OCS REPORT
MMS 87-0045

ESTIMATED OIL & GAS RESERVES

PACIFIC OUTER CONTINENTAL SHELF

(AS OF DECEMBER 31, 1986)

by

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DEDICATION

This document is dedicated to the memory of Cyril V. Bird, first supervisor of the Reserves Unit in the Pacific OCS Region.

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Estimated Oil and Gas Reserves

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ABSTRACT

Reserves of oil* and gas in the Pacific Outer Continental Shelf are estimated to be 1,302 million barrels of oil and 2,135 billion cubic feet of gas as of December 31, 1986. These reserves are attributed to 24 fields. Ultimate production from these fields is estimated as 1,670 million barrels of oil and 2,461 billion cubic feet of gas. The estimates for reserves and ultimate production of oil and gas are higher than the corresponding estimates for December 31, 1985. 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 1986, seven fields were producing.

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

INTRODUCTION

This report, which supersedes OCS Report, MMS 86-0066 (Raftery and Wolfson, 1986), presents estimates of ultimate oil and gas production, cumulative production through 1986, and estimates of reserves as of December 31, 1986, for the Pacific Outer Continental Shelf (OCS). These estimates were completed in March 1987.

The annual update of this report is part of a Minerals Management Service (MMS) continuing program to provide a current inventory of oil and gas reserves for the Pacific OCS. 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). Terms applicable to this report are defined:

"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 the following:

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.

Ultimate production -- An amount equal to the sum of cumulative production and reserves.

APPLICATION OF TERMS IN PRESENT REPORT

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

Five producing oil and gas fields in the Pacific OCS--Hondo, Dos Cuadras, Santa Clara, Hueneme, and Beta (fig. 1)--are undergoing fluid injection. 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 nonproducing fields, where it was determined that indicated reserves could be predicted through comparison

