

Estimated Oil and Gas Reserves

(as of December 31, 1988)

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by

Stephen D. Adams
Steven A. Wolfson

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United States Department of the Interior
Minerals Management Service
Pacific OCS Region
1340 West Sixth Street
Los Angeles, California 90017
Attn: Public Affairs
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ABBREVIATIONS

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

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By Stephen D. Adams
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Abstract

Proved reserves of oil* and gas in the Pacific Outer Continental Shelf, offshore California, are estimated to be 988 million barrels of oil and 1,572 billion cubic feet of gas as of December 31, 1988. These reserves are attributed to 13 fields. Ultimate production from these fields is estimated as 1,419 million barrels of oil and 1,999 billion cubic feet of gas. Unproved reserves of oil and gas in the Pacific Outer Continental Shelf, offshore California, are estimated to be 310 million barrels of oil and 468 billion cubic feet of gas as of December 31, 1988. These reserves are attributed to 11 fields. Ultimate production from these fields is estimated to be the same as the reserves as there has not been any sustained production from these fields. Reserve 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 1988, nine fields were producing.

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

Introduction

This report, which supersedes OCS Report MMS 88-0047, (Raftery and Wolfson, 1988), presents estimates of ultimate oil and gas production, cumulative production through 1988, and estimates of reserves as of December 31, 1988, for the Pacific Outer Continental Shelf (OCS), off the coast of California. These estimates were completed in April 1989.

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 Terminology

Recently the Society of Petroleum Engineers (SPE) adopted a new set of reserve categories and definitions (May 1987, p. 577-578). The MMS has also revised 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). In response to these changes the MMS Pacific OCS Regional Office has modified its definitions of reserve and resource terms as in figure 1. Reserves as of December 31, 1988, as reported in previous MMS OCS Reports are presented in the Appendix to provide a transition to the new reserve definitions.

"Undiscovered Resources -- Resources estimated from broad geologic knowledge and theory, existing outside of known fields or known

	Discovered Resources				Undiscovered Resources		
	Proved			Unproved		Known Fields	Untested Prospects
	Developed		Undeveloped	Probable	Possible		
	Producing	Nonproducing					
Economically Recoverable	Reserves of Producing Reservoirs	Reserves of Nonproducing Reservoirs					
Marginally Economically Recoverable							
Uneconomic							

← Increasing Geologic Assurance

↑ Increasing Economic Certainty

Figure 1. MMS petroleum reserve classification (modified from USGS & MMS, 1989, and SPE, 1987)

accumulations are undiscovered resources. Undiscovered resources can exist in untested prospects- unleased acreage and undrilled leased acreage- or in known fields, where undiscovered resources occur in undiscovered pools that exist as unrelated accumulations controlled by distinctly separate structural features or stratigraphic conditions." (Estimates of Undiscovered Conventional Oil and Gas Resources in the United States-A Part of the Nation's Energy Endowment, 1989)

Discovered Resources -- Once leased acreage is drilled and qualifies under Code of Federal Regulations (CFR) Title 30 Part 250, Subpart A, Section 11, Determination of Well Producibility, 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 evidence and that include economic, marginally economic, and subeconomic components. Discovered resources can be further characterized as unproved or proved reserves depending upon evidence of economic accumulations. The number of wells annually determined to be producible in accordance with a determination of well producibility 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 place the lease in an existing field or, if the lease is not associated with an established geologic structure, a new field. Regardless of whether the lease is assigned to an existing field or to a new field, the reserves associated with the lease are initially considered unproved reserves. Unproved reserves are based on geologic and/or engineering data similar to that used in estimates of proved reserves; but

