Pacific Outer Continental Shelf

OCS Report
MMS 90-0086

Estimated Oil and Gas Reserves
Pacific Outer Continental Shelf
(as of December 31, 1989)

MMS U.S. Department of the Interior
Minerals Management Service
Pacific OCS Region

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by
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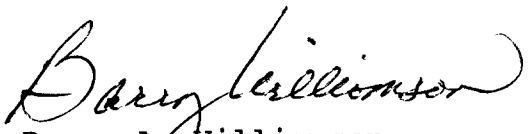
FOREWORD

The Minerals Management Service conducts studies of proved oil and gas reserves of fields in the Federal Outer Continental Shelf (OCS) of the United States. Currently, two separate reports, one for the Pacific OCS and the other for the Gulf of Mexico OCS, are published annually. This report, covering the Pacific OCS, contains estimates of the original and remaining recoverable reserves as well as the annual and cumulative production. It is of interest to note that 33 percent of the original recoverable proved oil reserves and 24 percent of the original recoverable proved gas reserves for the Pacific OCS have already been produced. The importance of the need for more exploration and resulting discoveries cannot be overstated in striving to meet this Nation's future energy needs.

A significant portion (22 percent measured in barrels of oil equivalent) of the proved remaining recoverable reserves in the Pacific OCS consists of natural gas. As the environmental consciousness of the Nation rises and traditional supplies of oil either decline or become less reliable, natural gas will become of increasingly greater importance. Currently, the OCS accounts for more than 1/4 of the total domestic U.S. natural gas production.

This report is intended to assist the public, the oil and gas industry, and other Government Agencies engaged in oil and gas activities on the OCS and analysis of domestic supplies.



Barry A. Williamson
Director
Minerals Management Service

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Abbreviations

ACT . . . Actively Drilling
API . . . . American Petroleum Institute
bbl . . . . Barrel of Oil (42 gallons)
Bcf . . . . Billion Cubic Feet of Gas
BOE . . . Barrels of Oil Equivalent
CFR . . . Code of Federal Regulations
DPP . . . Development and Production Plan
°F . . . . . Degrees Fahrenheit
GIW . . . Gas Injection Well
GSI . . . . Gas Well Shut-in
Mcf . . . Thousand Cubic Feet of Gas
MMbbl . Million Barrels of Oil
MMS . . Minerals Management Service
OCS . . . Outer Continental Shelf
OFR . . . Open File Report
OSI . . . . Oil Well Shut-in
PA . . . . Plugged and Abandoned
PGW . . . Producing Gas Well
POW . . . Producing Oil Well
psia . . . . Pounds per Square Inch Absolute
SPE . . . Society of Petroleum Engineers
SUSP . . Suspended (includes temporarily abandoned and inactive completions)
WDW . . Water Disposal Well
WIW . . . Water Injection Well
WSW . . Water Source Well

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Abstract

Proved reserves of oil* and gas** in the Pacific Outer Continental Shelf (OCS), offshore California, are estimated to be 951 million barrels of oil and 1,515 billion cubic feet of gas as of December 31, 1989. These reserves are attributed to 13 fields. Original recoverable reserves from these fields are estimated to be 1,415 million barrels of oil and 1,992 billion cubic feet of gas. Unproved reserves of oil and gas in the Pacific OCS, offshore California, are estimated to be 572 million barrels of oil and 731 billion cubic feet of gas as of December 31, 1989. These reserves are attributed to 24 fields. Original recoverable reserves from these 24 fields are the same as the remaining reserves because these fields have not had any sustained production. Of the 37 fields, reserve estimates for 30 fields were determined by individual reservoir volumetric studies, while decline-curve and volumetric analyses were used for the remaining seven. At the end of 1989, nine fields were producing.

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

Introduction

This report, which supersedes OCS Report MMS 89-0085 (Adams and Wolfson, 1989), presents estimates of original recoverable oil and gas reserves, cumulative production through 1989, and estimates of remaining reserves as of December 31, 1989 for the Pacific Outer Continental Shelf (OCS), offshore California. These estimates were completed in April 1990. 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 from the MMS, Pacific OCS Regional Office, Camarillo, California.

Definition of Resource and Reserve Terminology

The MMS has standardized its definitions of resources (Estimates of Undiscovered Conventional Oil and Gas Resources in the United States - A Part of the Nation's Energy Endowment, U.S. Geological Survey and Minerals Management Service, 1989). The Society of Petroleum Engineers (SPE) has also adopted a standardized set of reserve categories and definitions (1987, p. 577-578). The definitions used within this report conform with both these sources. Figure 1 shows how resource and reserve definitions relate.

Undiscovered Resources -- Resources estimated from broad geologic knowledge and theory, existing outside of known fields or known accumulations are undiscovered resources. Undiscovered resources can exist in untested prospects on unleased acreage, or on undrilled leased acreage, or in known fields. In known fields, undiscovered resources occur in undiscovered pools that are controlled by distinctly separate structural features or stratigraphic conditions from the discovered resources (U.S. Geological Survey and Minerals Management Service, 1989).

Discovered Resources -- Once leased acreage is drilled and is determined to contain oil or gas under Code of Federal Regulations (CFR) Title 30 Part 250, Subpart A, Section 11, Determination of Well Producibility (hereinafter referred to as 30 CFR 250.11), the lease is considered to have discovered resources. Discovered resources are the equivalent of identified resources as reported by Dolton and others (1981). Identified resources are resources whose location and quantity are known or are estimated from specific geologic and/or engineering evidence and include economic, marginally economic, and subeconomic components. Discovered resources can be further characterized as unproved or proved reserves depending upon evidence of economic viability. The number of wells determined to be producible in accordance with 30 CFR 250.11 is shown in figure 2.

Unproved Reserves -- After a lease qualifies under 30 CFR 250.11, the MMS Field Naming Committee reviews the new producible lease to assign it to an existing field or, if the lease is not associated with an established geologic structure, to a new field. Regardless of where the lease is assigned, the reserves associated with the lease are initially considered to be unproved