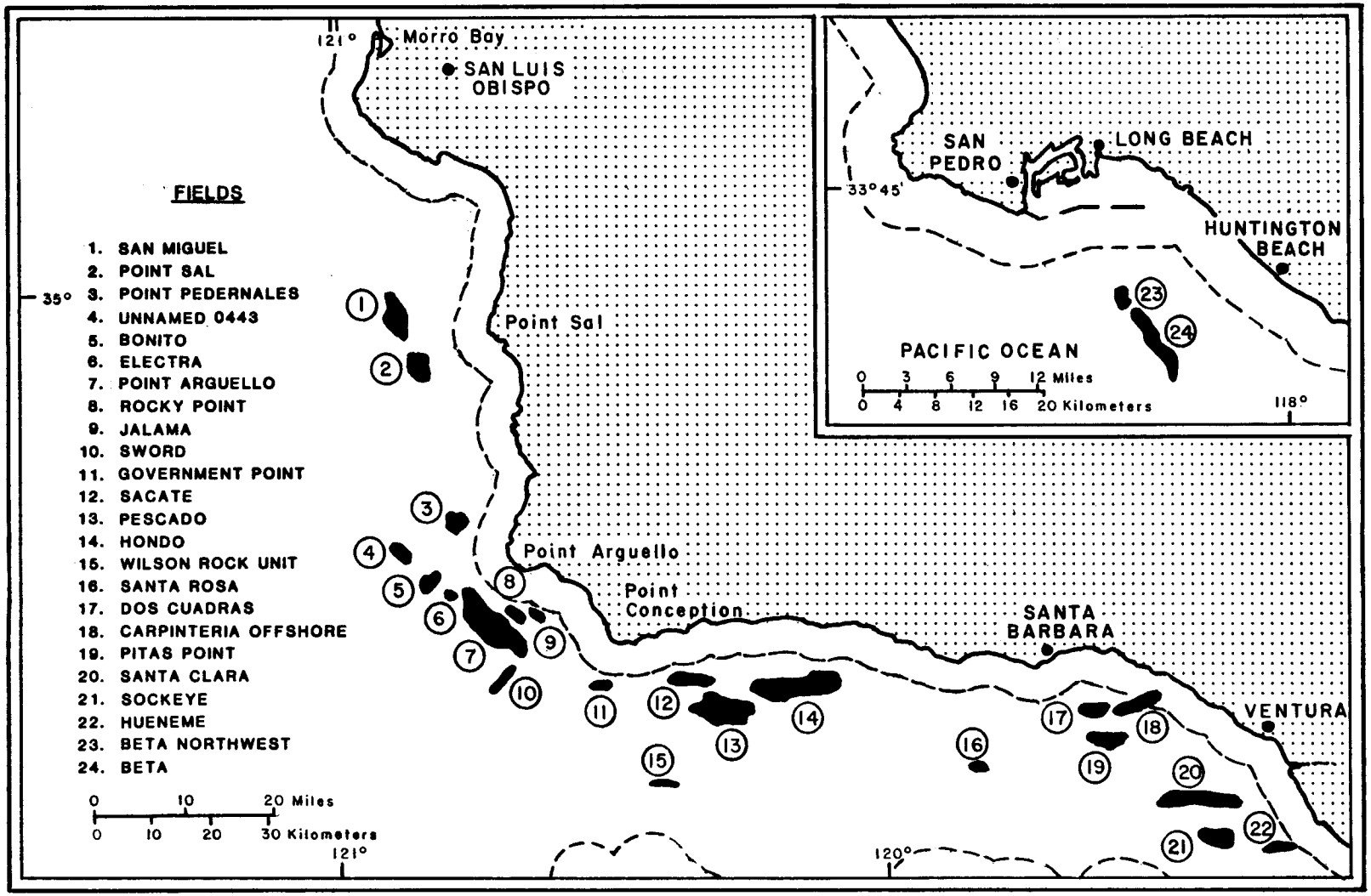

Figure 1. Recognized discoveries of federally controlled oil and gas fields in the Pacific OCS. Dashed lines indicate 3-geographical-mile boundary between State and Federal waters.

with currently producing fields, indicated reserves were included with the measured reserves for the 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 formation testing, whether or not a well is capable of producing in paying quantities (U.S. Geological Survey, 1980). The term "paying quantities," as used in this report, means production of oil and gas in quantities sufficient to yield a return in excess of operating costs for that well. In some instances, these "paying quantities", as defined in the OCS Order, may not prove to be "economically extractable" reserves, and these "paying quantities" are generally omitted from reserve calculations. They 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.

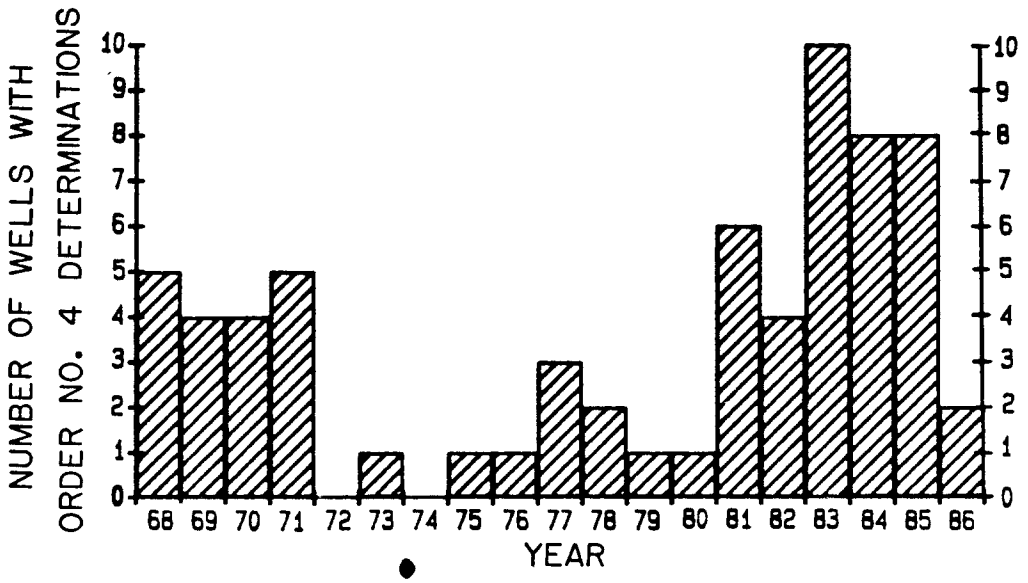

Figure 2. Wells determined to be producible in accordance with OCS Order No. 4.

