

ESTIMATED OIL & GAS RESERVES

**Pacific Outer Continental Shelf
(as of December 31, 1985)**

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PACIFIC OUTER CONTINENTAL SHELF
(AS OF DECEMBER 31, 1985)

by

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ABSTRACT

Remaining recoverable reserves of oil* and gas in the Pacific Outer Continental Shelf (POCS) are estimated to be 1,259 million barrels of oil and 2,067 billion cubic feet of gas as of December 31, 1985. These reserves are attributed to 24 fields. Original recoverable reserves from these fields are estimated at 1,599 million barrels of oil and 2,334 billion cubic feet of gas. The estimates for remaining and original recoverable reserves of oil are higher than the corresponding estimates for December 31, 1984. The estimates for remaining and original recoverable reserves of gas are lower than in the previous report. Reserve estimates for 21 fields were determined by individual volumetric reservoir studies. Decline-curve and volumetric analyses were used for the remaining three fields. At the end of 1985, seven fields were on production.

*The term "oil" as used in this report includes crude oil, condensate, and gas-plant liquids.

INTRODUCTION

This report, which supersedes OCS Report, MMS 85-0041 (Wolfson, 1985), presents estimates of original recoverable oil and gas reserves, cumulative production through 1985, and estimates of remaining recoverable reserves as of December 31, 1985, for the Pacific Outer Continental Shelf. These estimates were completed in April 1986.

The annual update of this report is part of a Minerals Management Service continuing program to provide a current inventory of oil and gas reserves for the POCS. The estimates presented here were prepared by geologists, geophysicists, petroleum engineers, and other personnel within the Minerals Management Service's Pacific OCS Regional offices in Los Angeles, California.

DEFINITION OF RESERVE AND RESOURCE TERMS

The reserve and resource terminology in this report conforms with Dolton and others (1981, p. 6-7). The quoted definitions of terms applicable to this report are:

"Resources.--Concentrations of naturally occurring liquid or gaseous hydrocarbons in the Earth's crust, some part of which is currently or potentially economically extractable."

"Measured reserves.--That part of the economic identified resource that is estimated from geologic evidence supported directly by engineering measurements. Measured reserves here are equivalent to proved reserves as defined by the American Petroleum Institute (API) and others (1976, p. 1)."

"Indicated reserves.--Reserves equivalent to API indicated additional reserves, that are defined as economic reserves in known productive reservoirs in existing fields expected to respond to improved recovery techniques such as fluid injection where (a) an improved recovery technique has been installed but its effect cannot yet be fully evaluated; or (b) an improved technique has not been installed but knowledge of reservoir characteristics and the results of a known technique installed in a similar situation are available for use in the estimating procedure (API, 1976, p. 1, 2)."

Other definitions used in this report are:

Reserves.--That portion of the identified resource which can be economically extracted.

Demonstrated reserves.--A collective term for the sum of measured and indicated reserves.

APPLICATION OF TERMS IN PRESENT REPORT

In fields with limited well data, "measured reserves" as used in this report refer to hydrocarbons within boundaries defined by the use of both seismic interpretation and well control.

Five producing oil and gas fields in the Pacific Outer Continental Shelf, Hondo, Dos Cuadras, Santa Clara, Hueneme, and Beta (fig. 1), are undergoing fluid injection, and recovery beyond primary production is in progress or can be anticipated (table 1). One field, Hondo, is undergoing gas injection; three fields, Santa Clara, Hueneme, and Beta, are undergoing water injection; one field, Dos Cuadras, is undergoing polymer injection. For several non-producing fields, where it was determined that indicated reserves could be

