

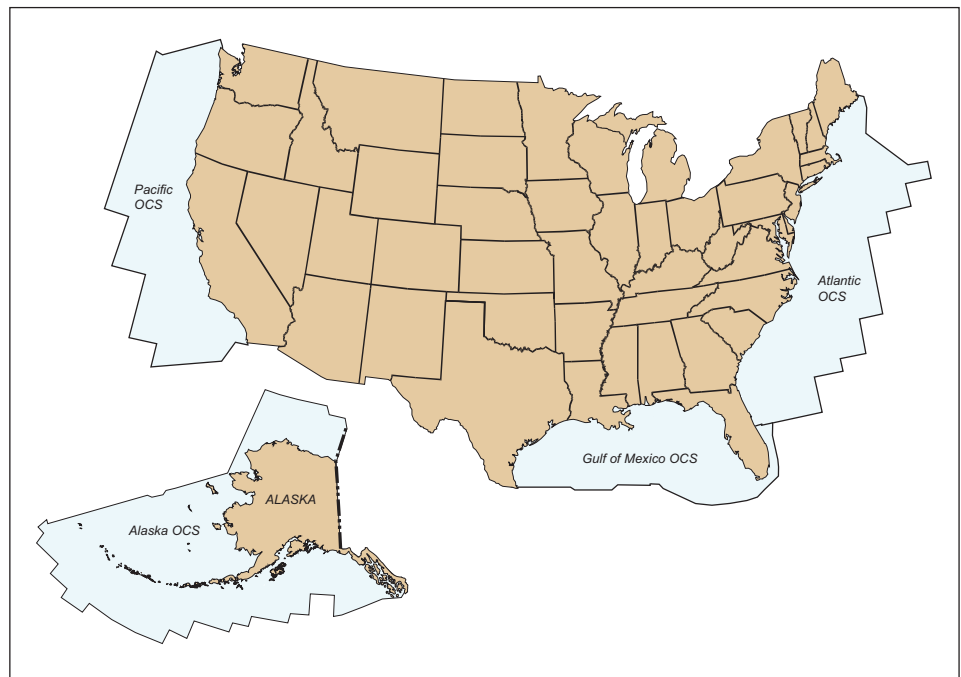
# Assessment of Undiscovered Technically Recoverable Oil and Gas Resources of the Nation's Outer Continental Shelf, 2006

*Using a play-based assessment methodology, the Minerals Management Service estimated a mean of 85.9 billion barrels of undiscovered recoverable oil and a mean of 419.9 trillion cubic feet of undiscovered recoverable natural gas in the Federal Outer Continental Shelf of the United States.*

## Introduction

This report summarizes the results of the Minerals Management Service (MMS) 2006 assessment of the technically recoverable oil and gas resources for the U.S. Outer Continental Shelf (OCS) (see figure 1). The OCS comprises the portion of the submerged seabed whose mineral estate is subject to Federal jurisdiction. The 2006 assessment represents a comprehensive appraisal that considered relevant data and information available as of January 1, 2003, incorporated advances in petroleum exploration and development technologies, and employed new methods of resource assessment.

This assessment provides estimates of the undiscovered, technically and economically recoverable oil and natural gas resources located outside of known oil and gas fields on the OCS. It considers recent geophysical, geological, technological, and economic information and utilizes a probabilistic play-based approach to estimate the undiscovered technically recoverable resources (UTRR) of oil and gas for individual plays. This methodology is suitable for both conceptual plays where there is little or no specific information available, and for developed plays where there are discovered oil and gas fields and considerable information is available. After estimation, individual play results are aggregated to larger areas such as basins and regions. Estimates of the quantities of historical production, reserves, and future reserves appreciation are presented to provide a frame of reference for analyzing the estimates of UTRR.



**Figure 1.** Federal OCS Areas of the United States.

More detailed information about the geology, assessment methodology, and economics will be published in separate regional assessment reports.

## Commodities Assessed

The petroleum commodities assessed in this inventory are crude oil, natural gas liquids (condensate), and natural gas that exist in conventional reservoirs and are producible with conventional recovery techniques. Crude oil and condensate are reported jointly as oil; associated and nonassociated gas are reported as gas. Oil volumes are reported as stock tank barrels and gas as standard cubic feet. Oil-equivalent gas is a volume of gas (associated and/or nonassociated) expressed in terms of its energy equivalence to oil (i.e., 5,620 cubic feet of gas per barrel of oil) and is reported in barrels. The combined volume of oil and oil-equivalent gas resources is referred to as barrel of oil-equivalent (BOE) and is reported in barrels.