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 using data from bore holes and seismic profiles. Maps of net oil and gas sand thicknesses are drawn, measured with a planimeter, and the results are converted to bulk volume using the appropriate equations. Rock porosity and the amounts of water, oil, and gas in the pore space are interpreted from well logs and core analyses. The total amount of oil and gas in place is converted to standard conditions by analysis of pressure, volume, and temperature relationships, and by the use of standard correlation charts.

The amount of the original oil and gas in place that can be recovered is estimated from information on 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 percentages versus time. The ultimate production is determined by adding past production to predicted future production.

FIELDS REPORTED

As of December 31, 1986, 24 fields in the Pacific OCS (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 8 are combination oil and gas fields.

The current estimates of oil and gas reserves and ultimate production are greater than those for the preceding year. Several estimates of ultimate production for individual fields were refined as development drilling continued to delineate the fields. Fields that cover both State and Federal lands have reserves estimated for only the Federal portions, seaward of the 3-geographical-mile line.

The current Pacific OCS total estimates for oil and gas reserves are shown in table 2. The totals appear as composite numbers so as to protect the proprietary data used to determine the estimates. Reserve estimates are shown in table 3 and figure 3. Estimated ultimate production is shown in table 3 and figure 4.

Table 2. Estimated demonstrated oil and gas reserves for 24 fields, Pacific OCS, December 31, 1986 ("Oil" includes crude oil, condensate, and gas-plant products sold; "Gas" includes both associated and nonassociated dry gas).

	Oil (MMBBL)	Gas (BCF)
Ultimate production:		
Estimated as of 12/31/86 (MMS 87-0045)..	1,670	2,461
Estimated as of 12/31/85 (MMS 86-0066)..	1,599	2,334
Change.....	+71	+127
Cumulative production:		
Through 1986.....	369	326
Through 1985.....	340	267
Demonstrated reserves:		
Estimated as of 12/31/86 (MMS 87-0045)..	1,302	2,135
Estimated as of 12/31/85 (MMS 86-0066)..	1,259	2,067
Change.....	+43	+68

Table 3. Annual estimates of demonstrated reserves and ultimate production with agency publication identification numbers.

YEAR	PUBLICATION	REMAINING RESERVES OIL (MMBBL)	REMAINING RESERVES GAS (BCF)	ESTIMATED ULTIMATE PRODUCTION OIL (MMBBL)	ESTIMATED ULTIMATE PRODUCTION GAS (BCF)
1976	OFR 78-384	673	1,451	829	1,530
1977	OFR 79-345	675	1,461	843	1,546
1978	OFR 80-477	695	1,575	875	1,665
1979	OFR 80-1042	730	1,750	920	1,845
1980	OFR 81-623	787	1,752	988	1,853
1981	OFR 82-37	861	1,733	1,082	1,847
1982	OFR 83-559	968	1,851	1,217	1,983
1983	MMS 84-0024	1,153	2,141	1,433	2,298
1984	MMS 85-0041	1,205	2,198	1,515	2,400
1985	MMS 86-0066	1,259	2,067	1,599	2,334
1986	MMS 87-0045	1,302	2,135	1,670	2,461