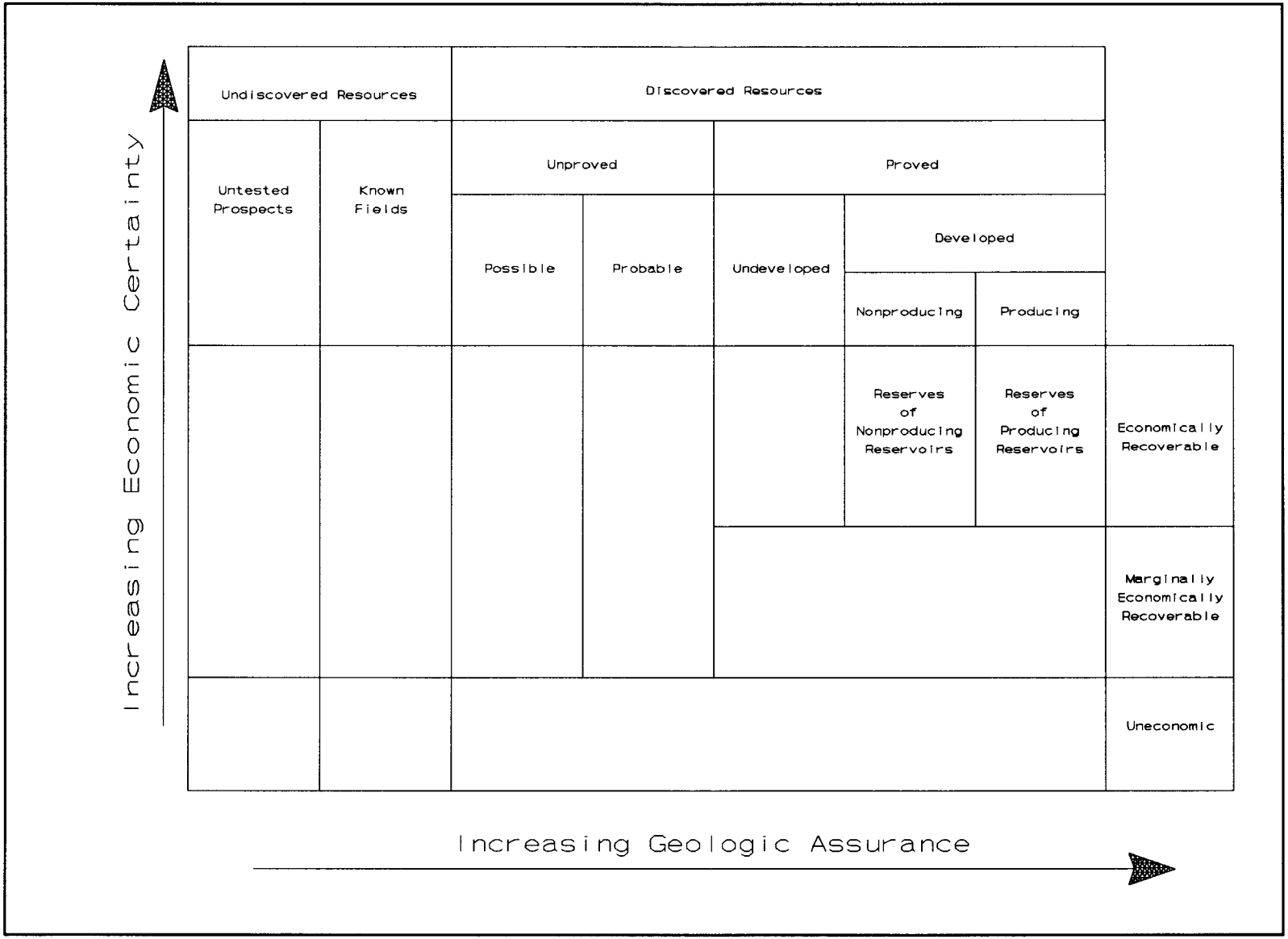

Figure 1. MMS petroleum reserve classification (modified from USGS & MMS, and SPE, 1987)

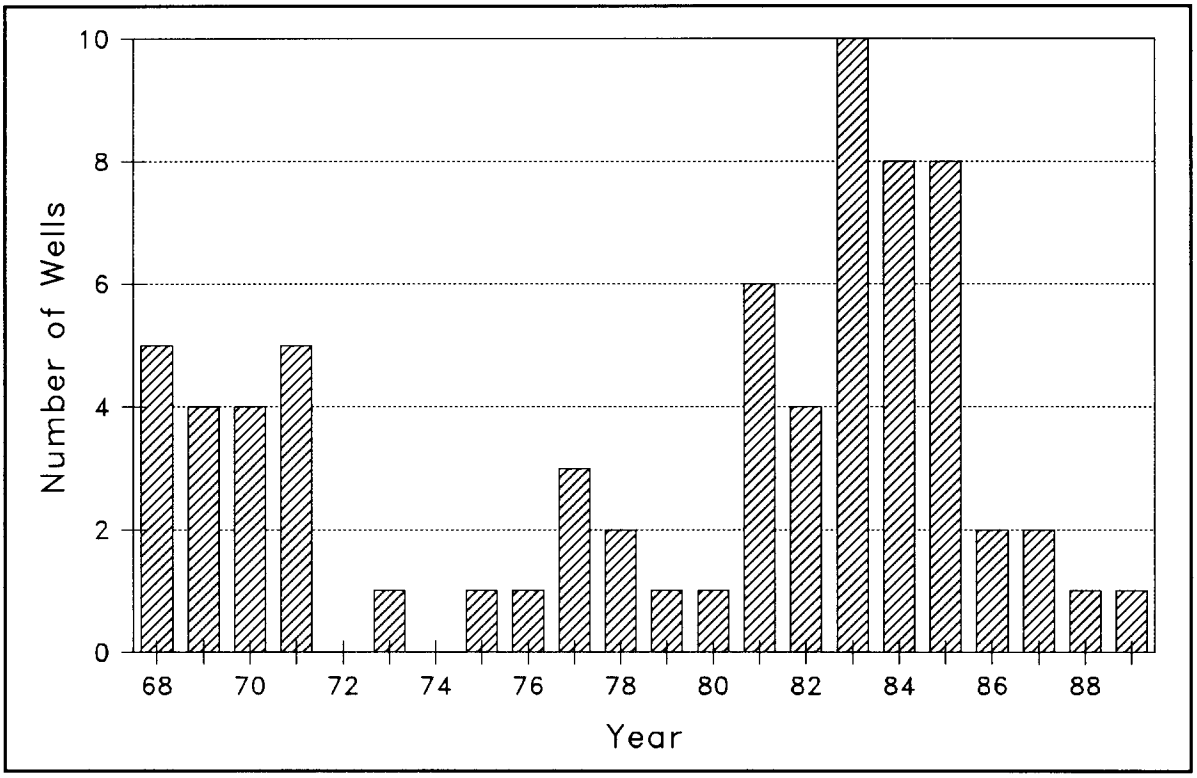

Figure 2. Wells determined to be producible in accordance with 30 CFR 250.11.

reserves. Unproved reserves are based on geologic and/or engineering information similar to that used in estimates of proved reserves; but technical, contractual, economic, or regulatory uncertainties preclude such reserves being classified as proved.

Unproved reserves may be divided into two subclassifications, possible and probable, which are similarly based on the level of uncertainty.

Unproved Possible Reserves -- "Unproved possible reserves are less certain than unproved probable reserves and can be estimated with a low degree of certainty, which is insufficient to indicate whether they are more likely to be recovered than not. Reservoir characteristics are such that a reasonable doubt exists that the project will be commercial" (SPE, 1987). After a lease qualifies under 30 CFR 250.11, the reserves associated with the lease are initially classified as unproved possible.