This assessment does not include potentially large quantities of hydrocarbon resources that could be recovered from known and future fields by enhanced recovery techniques, gas in

geopressed brines, natural gas hydrates, or oil and natural gas that may be present in insufficient quantities or quality (low permeability “tight” reservoirs) to be produced by conventional recovery techniques. In some instances the boundary between these resources is somewhat indistinct; however, we have not included in this assessment any significant volume of unconventional resources.

Estimates of undiscovered recoverable resources are presented in two categories, undiscovered technically recoverable resources (UTRR) and undiscovered economically recoverable resources (UERR). In addition, the quantities of historical production, reserves, and future reserves appreciation are presented to provide a frame of reference for analyzing the estimates of UTRR. The UERR results are presented as price-supply curves which show the relationship of price to economically recoverable resource.

## Methodology

This assessment incorporated a comprehensive play-based (see list of terms) approach toward the analysis of hydrocarbon potential. A major strength of this method is that it has a strong relationship between information derived from oil and gas exploration activities and the geologic model developed by the assessment team. An extensive effort was involved in developing play models, delineating the geographic limits of each play, and compiling data on critical geologic and reservoir engineering parameters. These parameters were crucial input in the determination of the total quantities of recoverable resources in each play.

Due to the inherent uncertainties associated with an assessment of undiscovered resources, probabilistic techniques were employed and the results reported as a range of values corresponding to different probabilities of occurrence. For plays in frontier areas with sparse data, analogs were developed using subjective probabilities to cover the range of uncertainties. Most plays in the Alaska, Atlantic and some in the Pacific OCS were assessed this way. For mature areas with significant amounts of data, such as the Gulf of Mexico and southern California, plays were analyzed using a method based on statistical parameters of discovered pools and historical trends.

## Assessment Results

The MMS completed an assessment of the undiscovered technically recoverable oil and natural gas resources of the OCS, which reflects data and information available as of January 1, 2003. This assessment was the culmination of a multi-year effort that included data and information not available at the time of the previous assessment (MMS, 2001), incorporated advances in petroleum exploration and development technologies, and employed new methods of resource assessment.

UTRR estimates are presented at 95<sup>th</sup> and 5<sup>th</sup> percentile levels, as well as the mean estimate. This range of estimates corresponds to a 95-percent probability (a 19 in 20 chance) and a 5-percent probability (a 1 in 20 chance) of there being more than those amounts present, respectively. The 95- and 5-percent probabilities are considered reasonable minimum and maximum values, and the mean is the average or expected value. Results for individual plays, basins, and planning areas will be presented in subsequent regional reports.

Estimates of UTRR for the entire OCS range from 66.6 Bbo at the F<sub>95</sub> fractile to 115.1 Bbo at the F<sub>5</sub> fractile with a mean of 85.9 Bbo (figure 2 and table 1). Similarly, gas estimates range from 326.4 to 565.9 Tcf with a mean of 419.9 Tcf. On a barrel of oil-equivalence (BOE) basis 54 percent of the potential is located within the Gulf of Mexico. The Alaska OCS ranks second with 31 percent. The Pacific is third among the regions