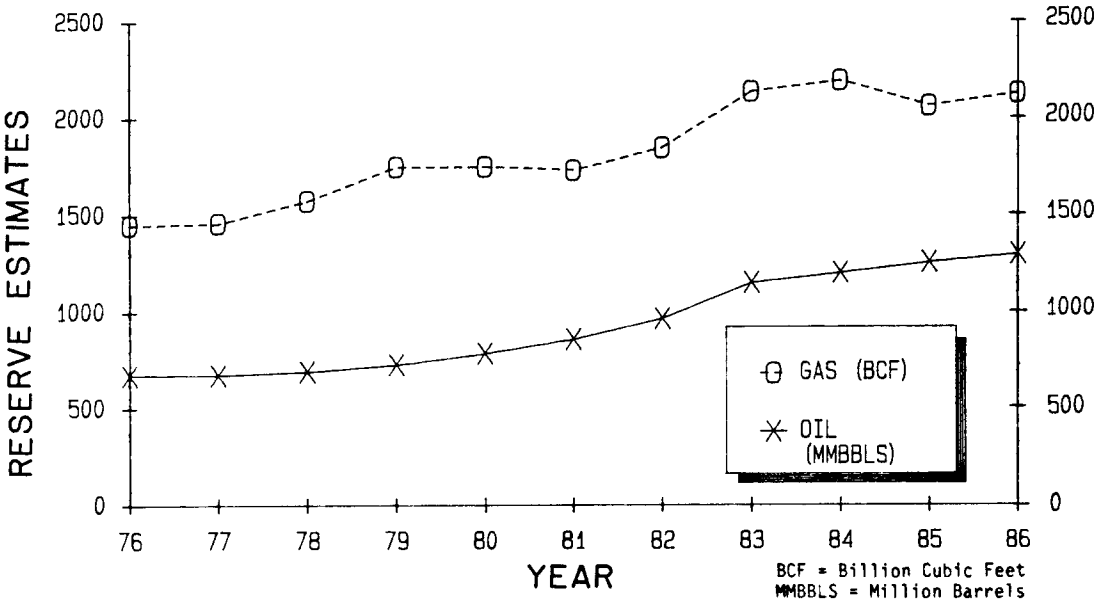

Figure 3. Annual estimates of demonstrated reserves from known fields.

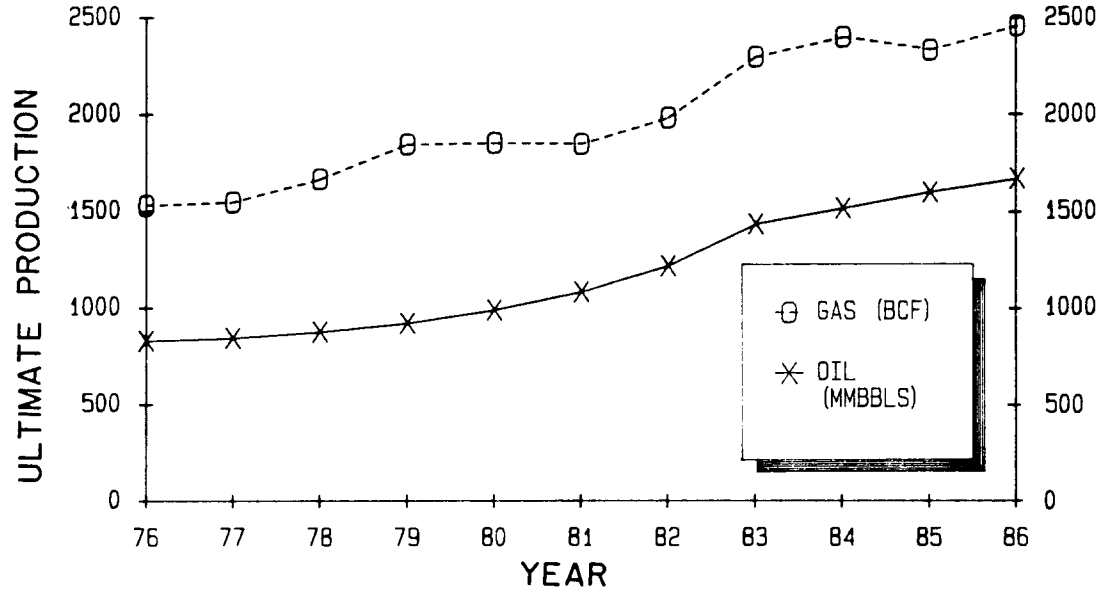

Figure 4. Annual estimates of ultimate production from known fields.