Unproved Probable Reserves -- "Unproved probable reserves are less certain than proved reserves and can be estimated with a degree of certainty sufficient to indicate they are more likely to be recovered than not" (SPE, 1987). Reserves in fields for which a Development and Production Plan (DPP) and schedule leading to production have been submitted to the MMS have been classified as unproved probable.

Proved Reserves -- "Proved reserves can be estimated with reasonable certainty to be recoverable under current economic conditions, such as prices and costs prevailing at the time of the estimate. Proved reserves must either have facilities that are operational at the time of the estimate to process and transport those reserves to market or a commitment or reasonable expectation to install such facilities in the future" (SPE, 1987). Proved reserves can be subdivided into undeveloped and developed.

Proved Undeveloped Reserves -- Reserves are classified proved undeveloped when a relatively large expenditure is required to install production and/or transportation facilities, a commitment by the operator is made, and a time frame to commence production is established. Proved undeveloped reserves are reserves expected to be recovered from (1) yet undrilled wells, (2) deepening existing wells, or (3) existing wells for which a relatively large expenditure is required for recompletion.

Proved Developed Reserves -- "Reserves that are expected to be recovered from existing wells (including reserves behind-pipe) are classified as proved developed reserves. Reserves are considered developed only after necessary production and transportation equipment have been installed or when the installation costs are relatively minor. Proved developed reserves are subcategorized as producing or non-producing" (SPE, 1987). This distinction is made at the reservoir level and not the field level.

Proved Developed Producing Reserves -- Once the first reservoir in a field begins production, the reservoir is considered to contain proved developed producing reserves, and the field is considered on production. If a reservoir had sustained production during the last year, it is considered to contain proved developed producing reserves.

Proved Developed Nonproducing Reserves -- Any developed reservoir in a developed field that has not produced or has not had sustained production during the past year is considered to contain proved developed nonproducing reserves. This category includes reserves contained in nonproducing reservoirs, containing reserves behind-pipe and reservoirs awaiting well workovers or transportation facilities. A diagram of the reserves classification procedure is shown in figure 3.

Total Reserves -- An amount equal to the sum of proved and unproved reserves.

Original Recoverable Reserves -- The amount of oil and gas expected to be recovered from the original oil in place or the amount equal to the sum of cumulative production and remaining reserves is considered to be the original recoverable reserves.

Production Data -- The measured volumes of gross hydrocarbons reported to the MMS by Federal lessees and operators. Oil and gas volume measurements and reserves are corrected to reference standard conditions of 60° F and 14.73 psia. Continuously measured volumes from production platforms and/or leases are allocated to individual wells and reservoirs on the basis of periodic well tests. These procedures introduce approximations in both production and reserves data by reservoirs and by fields.

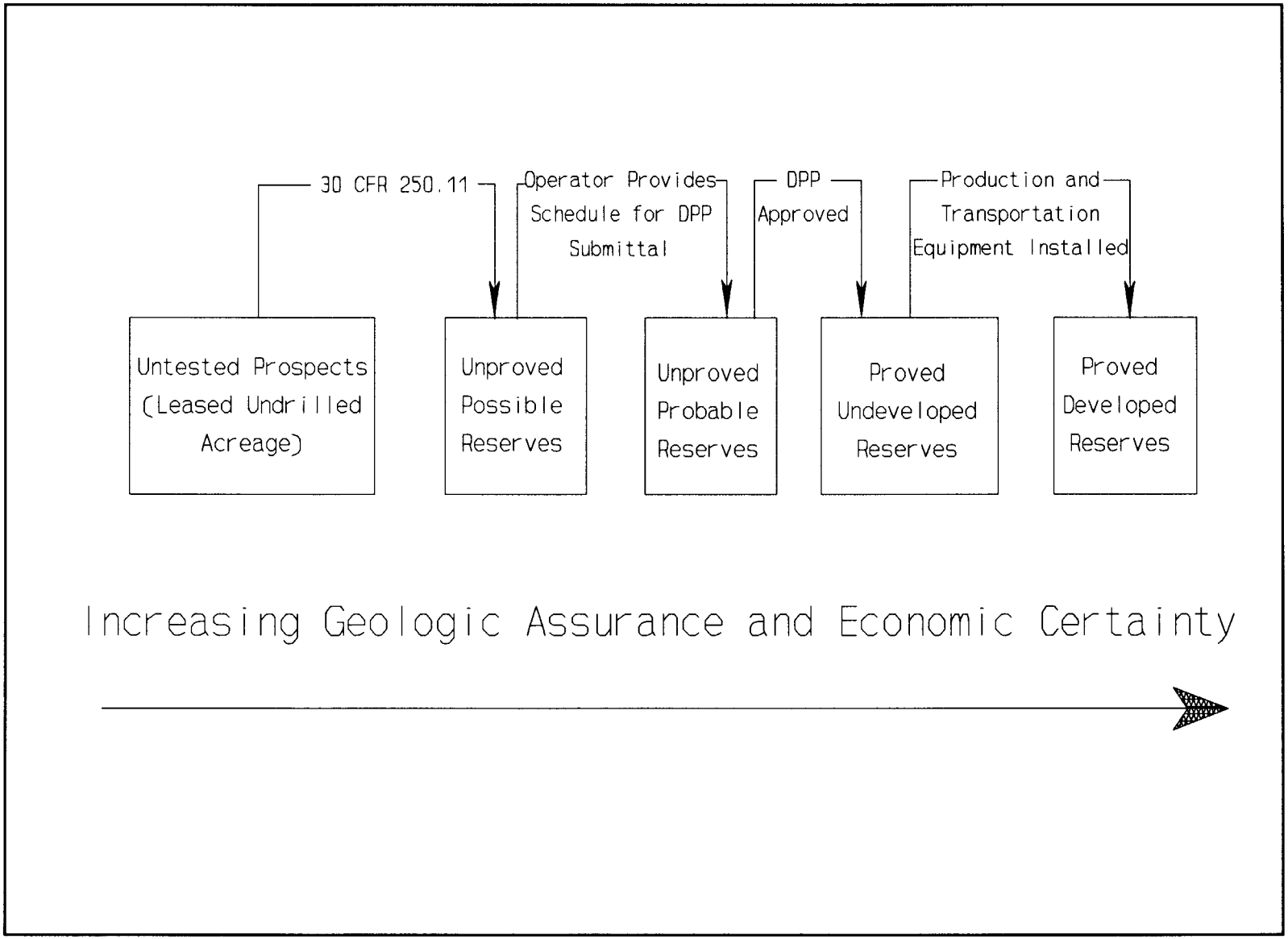

Figure 3. Pacific OCS MMS reserves classification procedure

Methods Used for Estimating Reserves

Volumetric calculation -- For the volumetric calculation of reserves, 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 and 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 estimated amount of original oil and gas in place is converted to standard conditions by analysis of pressure, volume, and temperature relationships and by the use of standard correlations. The amount of the original oil and gas in place that can be recovered is estimated from information about the reservoir drive-mechanism, spacing of the wells, analog field recovery factors, and API recovery factor equations (Arps and others, 1967, p. 19-20).