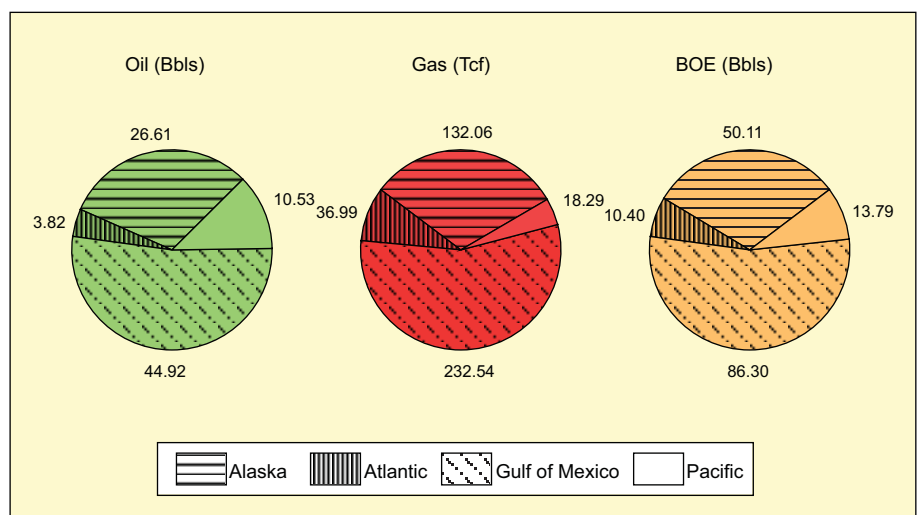


Figure 2. Undiscovered Technically Recoverable Resources by type and region.

in terms of oil potential and fourth with respect to gas. The Atlantic region, on the other hand, ranks third when considering gas potential and fourth in terms of oil.

Technological advances in hydrocarbon exploration and development are sure to occur in the future, yet the nature of advancement is extremely hard to predict and its impact difficult to estimate. However, past experience indicates most technological breakthroughs occur during high-cost scenarios and impact exploration and development by lowering the cost and sometimes by improving the chance of success. For the purpose of this assessment, recent technological advances in gathering, processing, and interpreting seismic data contributed to the identification and mapping of geological plays and development of geologic parameters used to model the plays. Similarly, recent technological advances in offshore drilling and development operations were incorporated through the assumptions associated with the costs of these activities.

However, no attempt was made to determine an empirical relationship between the future technological advancements and the estimated undiscovered resources. MMS believes that future technological advances will significantly affect the

**Table 1.** Undiscovered Technically Recoverable Resources of the OCS

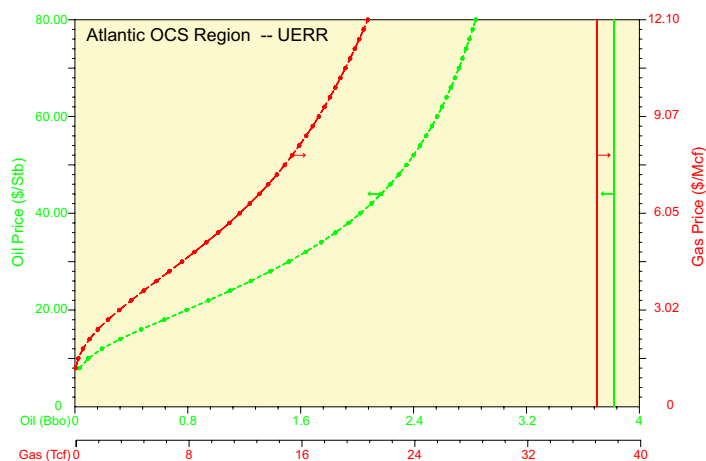
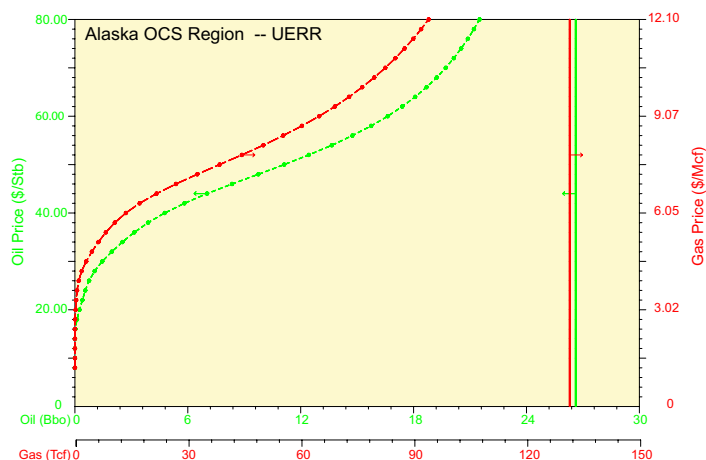
(Bbo, billion barrels of oil, Tcf, trillion cubic of gas. F95 indicates a 95 percent chance of at least the amount listed, F5 indicates a 5 percent chance of at least the amount listed. Only mean values are additive.)