STATUS OF DEVELOPMENT

As of December 31, 1986, four of the fields in the Pacific OCS 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, 7 were producing in December of 1986: 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. The Point Pedernales Field commenced sustained production in the second quarter of 1987. Startup of initial production from the Point Arguello Field is planned for early-1988. Annual production through 1986 is shown in table 4 and figure 5.

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.

Table 4. Annual and cumulative production for the Pacific OCS.

YEAR	ANNUAL OIL (BBLS)	CUMULATIVE OIL (BBLS)	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	30,500,506	310,149,603	46,189,540	201,742,960
1985	29,674,099	339,823,702	64,831,185	266,574,145
1986	28,780,051	368,603,753	59,148,908	325,723,053

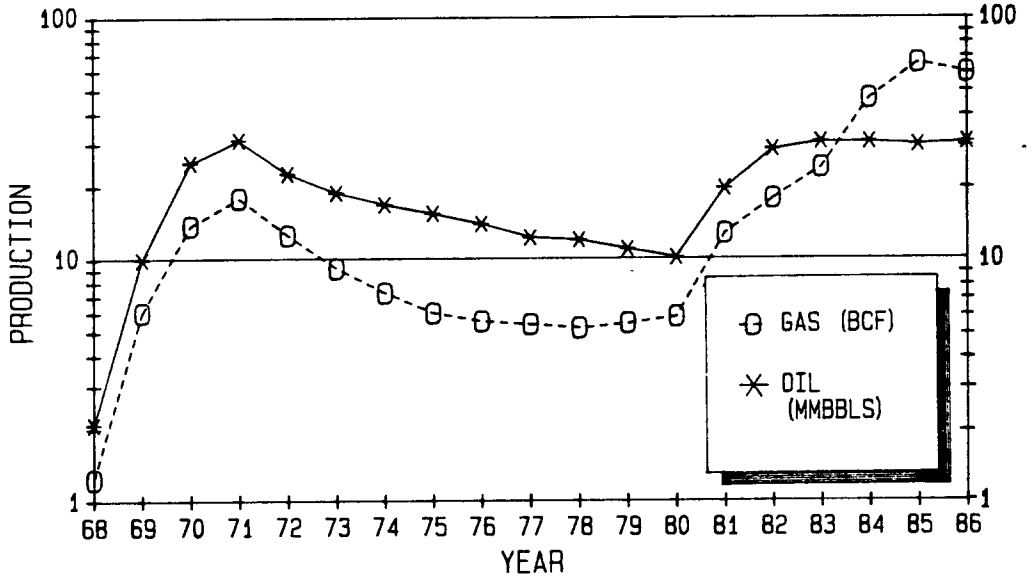

Figure 5. Annual production for the Pacific OCS.

FIELD SIZE DISTRIBUTION

Figure 6 shows the field size distribution of the estimated ultimate production 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 has the approximate heating value of 1 barrel of oil).

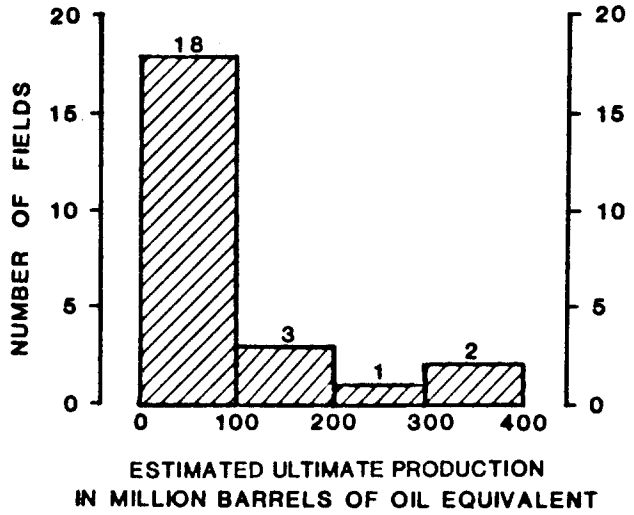

Figure 6. Histogram showing size distribution of oil and gas fields.