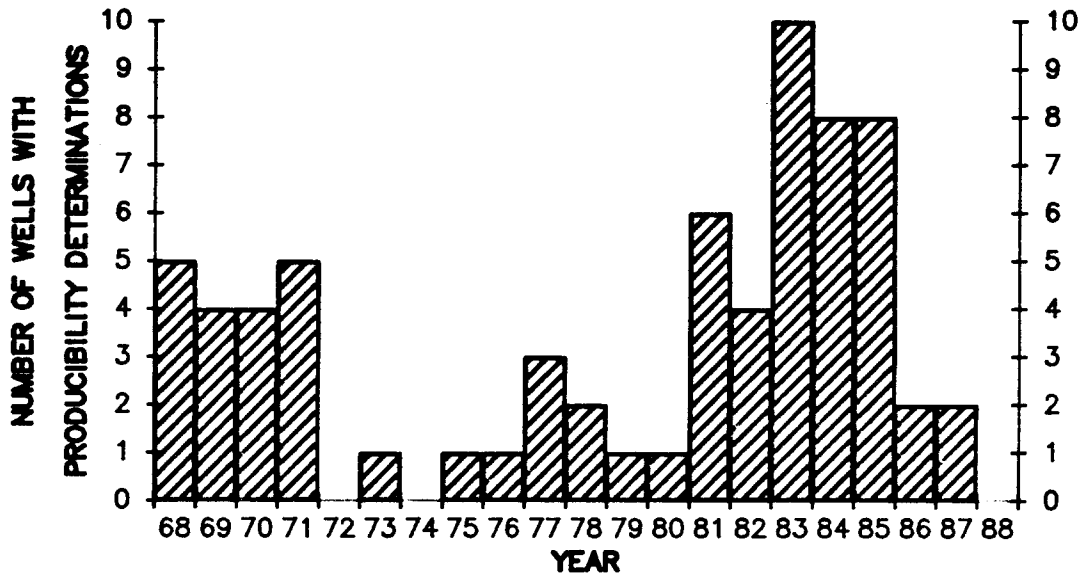


Figure 2. Wells determined to be producible in accordance with 30 CFR 250.11.

technical, contractual, economic, or regulatory uncertainties preclude such reserves being classified as proved.

Unproved reserves are not to be added to proved reserves because of different levels of uncertainty. Unproved reserves may be divided into two subclassifications, possible and probable, which are again 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, May 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, May 1987). Fields that have a Development and Production Plan (DPP) submitted to the MMS would be classified as unproved probable.

Proved Reserves -- "Proved Reserves can be estimated with reasonable certainty to be recoverable under current economic conditions. Current economic conditions include 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, May 1987). The approval of a DPP is considered such a commitment. Proved reserves can be subdivided into undeveloped and developed.

Proved Undeveloped Reserves -- Proved undeveloped reserves exist where a relatively large expenditure 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 where 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 has been installed, or when the costs to do so are relatively minor. Proved developed reserves are subcategorized as producing or non-producing." (SPE, May 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 has produced any time during the 12 months before the reporting date, it is considered to contain proved developed producing reserves.

Proved Developed Nonproducing Reserves -- Any developed reservoir in a developed field that has not produced during the previous 12 months from the reporting date is considered to contain proved developed nonproducing reserves. This category includes reserves contained in off production reservoirs behind-pipe and reservoirs awaiting 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.

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

Production data are the metered volumes of raw liquids and gas reported to the MMS by Federal lessees and operators. Oil and gas volume