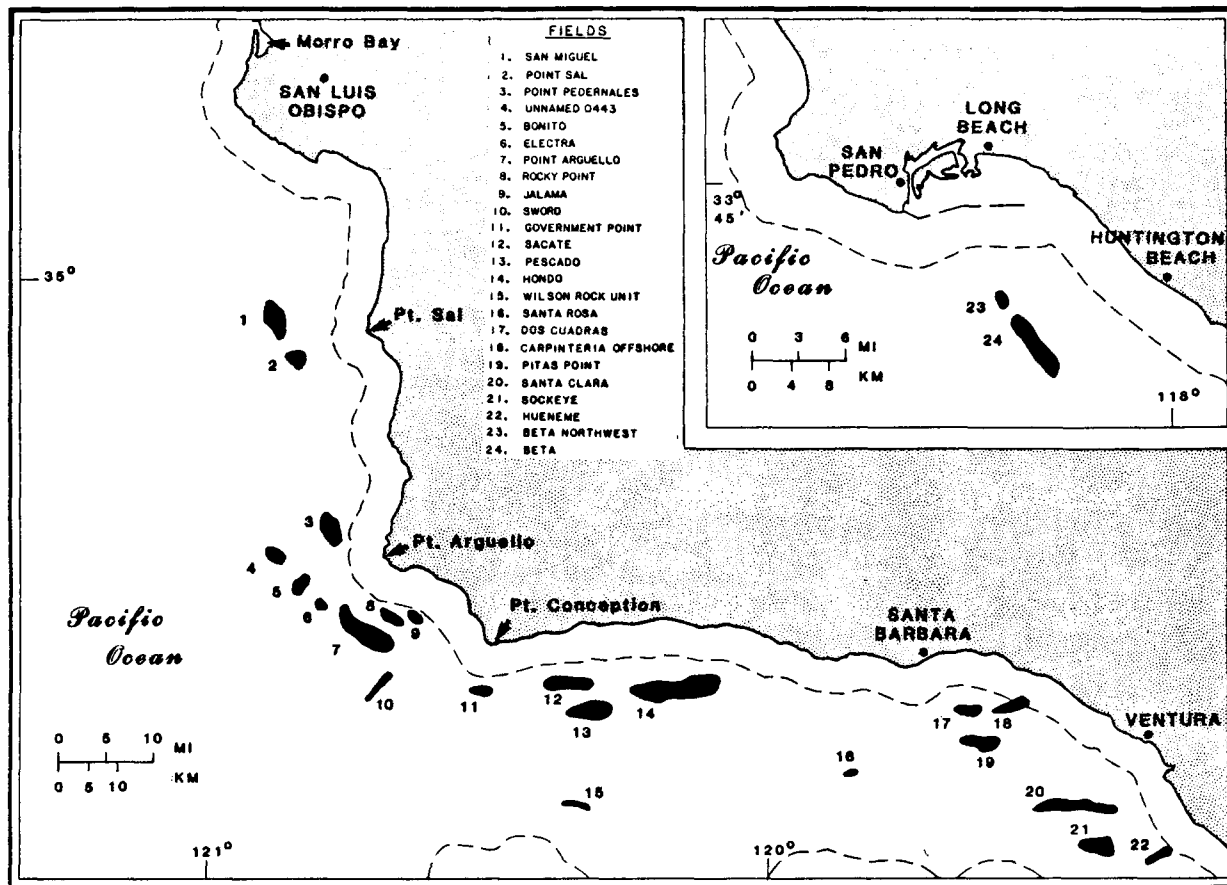


Figure 1. Recognized discoveries of federally controlled oil and gas fields in the Pacific Outer Continental Shelf. Dashed lines indicate 3-geographical-mile boundary between State and Federal waters.

anticipated by comparison with similar producing fields, indicated reserves were included with the measured reserves for a total estimate of demonstrated reserves.

Table 1. Secondary and tertiary recovery methods used in Pacific OCS fields

FIELD TYPE	POLYMER FLOOD	ACTIVE WATER INJECTION	ACTIVE GAS INJECTION
Oil	Dos Cuadras	Hueneme	
		Beta	
Oil & Gas		Santa Clara	Hondo

Fluid injection may be limited to specific reservoirs within each field.