DISTRIBUTION OF RESERVES BY RELATIVE AGE OF RESERVOIR ROCK

The reserves of the Pacific OCS can be divided into three groups based on the relative age of the reservoirs in which they occur. The three groups of reservoir rocks are (1) reservoirs in rocks younger than the Monterey Formation (late Miocene and younger), (2) reservoirs in the Monterey Formation (Miocene), and (3) reservoirs in rocks older than the Monterey Formation (early Miocene and older). The distribution of reserves is illustrated in table 5 and figure 7.

Table 5. Formations within each reservoir group.

Reservoir Group	Formations	Reserves *	Estimated Ultimate Production *
Post-Monterey	Foxen, Pico, Repetto, Santa Margarita, Sisquoc, Puente.	264 MMBBLS	592 MMBBLS
Monterey	Monterey.	1,218 MMBBLS	1,304 MMBBLS
Pre-Monterey	Pt. Sal, Hueneme, Topanga, Vaqueros, Gaviota, Sespe/Alegria, Camino Cielo, Matilija, Sacate, Jalama.	176 MMBBLS	184 MMBBLS

* Reserves: Barrels of oil equivalent.

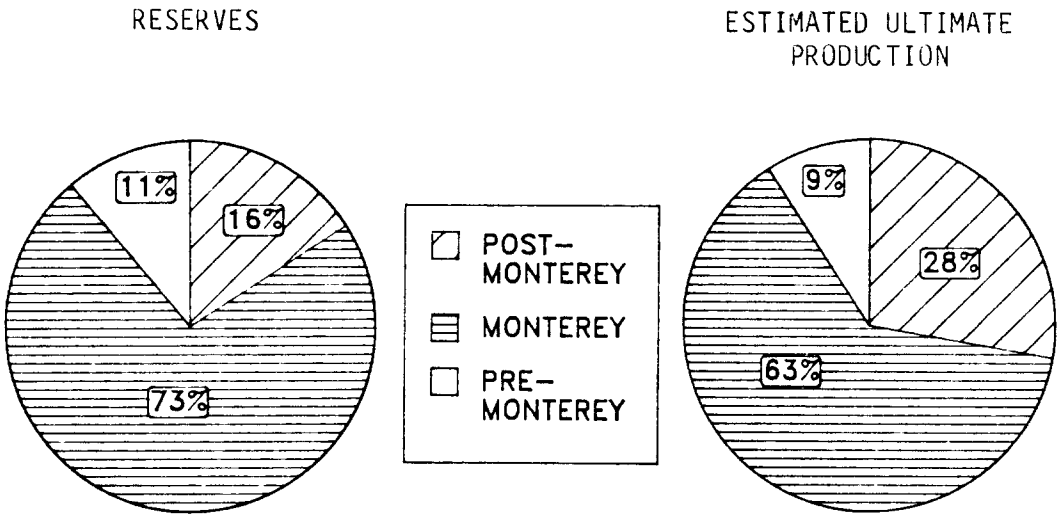

Figure 7. Reserves and estimated ultimate production by reservoir group.

CONCLUSIONS

As of December 31, 1986, the remaining recoverable reserves in 24 known oil and gas fields in the Pacific OCS are estimated at 1,302 million barrels of oil and 2,135 billion cubic feet of gas. These figures represent an increase of 43 million barrels of oil and an increase of 68 billion cubic feet of gas from the December 31, 1985, estimates. These changes result from the refinement of estimates for several fields.

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