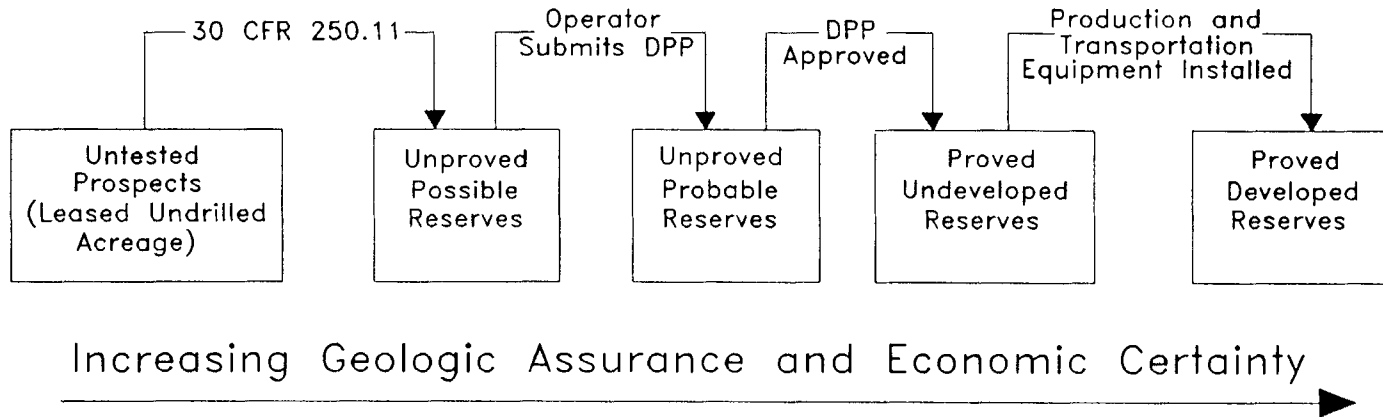


Figure 3. Pacific OCS MMS reserves classification procedure

measurements and reserves are corrected to reference standard conditions of 60 °F and 14.73 pounds per square inch absolute (psia). Continuously measured volumes from production platforms and/or leases are allocated to individual wells and reservoirs on the basis of periodic well test gauges. These procedures introduce approximations in both production and reserves data by reservoirs and by fields.

Methods Used for Reserves Estimation

Volumetric calculation -- For the 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 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 original 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 original amount of the 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 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, 1988, 24 fields in the Pacific OCS (fig. 4) are recognized as containing reserves under the criteria established under 30 CFR 250.11. Two of these fields are gas fields, 13 are oil fields, and 9 are combination oil and gas fields.

Thirteen fields were determined to have proved reserves of oil and gas. These 13 fields are San Miguel, Point Pedernales, Point Arguello, Sacate, Pescado, Hondo, Dos Cuadras, Carpinteria Offshore, Pitas Point, Santa Clara, Sockeye, Hueneme, and Beta (fig. 4, fields 1, 3, 7, 12, 13, 14, 17, 18, 19, 20, 21, 22, 23, and 24). The remaining 11 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 composite numbers so as to protect the proprietary data used to determine the estimates. 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. Previous estimates of ultimate production are shown in table 2 by year and publication. Annual estimates of ultimate production from known fields is shown in figure 5.

Studies Conducted

Reserve estimates for seven of the producing fields, Hondo, Dos Cuadras, Carpinteria Offshore, Pitas Point, Santa Clara, Hueneme and

