

Estimated Oil and Gas Reserves

**Pacific Outer Continental Shelf
(as of December 31, 1987)**

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ABBREVIATIONS

ACT ... Actively Drilling	OSI ... Oil Well Shut-in
API ... American Petroleum Institute	PA ... Plugged and Abandoned
BBL ... Barrel	PGW ... Producing Gas Well
BCF ... Billion Cubic Feet of Gas	POW ... Producing Oil Well
°F ... Degrees Fahrenheit	PSIA ... Pounds Per Square Inch Absolute
GIW ... Gas Injection Well	SUSP ... Suspended (includes temporarily abandoned and inactive completions)
GSI ... Gas Well Shut-in	WDW ... Water Disposal Well
MCF ... Thousand Cubic Feet	WIW ... Water Injection Well
MMBBL ... Million Barrels of Oil	WSW ... Water Source Well
MMS ... Minerals Management Service	
OCS ... Outer Continental Shelf	
OFR ... Open File Report	

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By Peter J. Raftery
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ABSTRACT

Reserves of oil* and gas in the Pacific Outer Continental Shelf are estimated to be 1,328 million barrels of oil and 2,123 billion cubic feet of gas as of December 31, 1987. These reserves are attributed to 24 fields. Ultimate production from these fields is estimated as 1,727 million barrels of oil and 2,501 billion cubic feet of gas. For oil, the current estimates of demonstrated reserves and ultimate production are higher than the corresponding estimates for December 31, 1986. The current estimate of ultimate gas production is also higher than the previous estimate. However, the estimate of demonstrated reserves of gas is lower. Reserves estimates for 17 fields were determined by individual volumetric reservoir studies. Decline-curve and volumetric analyses were used for the remaining seven fields. At the end of 1987, eight fields were producing.

*"Oil" as used in this report includes crude oil and condensate.
"Gas" includes both associated and non-associated dry gas.

INTRODUCTION

This report, which supersedes OCS Report, MMS 87-0045 (Raftery and Wolfson, 1987), presents estimates of ultimate oil and gas production, cumulative production through 1987, and estimates of reserves as of December 31, 1987, for the Pacific Outer Continental Shelf (OCS). These estimates were completed in April 1988.

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 petroleum engineers, geologists, geophysicists, and other personnel within the MMS'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 as follows:

"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 and others, 1976, p. 1-2)."

Other definitions used in this report quoted from Miller and others (1975, p. 8-9) 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."

An additional term used in this report is:

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

Oil and gas volumes are corrected to 60⁰F and 14.73 psia. Production volumes are the metered volumes of oil and gas reported to the MMS by Federal lessees and operators. Reserve figures presented in this report are demonstrated reserves as defined above.

APPLICATION OF TERMS

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 for reservoir pressure maintenance. Four fields, Hueneme, Beta, Hondo, and Santa Clara, 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 with currently producing fields, indicated reserves were included with the measured reserves for the total estimate of demonstrated reserves.

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 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.