Decline-curve analysis -- In the decline-curve analysis 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, 1989, 37 fields in the Pacific OCS (figure 4) are recognized as containing reserves under the established criteria. Two of these fields are gas fields, 26 are oil fields, and 9 are combination oil and gas fields. The number of fields increased by 13 from the previous report (Adams and Wolfson, 1989), and this increase is attributed to the evaluation of wells that were analyzed subsequent to the change in reserves definitions and determined to have tested unproved possible oil reserves.

Thirteen fields were determined to have proved reserves of oil and gas. These 13 fields are San Miguel, Point Pedernales, Point Arguello, Pescado, Sacate, Hondo, Dos Cuadras, Pitas Point, Carpinteria Offshore, Santa Clara, Sockeye, Hueneme, and Beta (figure 4, fields 2, 7, 11, 19, 20, 22, 28, 29, 30, 32, 33, 35, and 37). The remaining 24 fields were determined to have unproved reserves of oil and gas.

The current Pacific OCS total estimates for proved, unproved, and total reserves of oil and gas are shown in table 1. The totals appear as aggregate numbers to protect the proprietary data used to determine the estimates. Annual estimates of remaining recoverable reserves from Pacific OCS fields are graphically shown in figure 5. Estimates of original recoverable reserves for several individual fields were refined as development drilling continued to delineate the fields. Previous estimates of original recoverable reserves are shown in table 2 by year and source publication. Annual estimates of original recoverable reserves from Pacific OCS fields are shown in figure 6. Differences in reported reserves and production from the previous report (Adams and Wolfson, 1989) are summarized in table 3.

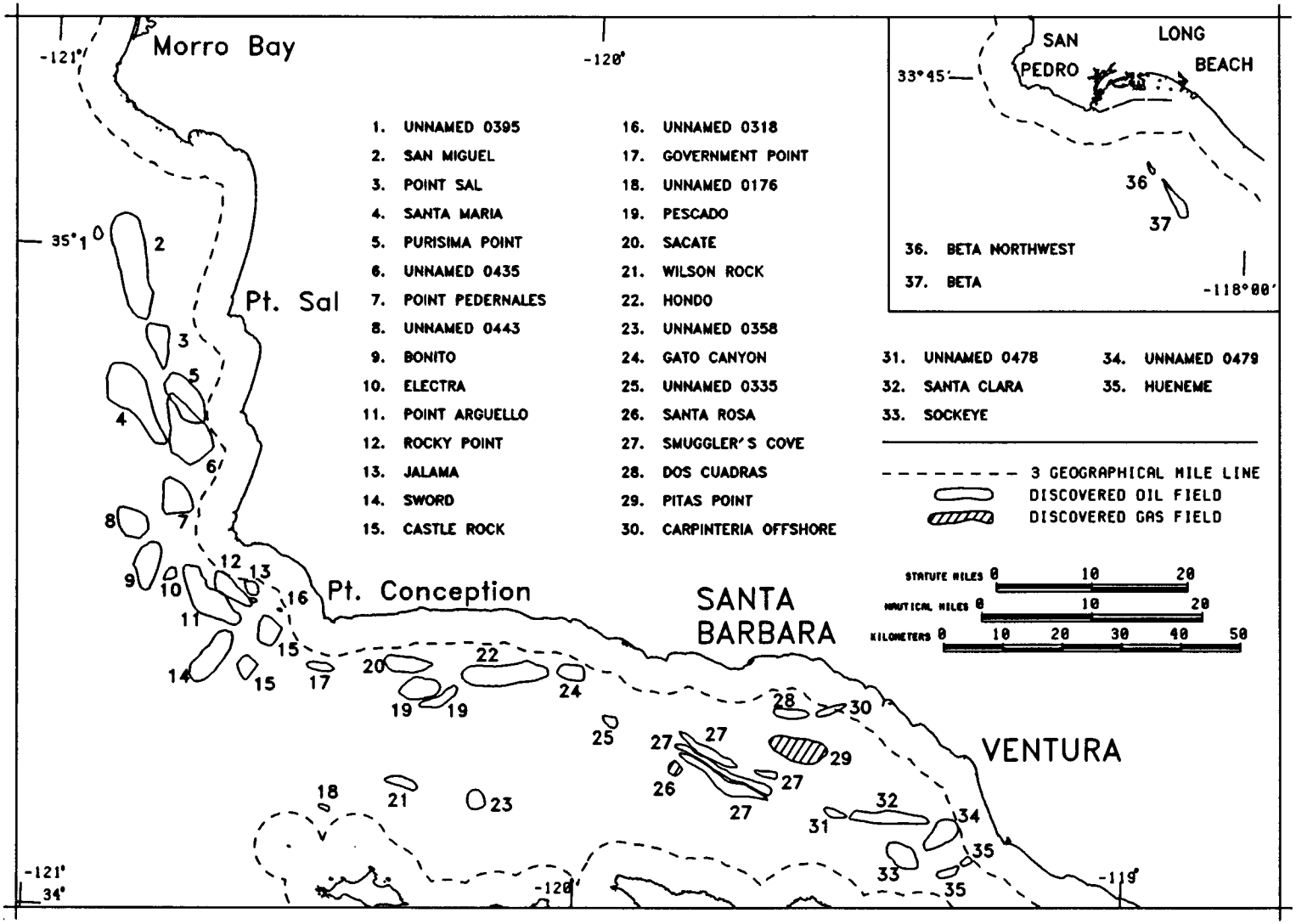

Figure 4. Recognized discoveries of federally controlled oil and gas fields in the Pacific OCS. Dashed lines indicate 3-geographical mile boundary between State and Federal waters.

Studies Conducted

Reserve estimates for seven of the producing fields were conducted from volumetric calculations and decline-curve analyses: Hondo, Dos Cuadras, Pitas Point, Carpinteria Offshore, Santa Clara, Hueneme and Beta (figure 4, fields 22, 28, 29, 30, 32, 35, and 37)

Individual reservoirs in each field were grouped for volumetric calculations, while decline-curve analyses were made on lease-by-lease and platform bases. The 30 remaining fields were studied on a reservoir-by-reservoir basis, and the reserve estimates were determined solely by the volumetric calculation method.

Field Size Distribution

Figure 7 shows the field size distribution based on current estimated original recoverable reserves for 35 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 (5,620 cubic feet of gas has the approximate heating value of one barrel of oil), hereinafter referred to as BOE.