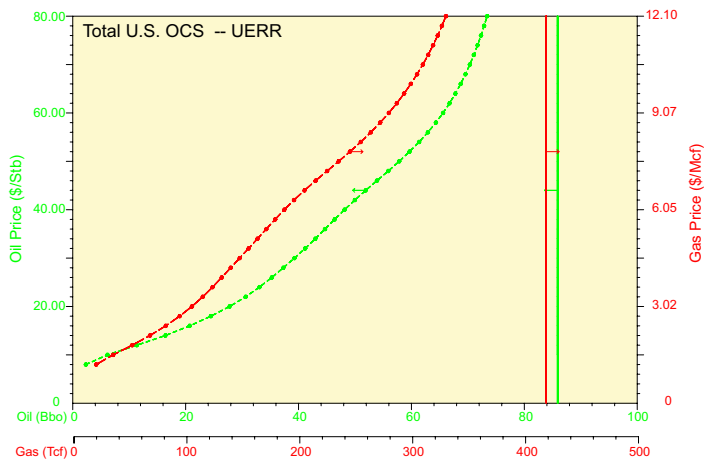
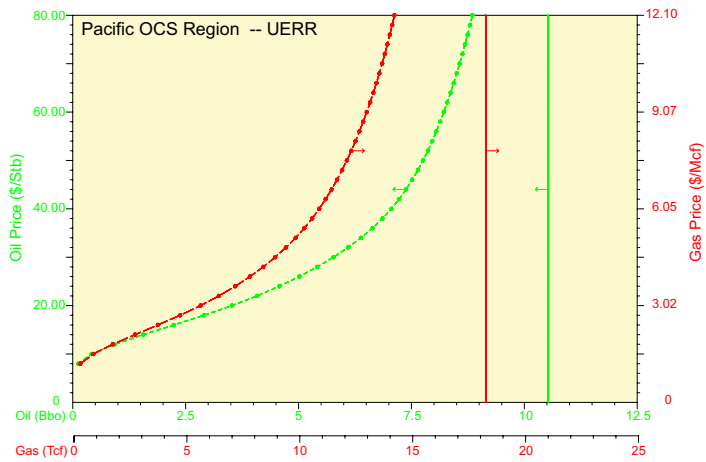
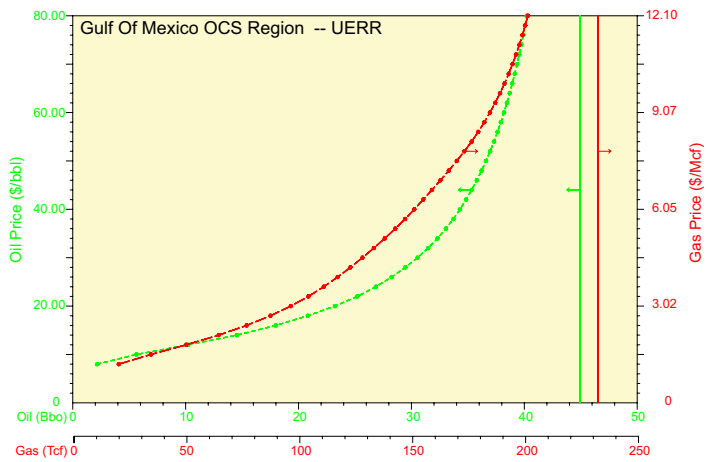
Region	Oil (Bbo)			Natural Gas (Tcf)			BOE (Bbo)		
	95%	Mean	5%	95%	Mean	5%	95%	Mean	5%
Alaska OCS	8.66	26.61	55.14	48.28	132.06	279.62	17.25	50.11	104.89
Atlantic OCS	1.12	3.82	7.57	14.30	36.99	66.46	3.67	10.40	19.39
Gulf of Mexico OCS	41.21	44.92	49.11	218.83	232.54	249.08	80.15	86.30	93.43
Pacific OCS	7.55	10.53	13.94	13.28	18.29	24.12	9.91	13.79	18.24
<b>Total U.S. OCS</b>	<b>66.60</b>	<b>85.88</b>	<b>115.13</b>	<b>326.40</b>	<b>419.88</b>	<b>565.87</b>	<b>124.68</b>	<b>160.60</b>	<b>215.82</b>

portion of the undiscovered resources represented by estimates of UTRR, resulting in an increased percentage being classified as economically recoverable resources.