Pacific Region OCS Order No. 4, "Determination of Well Producibility," provides criteria for determining, through evaluation of borehole testing, whether a well is capable of producing in paying quantities (Minerals Management Service, 1980). The term "paying quantities," as used herein, means production of oil and gas in quantities sufficient to yield a return in excess of operating costs. In some instances, these "paying quantities" as defined in the OCS Order may not prove to be "economically extractable" reserves, and these accumulations are generally omitted from reserve calculations. The accumulations are included here, however, because they may be necessary for effective planning and lease management. The number of wells annually determined to be producible in accordance with OCS Order No. 4 is shown in figure 2.

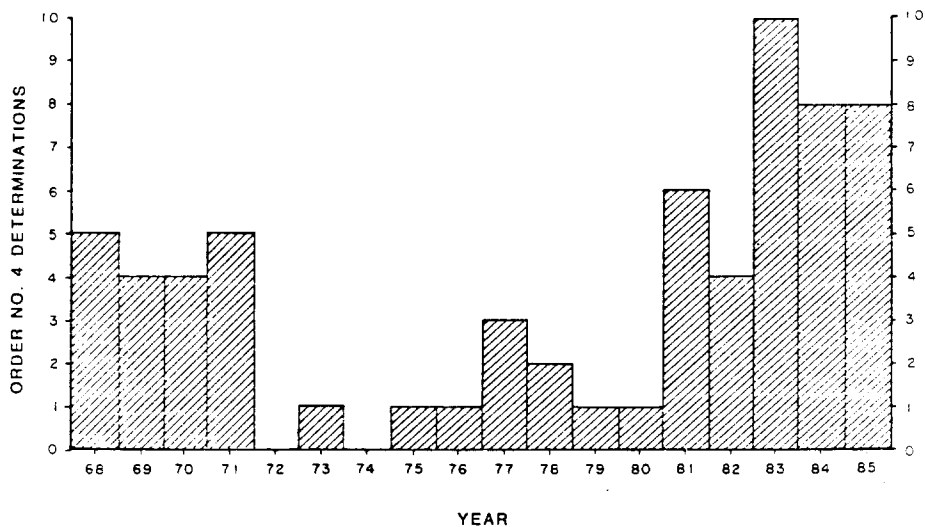


Figure 2. Wells determined to be producible in accordance with OCS Order No. 4.

METHODS USED FOR RESERVES ESTIMATION

Volumetric calculation.--The amount of original oil and gas in place is estimated from the bulk volume of the reservoir as mapped utilizing data from drill holes and seismic profiles. Maps of net oil and gas sand thickness are made and planimetered, and the results are converted to bulk volume by use of pyramidal formulas. Porosity of the rock and the amount of water, oil, and gas in the pore space are interpreted from well logs and analyses of cores. The total amount of oil and gas in place is converted to standard conditions by analysis of pressure, volume, and temperature relationships, and the use of standard correlation charts.

The amount of the original oil and gas in place that can be recovered is estimated from knowledge of the reservoir-drive mechanism, spacing of the wells, and API recovery-factor equations (Arps and others, 1967, p. 19-20).

Decline curves.--In the decline-curve method, future production is estimated by extrapolating plots of production rates and fluid percentage against time. The original recoverable reserves are determined by adding past production to predicted future production.

FIELDS REPORTED

As of December 31, 1985, 24 fields in the Pacific Outer Continental Shelf (fig. 1) are recognized as producing or capable of production on the basis of the "producible in paying quantities" criterion. Two of these fields are gas fields, 14 are oil fields, and eight are combination oil and gas fields.

The current estimates of the remaining and the original recoverable reserves for oil are higher than those for the preceding year. The higher figures result from the inclusion of oil estimates for a newly discovered field in the Santa Maria Basin. Estimates for remaining and original recoverable reserves of gas are lower than in the previous report. Several estimates of original recoverable reserves for individual fields were refined as development drilling continued to delineate the fields.

