.08	18.80
2020	89	9	16.2	0.10	18.90
2021	97	8	9.3	0.08	19.00
2022	90	6	1.8	0.07	19.11
2023	84	9	32.3	0.11	19.22

* Million Barrels of Oil Equivalent

Table A.2

Crude Oil Price Forecasts. EIA's High, Low, and Reference Forecast; EIA's High Plus Two Standard Errors (High-Plus); and EIA's Low Forecasts Minus Two Standard Errors (Low Minus) for the 1999 - 2023 Period

Year	High Plus	EIA High	EIA Reference	EIA Low	Low Minus
1999	18.91	16.15	15.96	15.76	14.41
2000	19.19	16.43	16.17	15.91	14.55
2001	19.48	16.72	16.39	16.05	14.70
2002	19.77	17.02	16.61	16.20	14.85
2003	20.07	17.32	16.83	16.35	15.00
[redacted]	20.38	17.62	[redacted]	16.51	15.15
[redacted]	20.69	17.93	[redacted]	16.66	15.30
[redacted]	20.83	18.07	[redacted]	16.75	15.39
[redacted]	20.97	18.21	[redacted]	16.83	15.48
[redacted]	21.12	18.36	[redacted]	00617	

[redacted]

[redacted]

Table A.4

Table A.5
Alternative Forecasts of High(Case I), Low (Case III), and Reference (Case II) Forecasts of New Field Discoveries and the Reference Price Forecast

Year	Platforms To Be Operated			Platforms To Be Installed			Platforms To Be Removed
	Case I	Case II	Case III	Case I	Case II	Case III	
1999	3,690	3,687	3,680	136	137	135	165
2000	3,644	3,642	3,634	137	138	137	183
2001	3,624	3,623	3,615	138	138	138	158
2002	3,607	3,605	3,598	139	139	139	157
2003	3,569	3,566	3,559	140	140	140	178
2004	3,552	3,550	3,542	140	140	141	157
2005	3,501	3,498	3,490	141	141	141	193
2006	3,477	3,475	3,467	141	141	141	165
2007	3,532	3,529	3,521	142	142	142	87
2008	3,539	3,534	3,526	142	142	142	136
2009	3,516	3,510	3,502	143	142	142	166
2010	3,482	3,475	3,467	143	142	142	177
2011	3,410	3,402	3,393	143	142	142	215
2012	3,351	3,342	3,332	143	143	142	203
2013	3,302	3,292	3,282	143	143	142	192
2014	3,244	3,233	3,223	143	143	142	202
2015	3,141	3,130	3,119	143	143	142	246
2016	3,076	3,064	3,053	143	143	143	208
2017	2,969	2,957	2,945	144	143	143	251
2018	2,868	2,855	2,843	144	143	143	245
2019	2,864	2,849	2,837	144	143	143	149
2020	2,850	2,834	2,821	144	143	143	158
2021	2,788	2,772	2,759	144	144	143	206
2022	2,698	2,682	2,668	144	144	143	234
2023	2,628	2,612	2,598	144	144	143	214

Note: Case I: Reference new fields plus two standard errors; Case II: Reference new fields; Case III: Reference new fields minus two standard errors.
Prices are kept at the reference case.

Table A.6
Predicted Number of Platforms to be Installed, Removed, and Operated with Both Price and New Fields Increased by Two Standard Errors (Case I) and Both Variables Decreased by Two Standard Errors (Case III) on the Gulf of Mexico OCS, 1999 - 2023