Estimates of UERR are presented as price-supply curves for the entire OCS as well as individual regions (figure 3). A price-supply curve shows the relationship of price to economically recoverable resource volumes (i.e., a horizontal line from the price axis to the curve yields the quantity of economically recoverable resources at the selected price). The price-supply curve for each region shows two curves and two price scales, one for oil and one for gas. The curves represent mean values at any specific price. They are not independent of each other; that is, one specific oil price cannot be used to obtain an oil resource and a separate gas price used to get a gas resource. The gas price is dependent on the oil price and must be used in conjunction with the oil price on the opposite axis to calculate resources. The reason for this condition is that oil and gas frequently occur together and the individual pool economics are calculated using the coupled pricing. A different gas price associated with the oil price would result in a different resource number than that shown on the curve.

The two vertical lines (green for oil and red for natural gas) indicate the mean estimates of UTRR. At high prices, the economically recoverable resource volumes approach the conventionally recoverable volumes. These curves represent resources available with sufficient exploration and development efforts and do not imply an immediate response to price changes.

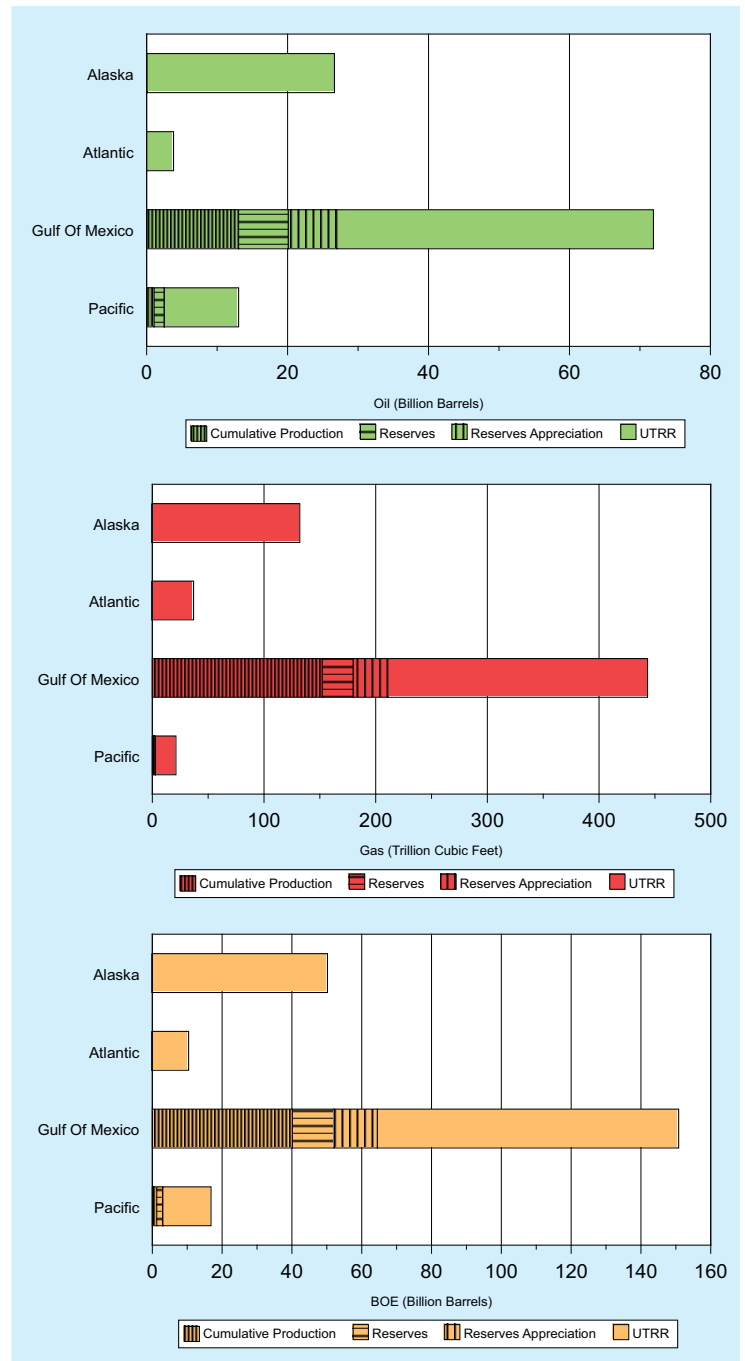




**Figure 3.** Price Supply Curves for Federal OCS Regions and Total Federal OCS.

Estimates of the quantities of historical production, reserves, and future reserves appreciation are presented to provide a frame of reference for analyzing the estimates of UTRR. The *total endowment* is the sum of historic production, reserves, future reserves appreciation, and UTRR. Mean estimates of the total endowment for the entire OCS are 115.4 Bbo and 633.6 Tcfg (228.2 BBOE). The total endowment distribution by resource category can be seen in figure 4 and table 2. More