Those fields that cover both State and Federal lands have reserves estimated for only the Federal portions, seaward of the three-geographical-mile line.

The current POCS total estimates for oil and gas reserves are shown in table 2. The totals appear as composite numbers so as to protect the proprietary nature of the data used to determine the estimates. Reserve estimates are shown in table 3 and figure 3.

Table 2. Estimated demonstrated oil and gas reserves for 24 fields, Pacific Outer Continental Shelf, December 31, 1985
 ("Oil" includes crude oil, condensate, and gas-plant products sold.
 "Gas" includes both associated and nonassociated dry gas.)

	Oil (million bbl)	Gas (billion ft ³)
Original reserves:		
Estimated as of 12/31/85 (this report)..	1,599	2,334
Estimated as of 12/31/84 (MMS 85-0041)..	1,515	2,400
Change.....	+84	-66
Cumulative production:		
Through 1985.....	340	267
Through 1984.....	310	202
Remaining reserves:		
Estimated as of 12/31/85 (this report)..	1,259	2,067
Estimated as of 12/31/84 (MMS 85-0041)..	1,205	2,198
Change.....	+54	-131

Table 3: Annual estimates of original recoverable reserves with publication identification numbers

YEAR	PUBLICATION	OIL (MMBBL)	GAS (MMCF)
1976	OFR 78-384	829	1530
1977	OFR 79-345	843	1546
1978	OFR 80-477	875	1665
1979	OFR 80-1042	920	1845
1980	OFR 81-623	988	1853
1981	OFR 82-37	1082	1847
1982	OFR 83-559	1217	1983
1983	MMS 84-0024	1433	2298
1984	MMS 85-0041	1515	2400
1985	This Report	1599	2334

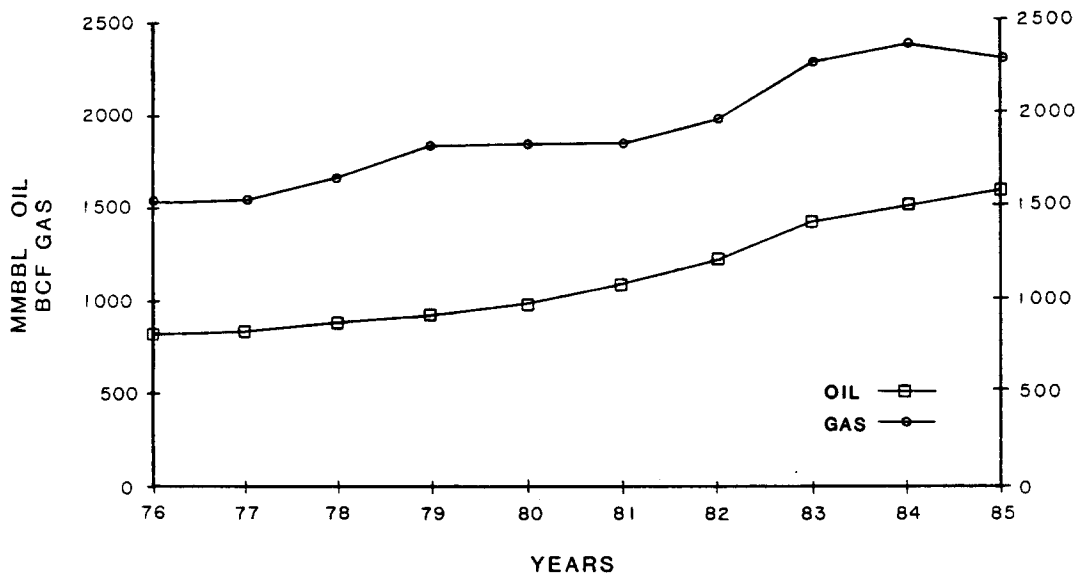


Figure 3. Annual estimates of original recoverable reserves.