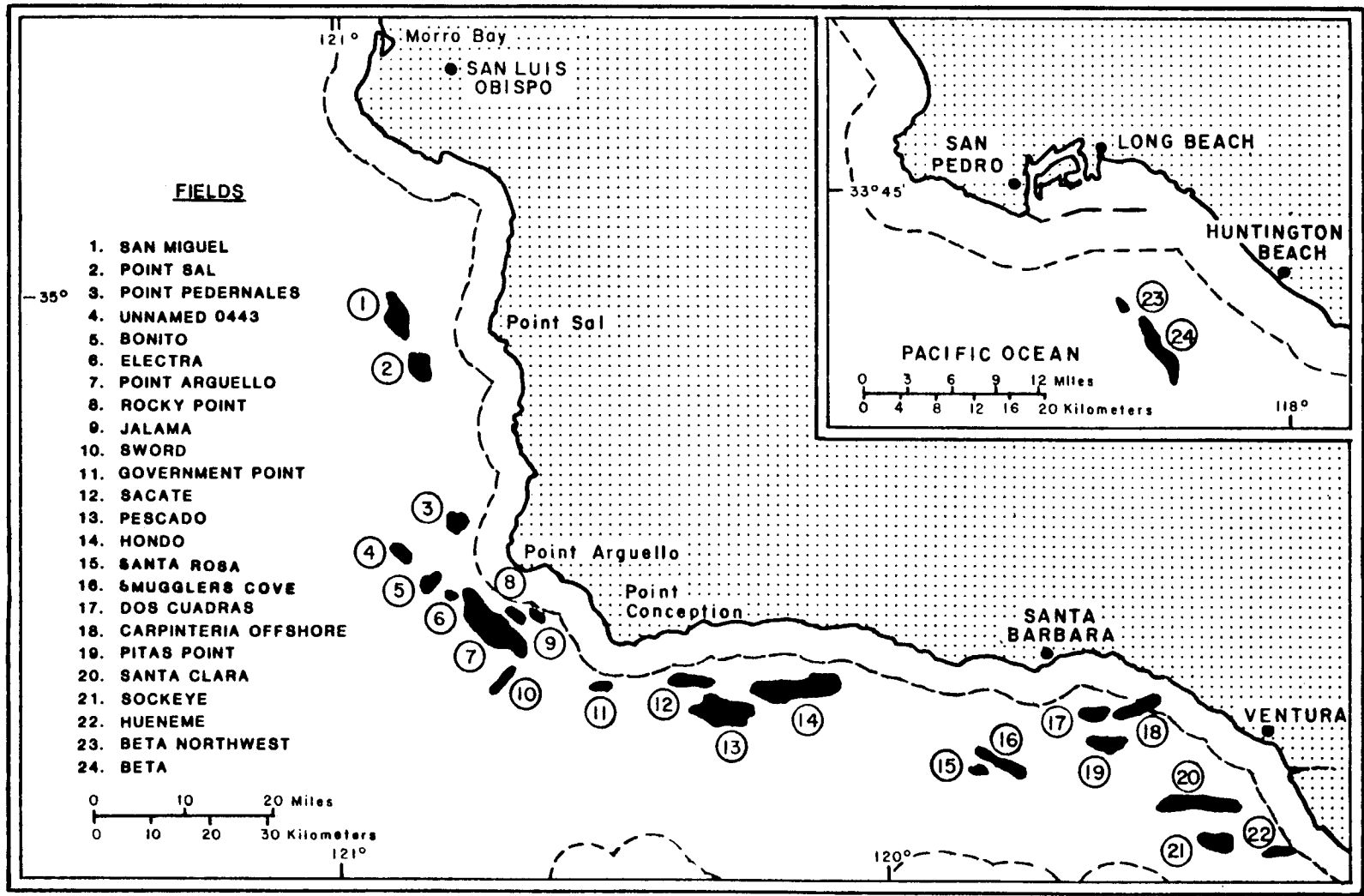


Figure 4. Recognized discoveries of federally controlled oil and gas fields in the Pacific OCS. Dashed lines indicate 3-geographical-mile boundary between State and Federal waters.

Table 1. Proved, unproved, and total oil and gas reserves for 24 fields, Pacific OCS, December 31, 1988.

Reserves	Number of Fields	Ultimate Production		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	1,419	1,999	431	427	32	49	988	1,572
Unproved Reserves	11	310	468	0	0	0	0	310	468
Total Reserves	24	1,729	2,467	431	427	32	49	1,298	2,040

Table 2. Annual estimates of ultimate production with publication numbers.

Year	Publication	Ultimate Production	
		Oil (MMBBL)	Gas (BCF)
1976	OFR 78-384	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	MMS 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