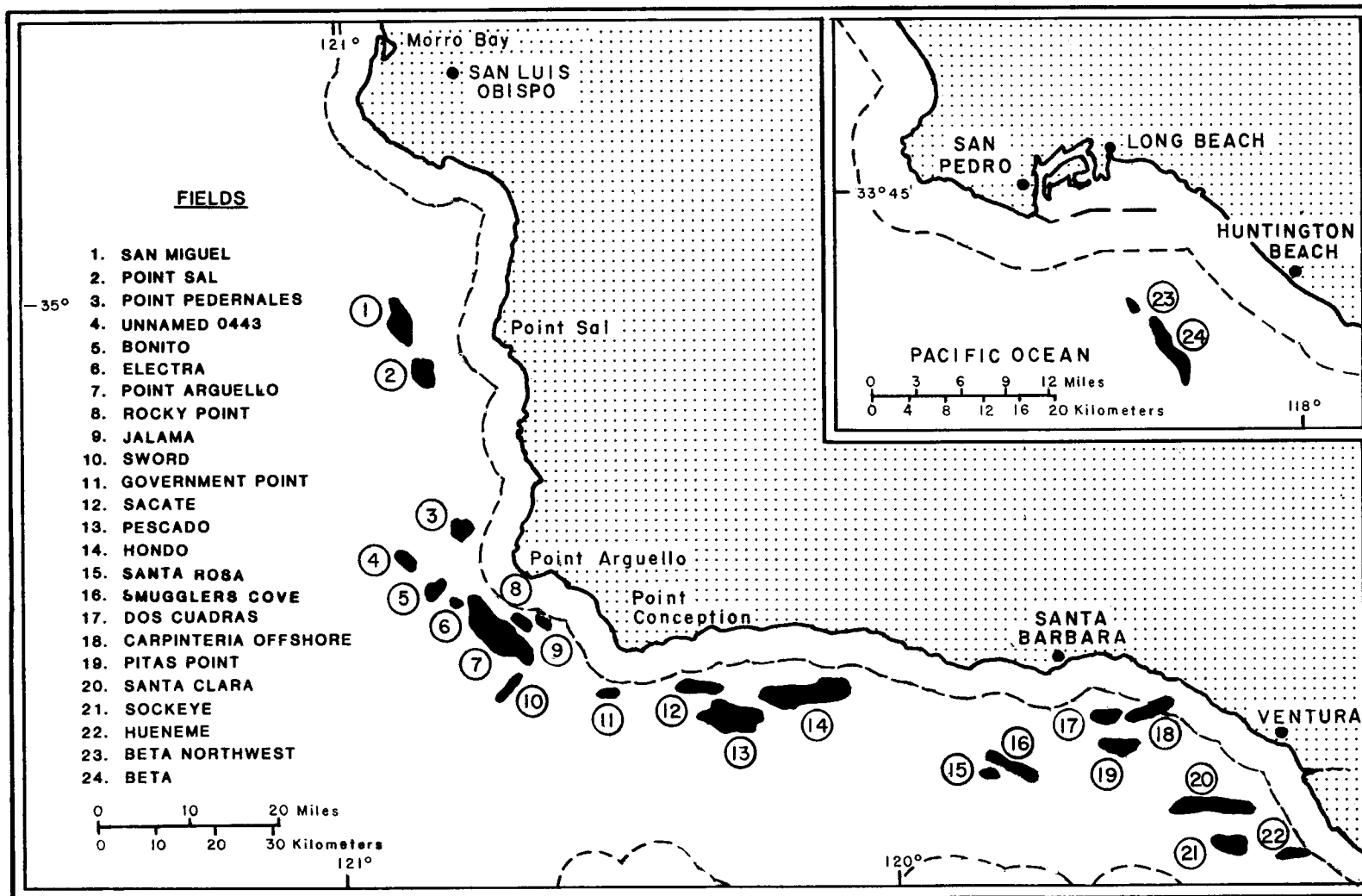


Figure 1. Recognized discoveries of federally controlled oil and gas fields in the Pacific OCS. Dashed lines indicate 3-geographical-mile boundary between State and Federal waters.