Status of Field Development

As of December 31, 1989, five of the fields in the Pacific OCS have completed their primary drilling programs: Dos Cuadras, Pitas Point, Carpinteria Offshore, Hueneme, and Beta (figure 4, fields 28, 29, 30, 35, and 37). Of the 37 recognized fields, 9 were producing in December, 1989: Point Pedernales, Hondo, Dos Cuadras, Pitas Point, Carpinteria Offshore, Santa Clara, Sockeye, Hueneme, and Beta (figure 4, fields 7, 22, 28, 29, 30, 32, 33, 35, and 37). Additional exploratory and delineation wells are anticipated in many of the remaining fields to further define productive limits and optimize oil and gas recovery.

Five producing oil and gas fields in the Pacific OCS are undergoing fluid injection: Hondo, Dos Cuadras, Santa Clara, Hueneme, and Beta (figure 4, fields 22, 28, 32, 35, and 37). Recovery beyond primary production is occurring or can be anticipated (table 4). One field, Hondo, is undergoing gas injection for reservoir pressure maintenance. Four fields, Hondo, Santa Clara, Hueneme, and Beta, are undergoing water injection. One field, Dos Cuadras, is undergoing polymer injection.

Production Rates and Drilling History

Annual production through 1989 is shown in table 5 and figure 8. The 1989 oil production of 33 million barrels was the highest annual total in the Pacific OCS Region's 22-year history. Cumulative production through 1989 is shown in table 5 and figure 9.

There were 329 exploratory wells and 692 development wells spudded by yearend. Drilled footage by year for all exploratory and development wells in the Pacific OCS is displayed in figure 10. Table 6 shows the yearend summary of the borehole status for all development wells.

Table 1. Proved, unproved, and total oil and gas reserves for 37 fields, Pacific OCS, December 31, 1989.

Reserves	Number of Fields	Original Recoverable Reserves		Cumulative Production		Annual Production		Remaining Reserves	
		Oil (MMbbl)	Gas (Bcf)	Oil (MMbbl)	Gas (Bcf)	Oil (MMbbl)	Gas (Bcf)	Oil (MMbbl)	Gas (Bcf)
Proved Reserves	13	1,415	1,992	464	478	33	51	951	1,515
Unproved Reserves	24	572	731	0	0	0	0	572	731
Total Reserves	37	1,987	2,723	464	478	33	51	1,523	2,246

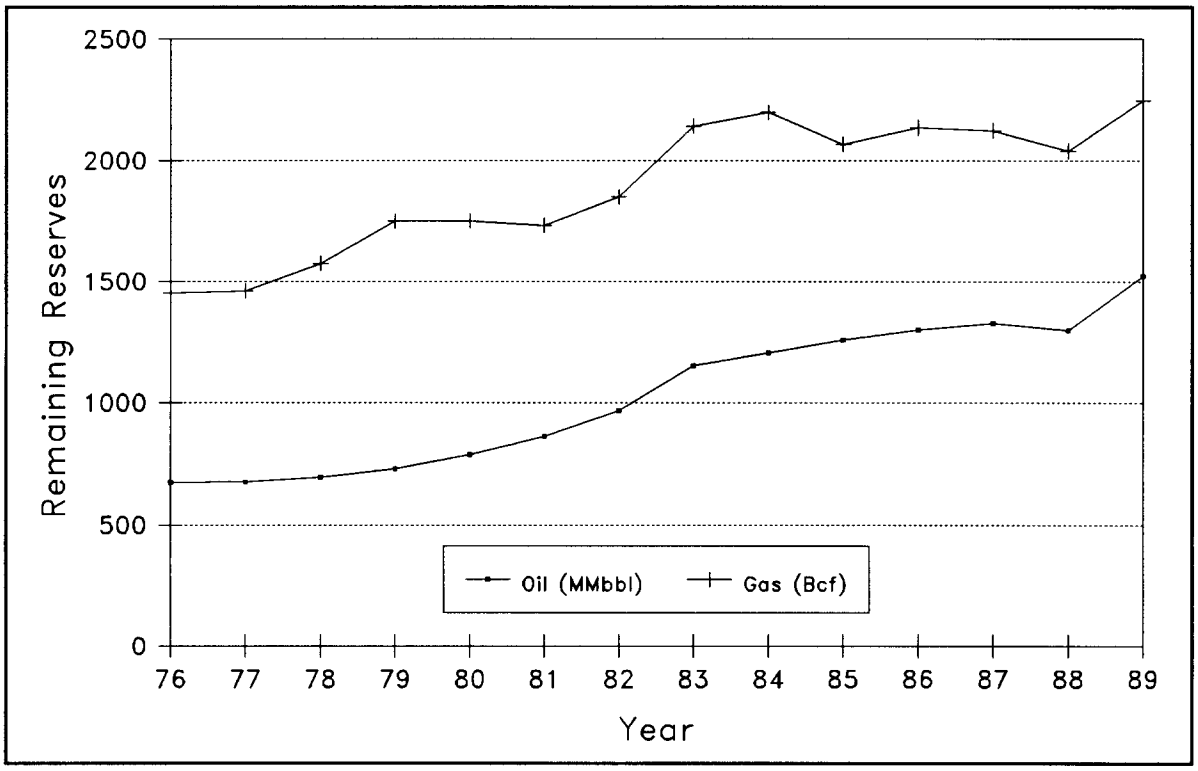

Figure 5. Annual estimates of remaining recoverable reserves from known fields.

Table 2. Annual estimates of original recoverable reserves with source publication numbers.

Original Recoverable Reserves			
Year	Publication	Oil (MMbbl)	Gas (Bcf)
1976	OFR 78-387	829	1,530
1977	OFR 79-345	843	1,546
1978	OFR 80-477	875	1,665
1979	OFR 80-1042	920	1,845
1980	OFR 81-623	988	1,853
1981	OFR 82-37	1,082	1,847
1982	OFR 83-559	1,217	1,983
1983	OFR 84-0024	1,433	2,298
1984	MMS 85-0041	1,515	2,400
1985	MMS 86-0066	1,599	2,334
1986	MMS 87-0045	1,670	2,461
1987	MMS 88-0047	1,727	2,501
1988	MMS 89-0085	1,729	2,467
1989	MMS 90-0086	1,987	2,723