STATUS OF DEVELOPMENT

As of December 31, 1985, four of the fields in the Pacific Outer Continental Shelf have completed their drilling programs: Dos Cuadras, Carpinteria Offshore, Pitas Point and Hueneme (fig. 1, fields 17, 18, 19 and 22). Of the 24 recognized fields, seven were producing in December of 1985: Hondo, Dos Cuadras, Carpinteria Offshore, Pitas Point, Santa Clara, Hueneme, and Beta (fig. 1, fields 14, 17, 18, 19, 20, 22 and 24). Additional exploratory and delineation drilling is anticipated in many of the remaining fields to further define productive limits and promote effective development. Several fields will commence production in the near future. It is anticipated that the Point Pedernales Field will commence sustained production in the last quarter of 1986. Startup of initial production from Point Arguello Field is planned for mid-1987. Annual production through 1985 is shown in table 4 and figure 4.

Table 4. Historical production data for the Pacific OCS

YEAR	ANNUAL OIL (BBL)	CUMULATIVE OIL (BBL)	ANNUAL GAS (MCF)	CUMULATIVE GAS (MCF)
1968	2,076,160	2,076,160	1,237,180	1,237,180
1969	9,942,733	12,018,893	6,016,485	7,253,665
1970	25,035,171	37,054,064	13,757,148	21,010,813
1971	31,103,681	68,157,745	17,853,055	38,863,868
1972	22,562,566	90,720,311	12,546,915	51,410,783
1973	18,811,721	109,532,032	9,154,599	60,565,382
1974	16,784,100	126,316,132	7,234,937	67,800,319
1975	15,426,630	141,742,762	5,976,521	73,776,840
1976	13,969,631	155,712,393	5,532,105	79,308,945
1977	12,249,515	167,961,908	5,363,333	84,672,278
1978	11,966,955	179,928,863	5,181,133	89,853,411
1979	10,971,013	190,899,876	5,430,689	95,284,100
1980	10,118,614	201,018,490	5,771,792	101,055,892
1981	19,613,794	220,632,284	12,767,957	113,823,849
1982	28,471,665	249,103,949	17,814,958	131,638,807
1983	30,545,148	279,649,097	23,914,613	155,553,420
1984	30,500,505	310,149,602	46,189,541	201,742,961
1985	29,669,070	339,818,672	64,779,111	266,522,072

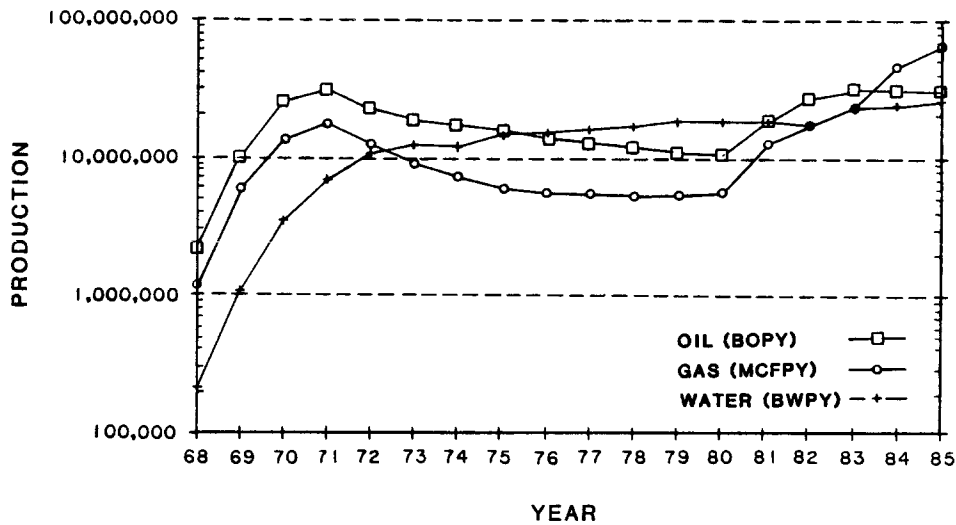


Figure 4. Annual production from the Pacific OCS.