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		Hondo Santa Clara	Hondo

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

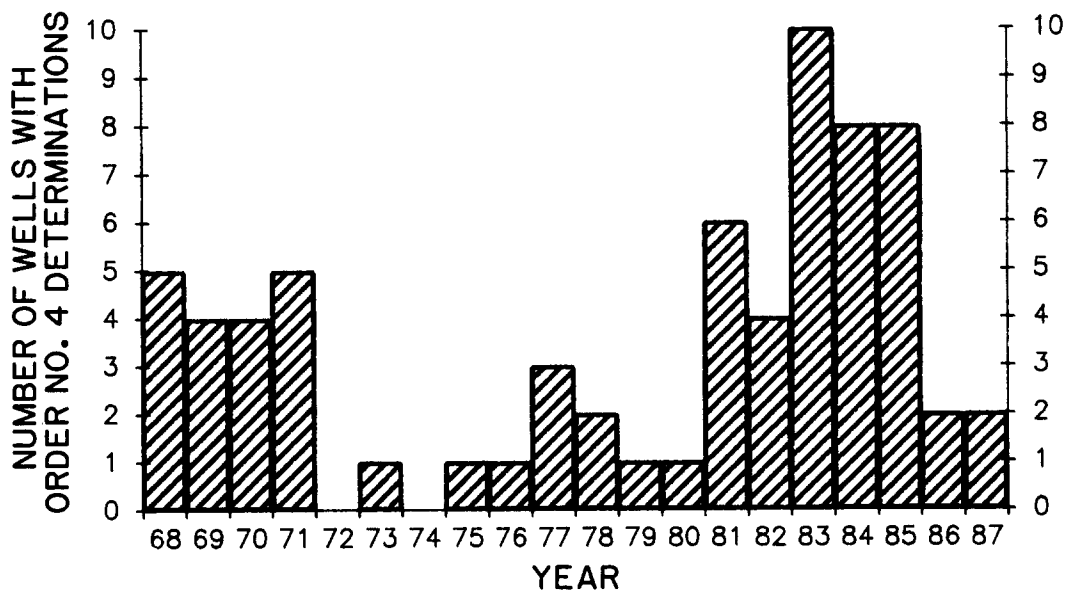


Figure 2. Wells determined to be producible in accordance with OCS Order No. 4.

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 boreholes 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, 1987, 24 fields in the Pacific OCS (fig. 1) were recognized as producing or capable of production on the basis of the "producible in paying quantities" criterion. Two of these fields are gas fields, 13 are oil fields, and 9 are combination oil and gas fields.

The current estimates of demonstrated oil reserves and ultimate production are greater than those for the preceding year. For gas estimates, demonstrated reserves are lower, whereas ultimate production is higher, than the corresponding estimates for December 31, 1986. One non-producing field was terminated. One new field, Smugglers Cove Field, in the Santa Barbara Channel, was added. 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 ultimate production and demonstrated reserves of oil and gas are shown in table 2. The totals appear as composite numbers to protect the proprietary data used to determine the estimates. Previous reserve estimates are shown in table 3 by year and publication. Annual estimates of demonstrated reserves and ultimate production from known fields are shown in figures 3 and 4, respectively.

Table 2. Ultimate production and demonstrated oil and gas reserves for 24 fields, Pacific OCS, December 31, 1987.

Production and Reserves	Oil (MMBBL)	Gas (BCF)
Ultimate production:		
Estimated as of 12/31/87 (MMS 88-0047)..	1,727	2,501
Estimated as of 12/31/86 (MMS 87-0045)..	1,670	2,461
Change.....	+57	+40
Cumulative production:		
Through 1987.....	399	378
Through 1986.....	369	326
Demonstrated reserves:		
Estimated as of 12/31/87 (MMS 88-0047)..	1,328	2,123
Estimated as of 12/31/86 (MMS 87-0045)..	1,302	2,135
Change.....	+26	-12

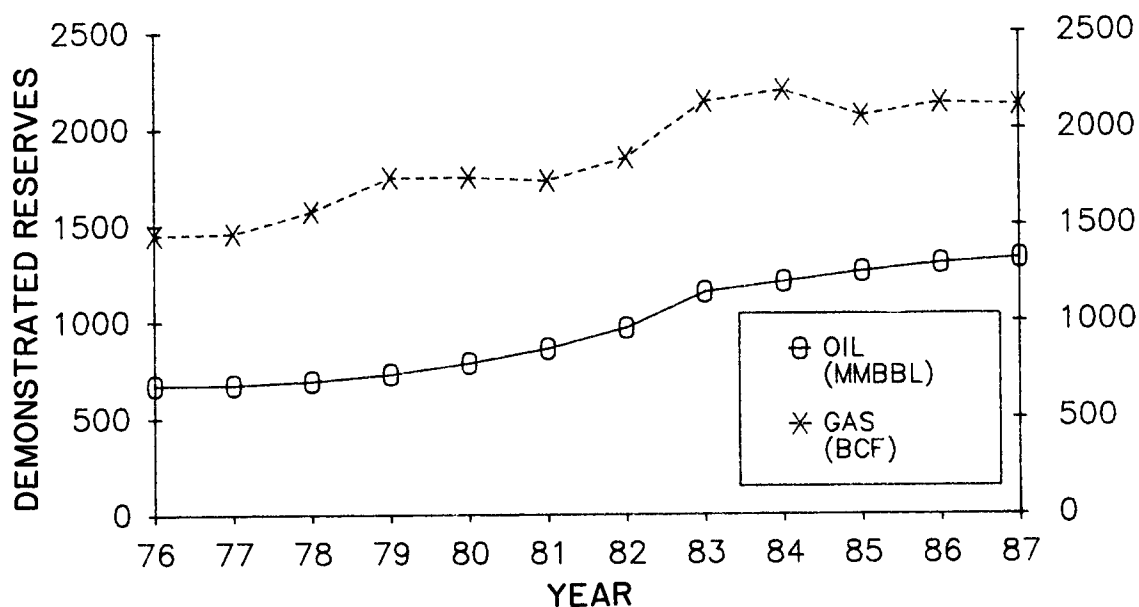


Figure 3. Annual estimates of demonstrated reserves from known fields.