than 18 percent of the total endowment in terms of the mean estimate of BOE has already been produced. An additional 11 percent is contained within the various reserves categories, the source of near and midterm production. After more than 50 years of OCS exploration and development, 70 percent of the mean BOE total endowment is still represented by undiscovered resources.



**Figure 4.** Distribution of total hydrocarbon endowment by type, region and resource category.

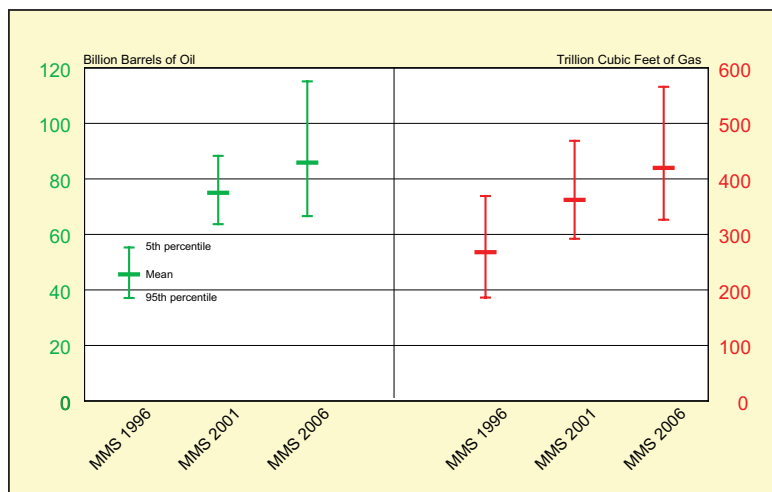
**Table 2.** Distribution of total hydrocarbon endowment by type, region and resource category.

Resource Category		Alaska	Atlantic	Gulf of Mexico	Pacific	Total OCS
Cumulative Production	Oil (Bbo)	.01	0	13.05	1.06	14.12
	Gas (Tcf)	0	0	152.25	1.32	153.57
	BOE (Bbo)	.01	0	40.14	1.29	41.45
Reserves	Oil (Bbo)	.03	0	7.06	1.46	8.55
	Gas (Tcf)	0	0	27.70	1.56	29.26
	BOE (Bbo)	.03	0	11.98	1.74	13.76
Reserves Appreciation	Oil (Bbo)	-	-	6.88	-	6.88
	Gas (Tcf)	-	-	30.91	-	30.91
	BOE (Bbo)	-	-	12.38	-	12.38
UTRR (Mean)	Oil (Bbo)	26.61	3.82	44.92	10.53	85.88
	Gas (Tcf)	132.06	36.99	232.54	18.29	419.88
	BOE (Bbo)	50.11	10.40	86.30	13.79	160.60
Total Endowment	Oil (Bbo)	26.65	3.82	71.91	13.05	115.43
	Gas (Tcf)	132.06	36.99	443.40	21.17	633.62
	BOE (Bbo)	50.15	10.40	150.81	16.82	228.18

### Comparison with Previous Assessments

A general comparison of 1996, 2001, and 2006 assessment UTRR results is shown in figure 5. At the mean level, the estimates of UTRR for the entire OCS represent an increase compared to the previous (2001) assessment of 10.9 Bbo and 57.7 Tcfg or about 15 percent for oil and gas. The vast majority of this increase occurred in the Gulf of Mexico, where estimates of UTRR range from 41.2 to 49.1 Bbo and 218.8 to 249.1 Tcfg with a mean of 44.9 Bbo and 232.5 Tcfg respectively. Significant increases in the estimates for the deepwater areas were the major contributor to the overall growth in the estimates of UTRR for oil. The majority of the increase in the estimate of UTRR from gas was related to deep gas plays located beneath the shallow water shelf of the Gulf of Mexico. This increase in UTRR was also accompanied by approximately 4.5 Bbo and 14 Tcfg that were discovered in fields such as Thunder Horse and Holstein, whose resources were moved to the reserve category during this time period.