STUDIES CONDUCTED

Reserve estimates for three of the producing fields, Dos Cuadras, Carpinteria Offshore and Hueneme (fig. 1, fields 17, 18, and 22), were made from volumetric and decline-curve analyses. Individual reservoirs in each field were grouped for volumetric calculations. Decline-curve analyses were made on a lease-by-lease and platform basis. The remaining fields were studied on a reservoir-by-reservoir basis and the reserve estimates were determined by the volumetric method.

FIELD-SIZE DISTRIBUTION

Figure 5 shows the field-size distribution of the original recoverable reserves of 22 oil and gas fields and 2 gas fields. For convenience of comparison, gas reserves are expressed in terms of oil on the basis of equivalent heating values (6,000 cubic feet of gas is approximately equivalent to 1 barrel of oil).

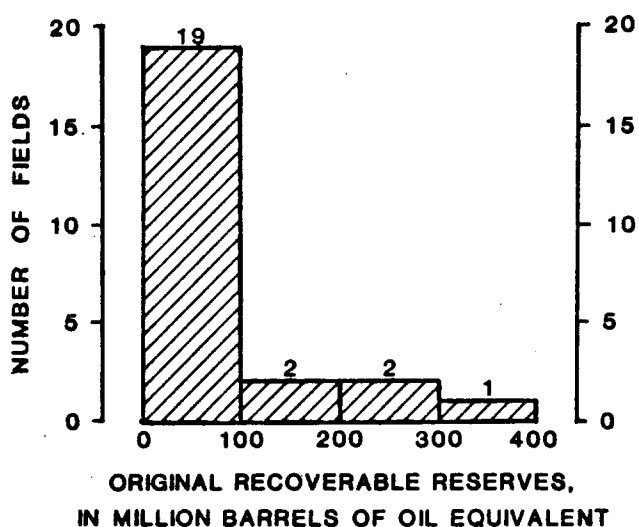


Figure 5. Histogram showing field-size distribution of oil and gas fields.

CONCLUSIONS

As of December 31, 1985, the remaining recoverable reserves in 24 known oil and gas fields in the Pacific Outer Continental Shelf are estimated at 1,259 million barrels of oil and 2,067 billion cubic feet of gas. These figures represent an increase of 54 million barrels of oil and a decrease of 131 billion cubic feet of gas from the December 31, 1984, estimates. These changes primarily result from the inclusion of estimates for a recently discovered field and the refinement of estimates for several other fields.

REFERENCES CITED

- American Petroleum Institute, American Gas Association, and Canadian Petroleum Association, 1976, Reserves of crude oil, natural gas liquids, and natural gas in the United States and Canada as of December 31, 1975: Washington, D.C., American Petroleum Institute.
- Arps, J. J., Brons, Folkert, van Everdingen, A. F., Buchwald, R. W., and Smith, A. E., 1967, A statistical study of recovery efficiency: American Petroleum Institute Bulletin D14, 33 p.
- Dolton, G. L., Carlson, K. H., Charpentier, R. R., Coury, A. B., Crovelli, A. B., Frezon, S. E., Khan, A. S., Lister, J. H., McMullin, R. H., Pike, R. S., Powers, R. B., Scott, E. W., and Varnes, K. L., 1981, Estimates of undiscovered recoverable conventional resources of oil and gas in the United States: U.S. Geological Survey Circular 860, 87 p.
- U.S. Geological Survey, 1980, Pacific Region OCS Order No. 4, Determination of well producibility: U.S. Geological Survey. (Available from Minerals Management Service, Regional Supervisor, Field Operations Office, 1340 West Sixth Street, Los Angeles, California 90017)
- Wolfson, S. A., 1985, Estimated oil and gas reserves, Southern California Outer Continental Shelf, December 31, 1984: OCS Report, MMS 85-0041, 8 p. (Superseded by present report).