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

Year	Publication	Demonstrated Reserves		Ultimate Production	
		Oil (MMBBL)	Gas (BCF)	Oil (MMBBL)	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
1987	MMS 88-0047	1,328	2,123	1,727	2,501

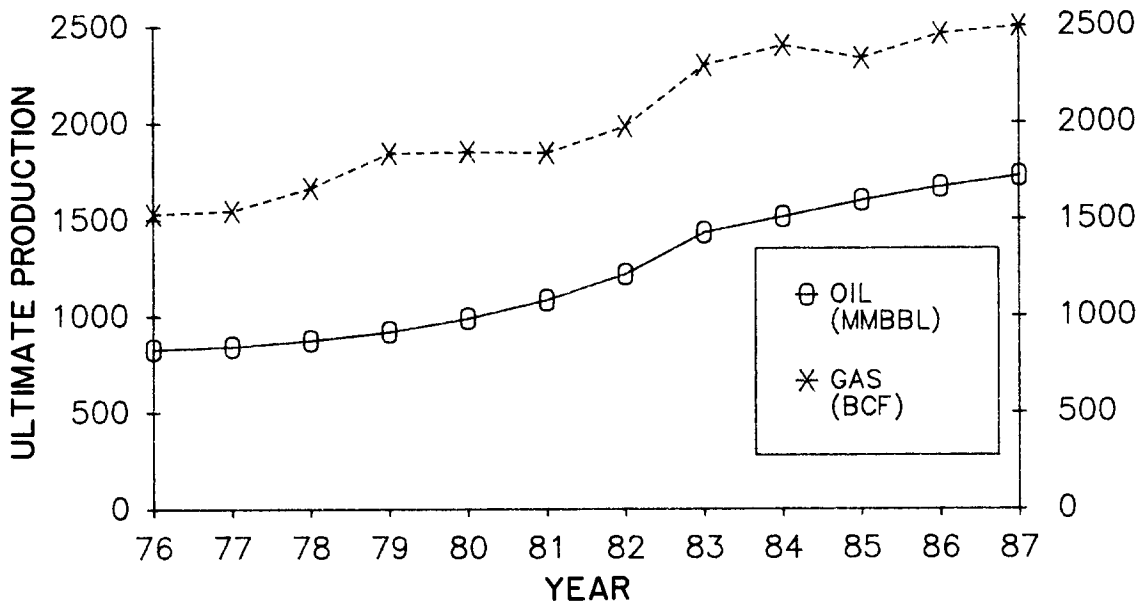


Figure 4. Annual estimates of ultimate production from known fields.

STUDIES CONDUCTED

Reserve estimates for seven of the producing fields--Hondo, Dos Cuadras, Carpinteria Offshore, Pitas Point, Santa Clara, Hueneme, and Beta (fig. 1, fields 14, 17, 18, 19, 20, 22, and 24)--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 17 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 based on current estimated ultimate production for 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).