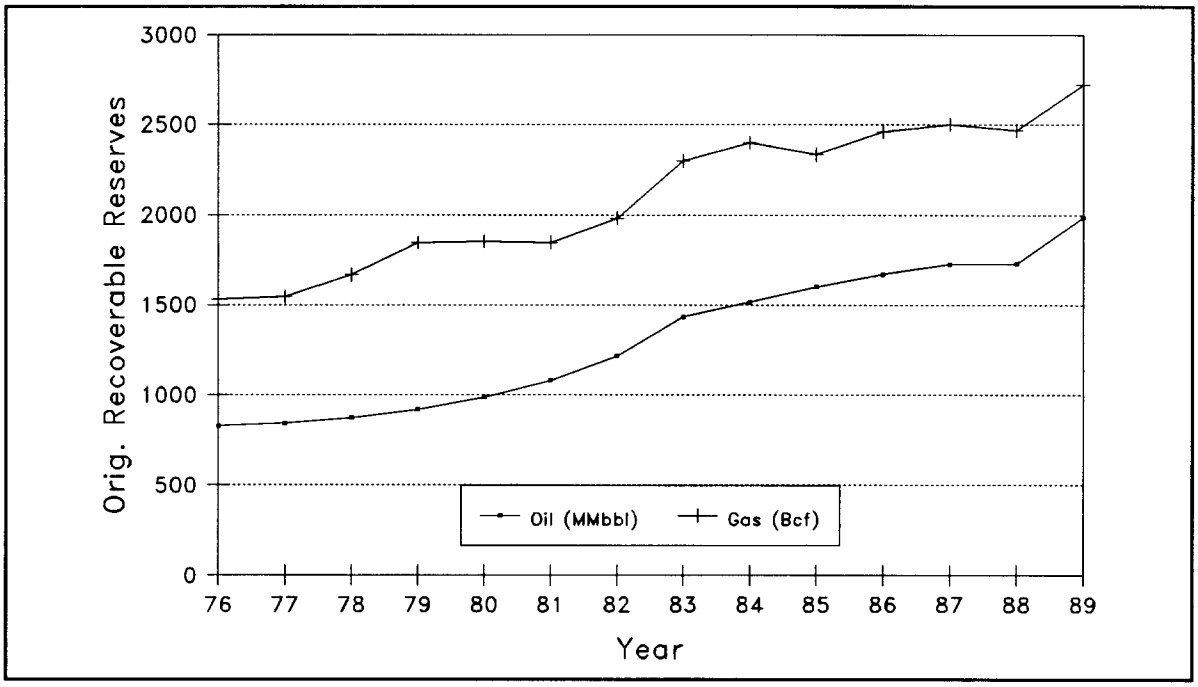

Figure 6. Annual estimates of original recoverable reserves from known fields.

Table 3. Changes in reported reserves and production, Pacific OCS, December 31, 1989.

Production and Reserves	Oil (MMbbl)	Gas (Bcf)
Original Recoverable Reserves:		
Estimated as of 12/31/89 (MMS 90-0086)	1,987	2,723
Estimated as of 12/31/88 (MMS 89-0085)	1,729	2,467
Change	+258	+256
Cumulative Production:		
Through 1989	464	478
Through 1988	431	427
Proved Reserves:		
Estimated as of 12/31/89 (MMS 90-0086)	951	1,515
Estimated as of 12/31/88 (MMS 89-0085)	988	1,572
Change	-37	-57
Total Reserves:		
Estimated as of 12/31/89 (MMS 90-0086)	1,523	2,246
Estimated as of 12/31/88 (MMS 89-0085)	1,298	2,040
Change	+225	+206

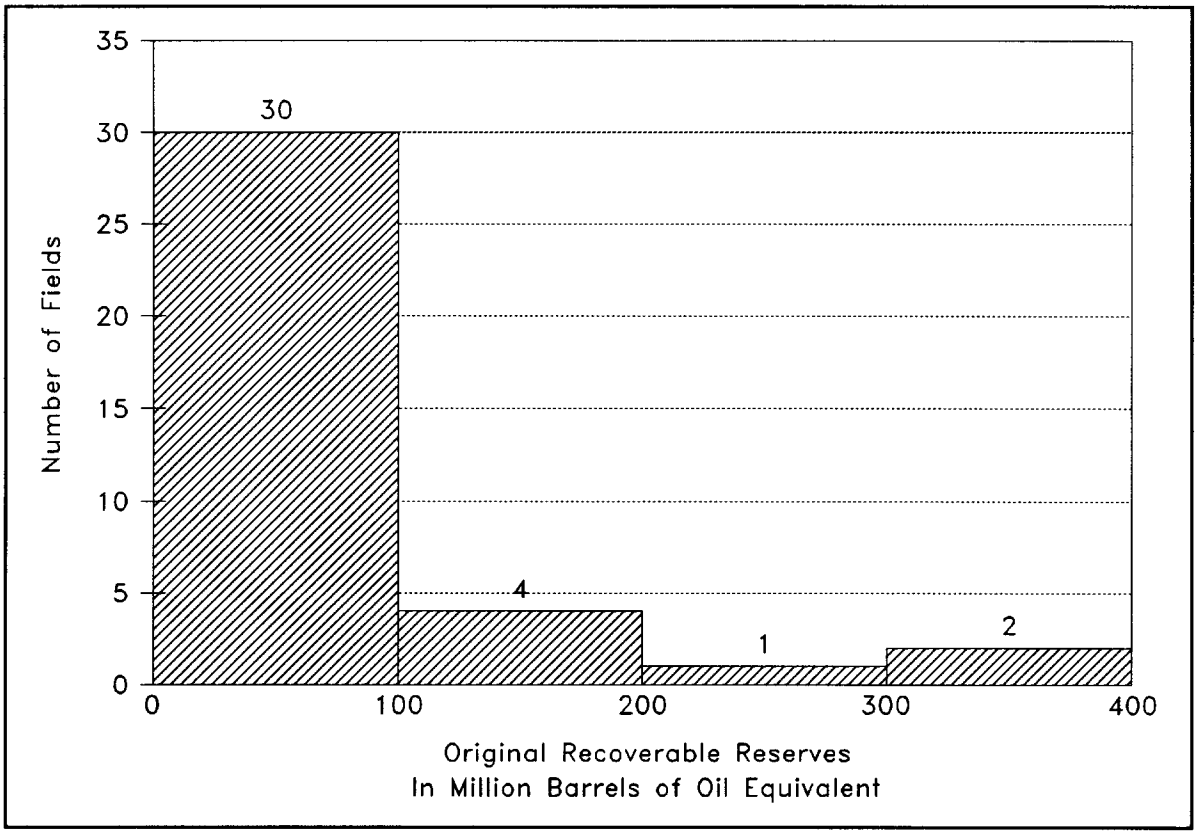

Figure 7. Size distribution of oil and gas fields.