In the Pacific Region, the mean estimate for UTRR of 10.5 Bbo and 18.3 Tcfg represented a slight decrease for both oil and natural gas. The Atlantic estimate of UTRR ranges from 1.1 to 7.6 Bbo and 14.3 to 66.5 Tcfg with a mean of 3.8 Bbo and 37.0 Tcfg. The estimates represent a 66 percent increase in oil resources and a 33 percent increase in gas resources in the Atlantic OCS, when compared with the MMS 2001 assessment. The last remaining leases in the Atlantic OCS, on the Manteo Prospect, expired in 2002 without a well being drilled. However, significant new analog information was available as the result of recent exploration in the Scotian Shelf offshore Canada and the West African Continental Slope offshore Mauritania. Applying these new exploration ideas to



**Figure 5.** Comparison of UTRR from MMS 1996, 2001, 2006 assessments.

the older Atlantic play models led to adjustments to risks in previously defined plays and the identification of additional new plays.

Estimates of UTRR on the Alaska OCS changed only slightly compared to the previous assessment. The mean oil estimate

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increased by 1.7 Bbo, while the mean natural gas estimate declined by 6.7 Tcf. The first Alaskan OCS production occurred in 2001 from the joint state/Federal Northstar unit in the Beaufort Sea.

Fifty-four percent of the mean estimate of UTRR on a BOE basis was projected to be present in the Gulf of Mexico OCS. The Alaska, Pacific and Atlantic OCS comprise 31, 9 and 6 percent respectively of the total UTRR.

## List of Terms

**Cumulative production:** The sum of all produced volumes of oil and gas prior to a specified point in time.

**Pool:** A discovered or undiscovered accumulation of hydrocarbons, typically within a single stratigraphic interval.

**Play:** A group of pools that share a common history of hydrocarbon generation, migration, reservoir development, and entrapment.

**Probability:** A means of expressing an outcome on a numerical scale that ranges from impossibility to absolute certainty; the chance that a specified event will occur.

**Prospect:** A geologic feature having the potential for trapping and accumulating hydrocarbons; a pool or potential field.

**Reserves:** The quantities of hydrocarbon resources anticipated to be recovered from known accumulations from a given date forward. All reserve estimates involve some degree of uncertainty.

**Reserves appreciation:** The observed incremental increase through time in the estimates of reserves (proved and unproved) of an oil and/or natural gas field as a consequence of extension, revision, improved recovery, and the addition of new reservoirs.

**Resources:** Concentrations in the earth's crust of naturally occurring liquid or gaseous hydrocarbons that can conceivably be discovered and recovered.

**Undiscovered resources:** Resources postulated, on the basis of geologic knowledge and theory, to exist outside of known fields or accumulations.

**Undiscovered technically recoverable resources (UTRR):** Oil and Gas that may be produced as a consequence of natural pressure, artificial lift, pressure maintenance, or other secondary recovery methods, but without any consideration of economic viability. They are primarily located outside of known fields.

**Undiscovered economically recoverable resources (UEER):** The portion of the undiscovered conventionally recoverable resources that is economically recoverable under imposed economic and technologic conditions.

## Selected References

Minerals Management Service. 1996: An assessment of the undiscovered hydrocarbon potential of the Nation's outer continental shelf. OCS Report MMS 96-0034, 40 p.

———. 2001: Outer Continental Shelf Petroleum Assessment, 2000, 12 p.

Society of Petroleum Engineers and World Petroleum Congress. 1997: Petroleum Reserves Definitions, p. 4-7.

## For Further Information

Supporting geological studies, previous assessment results, and methodologies used by MMS for resource assessment can be found on MMS's web site, [www.mms.gov/offshore](http://www.mms.gov/offshore).

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