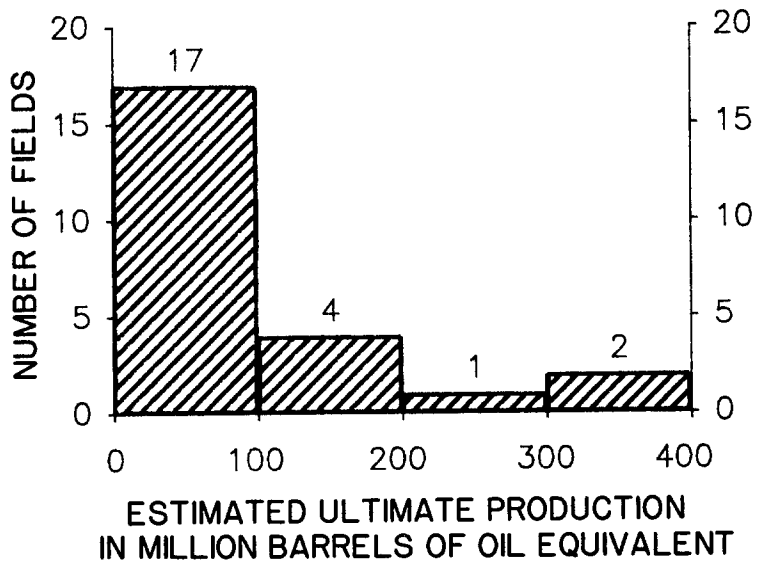


Figure 5. Size distribution of oil and gas fields.

STATUS OF DEVELOPMENT

As of December 31, 1987, five of the fields in the Pacific OCS have completed their primary drilling programs: Dos Cuadras, Carpinteria Offshore, Pitas Point, Hueneme, and Beta (fig. 1, fields 17, 18, 19, 20, 22, and 24). Of the 24 recognized fields, 8 were producing in December of 1987: Point Pedernales, Hondo, Dos Cuadras, Carpinteria Offshore, Pitas Point, Santa Clara, Hueneme, and Beta (fig. 1, fields 3, 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 to promote effective development. Startup of sustained production from the Point Arguello and Sockeye Fields is anticipated by late 1988.

PRODUCTION RATES AND DRILLING HISTORY

Annual production through 1987 is shown in table 4 and figure 6. The average daily production during 1987 was approximately 86,000 barrels of oil per day and 150,000 thousand cubic feet of gas per day. The 1987 oil production of 31.28 million barrels was the highest annual total in the region's 20-year production history. The average gas-oil ratio for the oil wells was approximately 1,000 cubic feet of gas per barrel.

There were 318 exploratory wells spudded by yearend. Historically, 68 determinations of producible in paying quantities (discovery wells) have been issued. Therefore, approximately 1 out of 5 wells has encountered new accumulations in the Pacific OCS Region. The term "exploratory wells" is used here to also include delineation, confirmation, and step-out wells.

Table 4. Annual and cumulative production 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	35,054,064	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	18,818,026	109,538,337	9,157,714	60,568,497
1974	16,784,100	126,322,437	7,234,937	67,803,434
1975	15,434,507	141,756,944	5,978,959	73,782,393
1976	13,977,436	155,734,380	5,533,258	79,315,651
1977	12,258,013	167,992,393	5,366,181	84,681,832
1978	11,979,674	179,972,067	5,193,985	89,875,817
1979	10,971,013	190,943,080	5,430,689	95,306,506
1980	10,118,614	201,061,694	5,771,792	101,078,298
1981	19,619,670	220,681,364	12,769,110	113,847,408
1982	28,471,665	249,153,029	17,814,958	131,662,366
1983	30,558,866	279,711,895	23,923,258	155,585,624
1984	30,500,506	310,212,401	45,912,435	201,498,059
1985	29,674,099	339,886,500	63,523,094	265,021,153
1986	28,778,859	368,665,359	58,003,316	323,024,469
1987	31,281,258	399,946,617	54,876,319	377,900,788