Table 4. Secondary 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

Table 5. 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	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	18,818,026	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	29,673,649	339,886,050	63,523,094	265,021,153
1986	28,779,936	368,665,986	57,989,035	323,010,188
1987	31,284,618	399,950,604	54,874,298	377,884,486
1988	31,529,776	431,480,380	49,132,759	427,017,245
1989	33,067,789	464,548,169	50,872,623	477,889,868

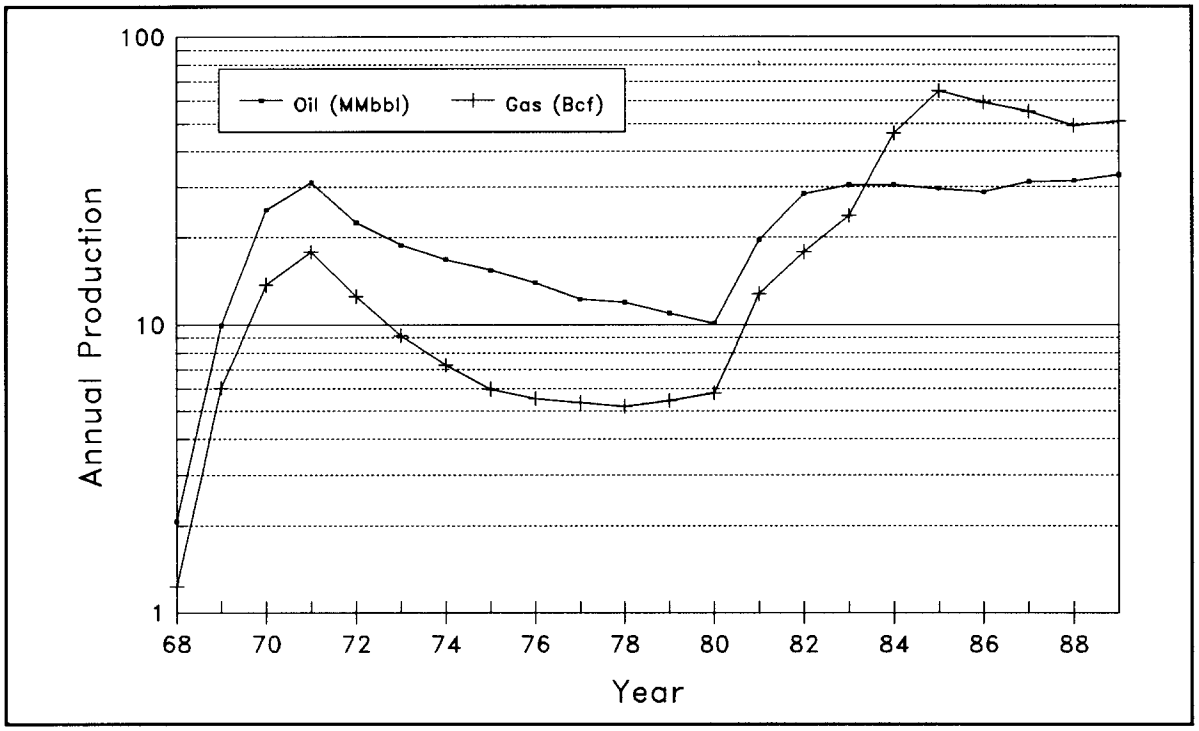

Figure 8. Annual production rates for the Pacific OCS.

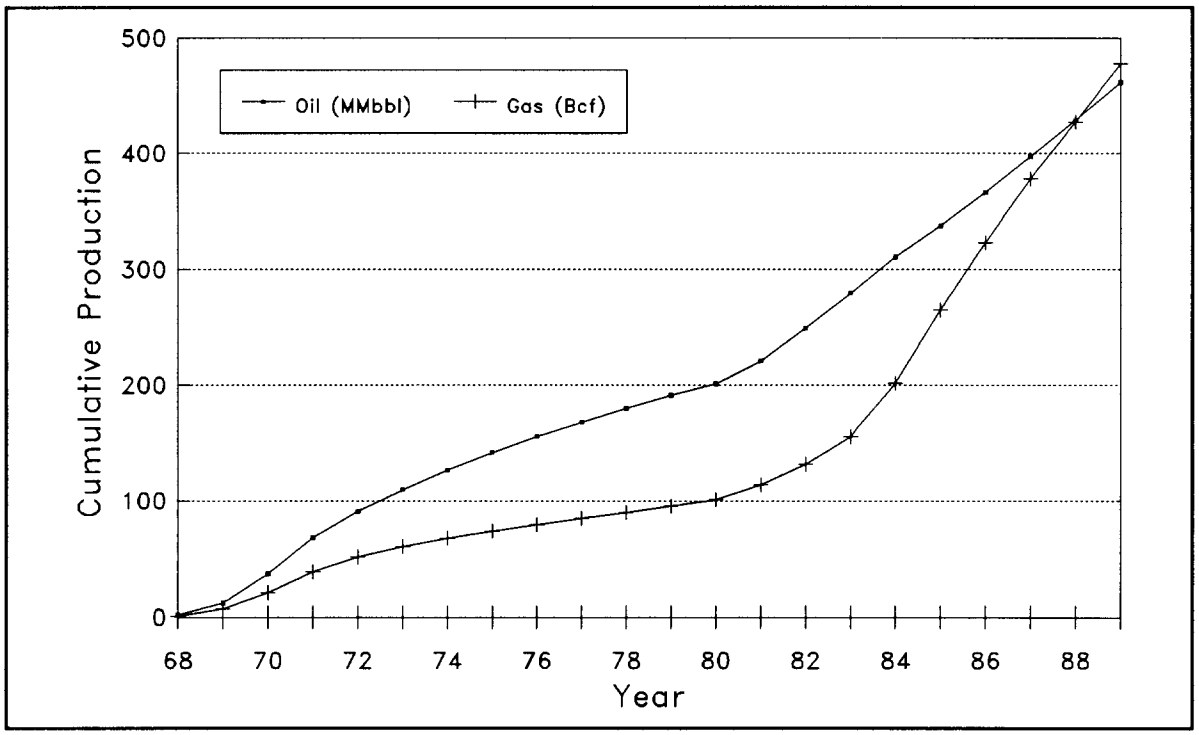

Figure 9. Cumulative production for the Pacific OCS.

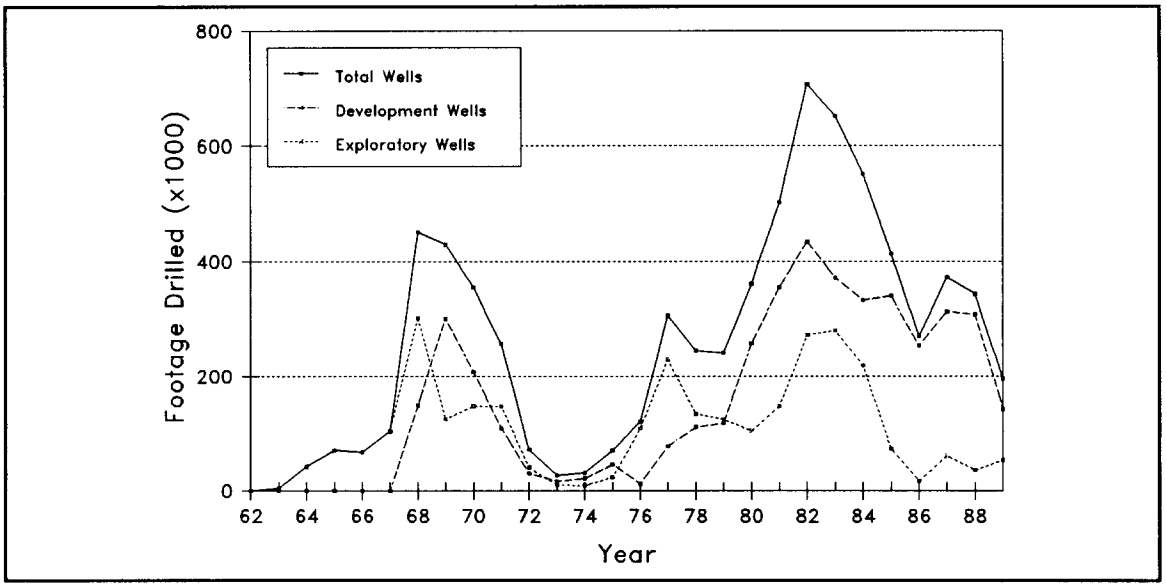

Figure 10. Annual drilled footage for wells in the Pacific OCS.

Table 6. Summary of development well borehole status.

Platform Name	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	37	0	7	0	0	4	0	0	0	19	67	0
C	20	0	3	0	0	4	0	0	0	0	27	0
Edith	17	0	1	0	0	0	0	0	2	1	21	0
Ellen	27	1	4	0	1	22	1	3	0	7	66	0
Eureka	27	0	1	0	0	14	1	0	0	1	44	0
Gail	8	1	0	0	0	0	0	0	0	0	9	2
Gilda	40	0	4	3	0	12	0	0	0	4	63	1
Gina	6	0	0	1	0	5	0	0	0	2	14	0
Grace	17	1	4	2	0	0	0	0	3	7	34	0
Habitat	0	8	0	5	0	0	0	0	3	1	17	1
Harvest	0	0	6	0	0	0	0	0	13	0	19	0
Henry	22	0	1	0	0	0	0	0	0	2	25	0
Hermosa	0	0	11	0	0	0	0	0	1	0	12	0
Hidalgo	0	0	6	0	0	0	0	0	1	0	7	0
Hillhouse	42	0	3	0	0	0	1	0	0	4	50	0
Hogan	17	0	14	0	2	0	3	0	0	14	50	0
Hondo	23	0	0	0	2	1	1	0	0	9	36	1
Houchin	26	0	6	0	0	0	0	0	1	10	43	0
Irene	12	0	3	0	0	0	0	0	1	2	18	0
Total	382	11	80	11	5	64	8	3	25	98	687	5

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 exist. The three age groups of reservoir rocks are (1) Pre-Monterey: rocks older than the Monterey Formation (early Miocene and older), (2) Monterey: rocks of the Monterey Formation (Miocene), and (3) Post-Monterey: rocks younger than the Monterey Formation (late Miocene and younger).

The distribution of remaining reserves and estimated original recoverable reserves in BOE is illustrated in table 7 and figure 11.

Conclusions

As of December 31, 1989, the remaining recoverable proved reserves in 13 known oil and gas fields in the Pacific OCS are estimated at 951 million barrels of oil and 1,515 billion cubic feet of gas. Remaining recoverable unproved reserves in 24 known oil and gas fields in the Pacific OCS are estimated to be 572 million barrels of oil and 731 billion cubic feet of gas. Nine oil and gas fields being produced by seventeen platforms have yielded 464 million barrels of oil and 478 billion cubic feet of gas since the first Pacific OCS platform began production in 1968. The 1989 oil production of 33 million barrels was the highest annual total in the region's 22-year history.

Table 7. Geologic formations within each reservoir age group.

Reservoir Age Group	Geologic Formations	Remaining Reserves* (MMbbl)	Estimated Original Recoverable Resources* (MMbbl)
Post-Monterey	Pico, Puente, Repetto, Santa Margarita, Sisquoc	198	583
Monterey	Monterey	1,519	1,667
Pre-Monterey	Point Sal, Vaqueros, Topanga, Hueneme, Sespe/ Alegria, Gaviota, Sacate, Camino Cielo, Jalama	205	222

*Barrels of oil equivalent

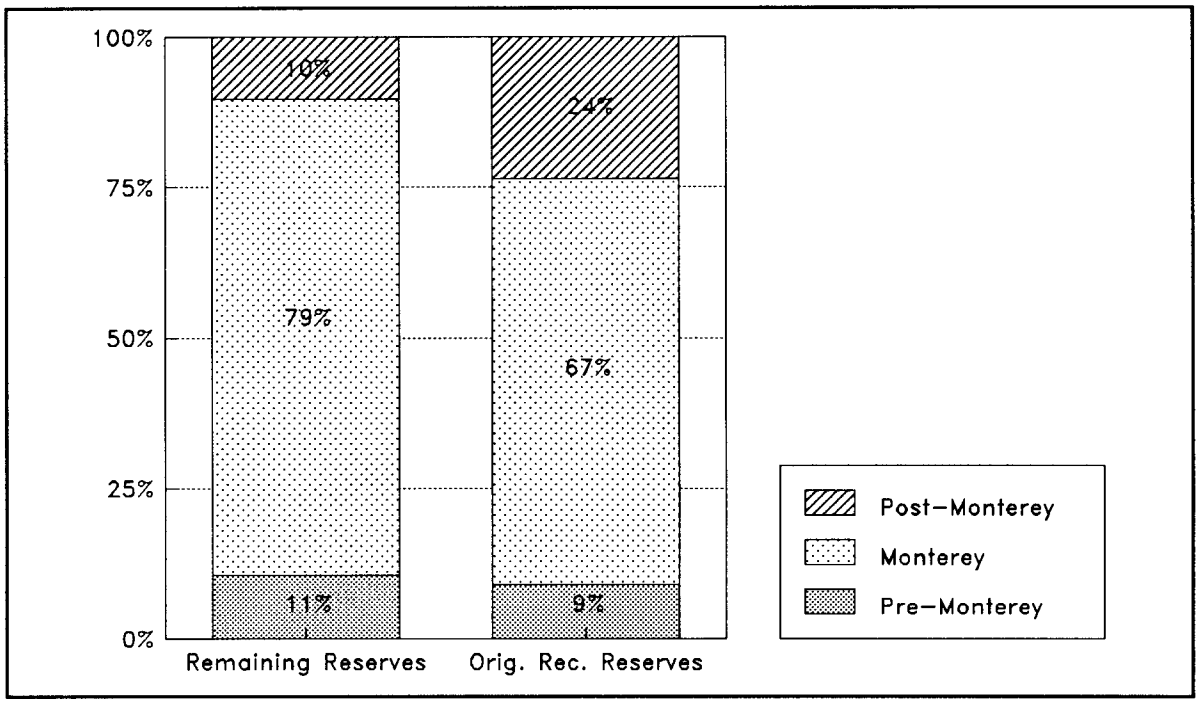

Figure 11. Remaining reserves and estimated original recoverable reserves (on a BOE basis) by reservoir age group.

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