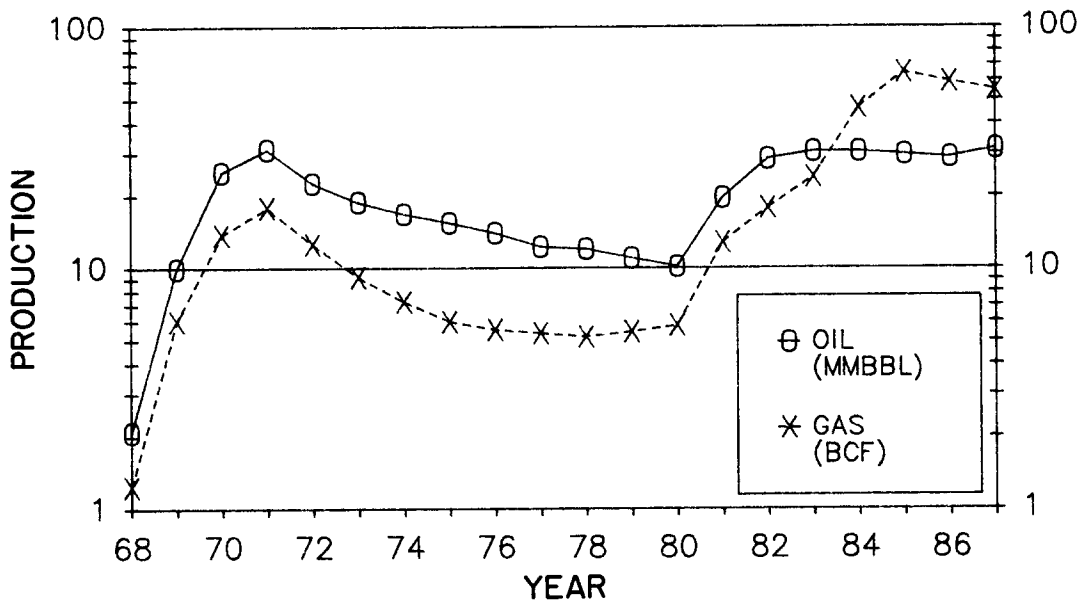


Figure 6. Annual production rates for the Pacific OCS.

Drilled footage by year for all exploratory and development wells spudded in the Pacific OCS Region is displayed in figure 7. Table 5 shows the yearend summary of the borehole status for all development wells.

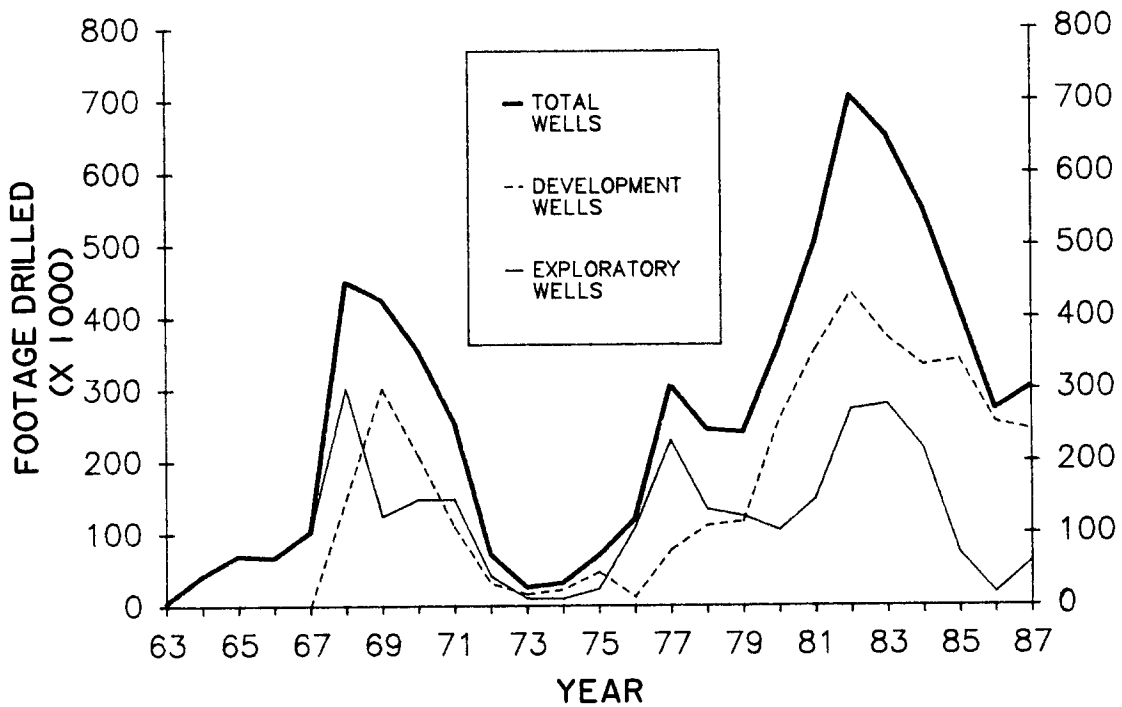


Figure 7. Annual drilled footage for wells in the Pacific OCS.

Table 5. Summary of development well borehole status.

PLATFORM	POW	PGW	OSI	GSI	GIW	WIW	WDW	WSW	SUSP	PA	TOTAL	ACT
A	41	0	6	0	0	2	1	0	0	15	65	0
B	39	0	5	0	0	4	0	0	0	19	67	0
C	22	0	1	0	0	4	0	0	0	0	27	0
EDITH	6	0	12	0	0	0	0	0	2	1	21	0
ELLEN	32	0	2	0	2	20	1	2	0	7	66	0
EUREKA	24	0	7	0	0	10	1	0	0	1	43	1
GILDA	39	2	2	1	0	12	0	0	0	4	60	2
GINA	6	0	0	0	0	5	0	0	0	1	12	0
GRACE	15	2	7	1	0	0	0	0	3	6	34	0
HABITAT	0	12	0	3	0	0	0	0	2	0	17	0
HARVEST	0	0	6	0	0	0	0	0	2	0	8	2
HENRY	22	0	1	0	0	0	0	0	0	2	25	0
HERMOSA	0	0	5	0	0	0	0	0	0	0	5	0
HIDALGO	0	0	0	0	0	0	0	0	0	0	0	1
HILLHOUSE	41	0	3	0	0	1	0	0	0	3	48	1
HOGAN	17	0	14	0	2	0	3	0	0	14	50	0
HONDO	20	0	3	0	2	1	2	0	0	4	32	1
HOUCHIN	25	0	7	0	0	0	0	0	1	10	43	0
IRENE	11	0	0	0	0	0	0	0	1	0	12	0
TOTAL	360	16	81	5	6	59	8	2	11	87	635	8

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 6 and figure 8.

Table 6. Formations within each reservoir age group.

Reservoir Age Group	Formations	Reserves* MMBBL	Estimated Production* MMBBL
Post-Monterey	Pico, Puente, Repetto, Santa Margarita, Sisquoc	226	573
Monterey	Monterey	1,281	1,386
Pre-Monterey	Camino Cielo, Gaviota, Cretaceous, Hueneme, Jalama, Matilija, Point Sal, Sacate, Sespe/Alegria, Topanga, Vaqueros	175	184

*Barrels of oil equivalent.

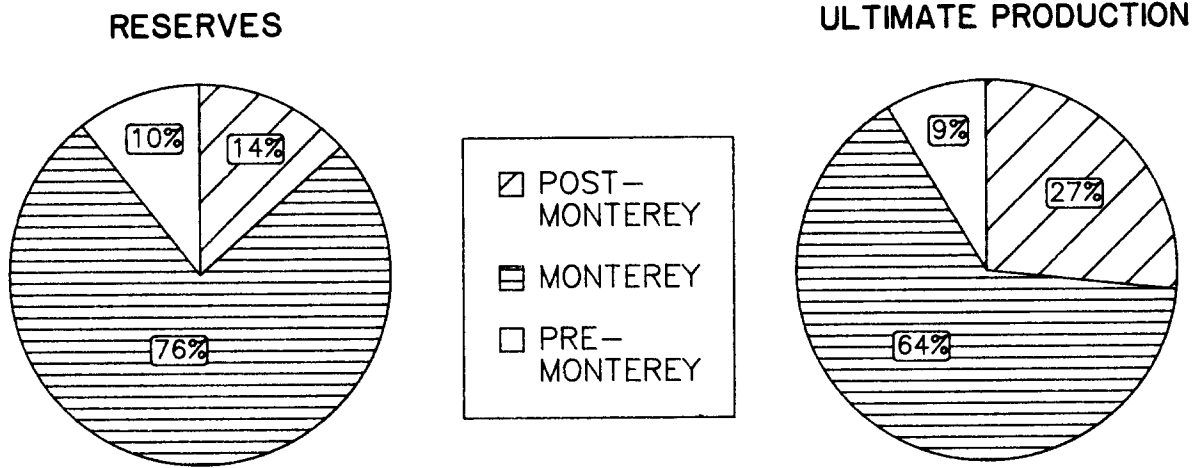


Figure 8. Reserves and estimated ultimate production by reservoir age group.

CONCLUSIONS

As of December 31, 1987, the remaining recoverable reserves in 24 known oil and gas fields in the Pacific OCS are estimated at 1,328 million barrels of oil and 2,123 billion cubic feet of gas. These figures represent an increase of 26 million barrels of oil and a decrease of 12 billion cubic feet of gas from the December 31, 1986 estimates. These changes result from the refinement of estimates for several fields, the addition of one new field, and the deletion of one field.

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