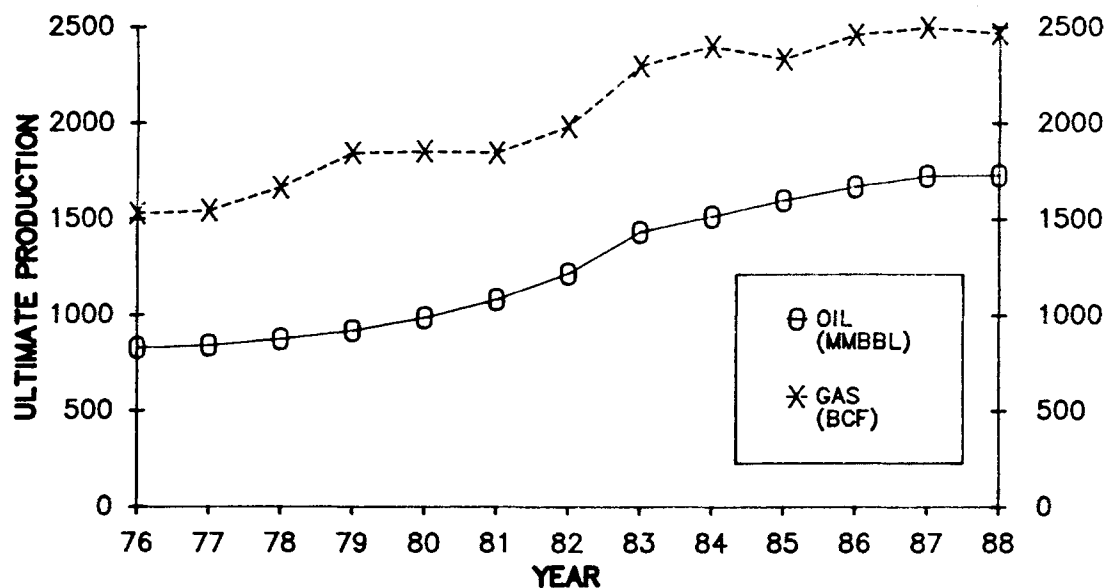


Figure 5. Annual estimates of ultimate production from known fields.

Beta (fig. 4, fields 14, 17, 18, 19, 20, 22 and 24), were made from volumetric calculations 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 calculations method.

Field Size Distribution

Figure 6 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 one barrel of oil).

Status of Field Development

As of December 31, 1988, five of the fields in the Pacific OCS have completed their primary drilling programs: Dos Cuadras, Carpinteria Offshore, Pitas Point, Hueneme, and Beta (fig. 4, fields 17, 18, 19, 22, and 24). Of the 24 recognized fields, 9 were producing in December, 1988: Point Pedernales, Hondo, Dos Cuadras, Carpinteria Offshore, Pitas Point, Santa Clara, Sockeye, Hueneme, and Beta (fig. 4, fields 3, 14, 17, 18, 19, 20, 21, 22, and 24). Additional exploratory

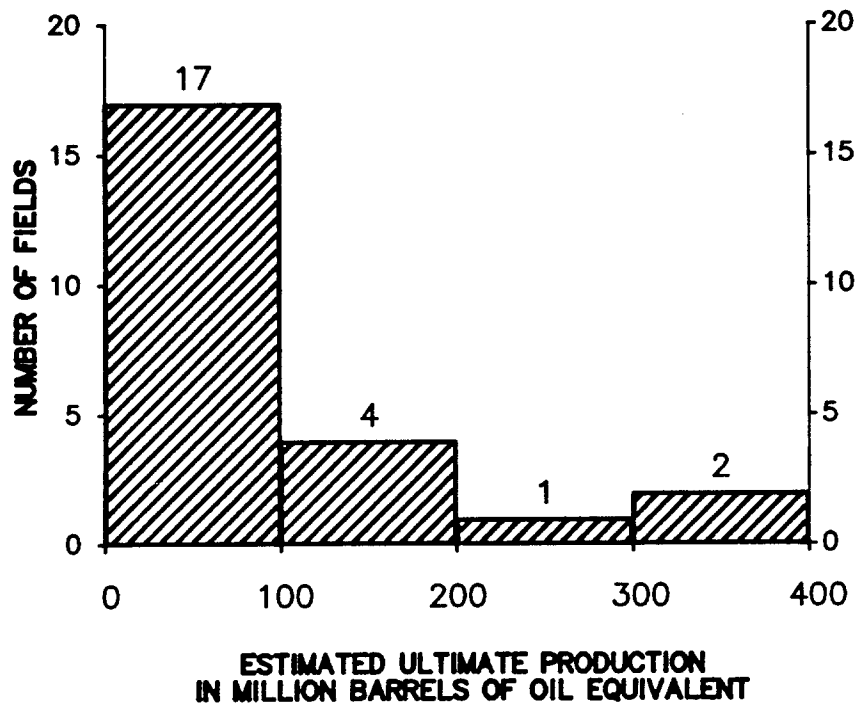


Figure 6. Size distribution of oil and gas fields.

and delineation drilling is anticipated in many of the remaining fields to further define productive limits and promote effective development. Startup of sustained production from the Point Arguello Field is anticipated in 1989.

Five producing oil and gas fields in the Pacific OCS--Hondo, Dos Cuadras, Santa Clara, Hueneme, and Beta (fig. 4)--are undergoing fluid injection. Recovery beyond primary production is in progress or can be anticipated (table 3). 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.

Table 3. 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.

Production Rates and Drilling History

Annual production through 1988 is shown in table 4 and figure 7. The 1988 oil production of 31.5 million barrels was the highest annual total in the region's 21-year history.

There were 322 exploratory wells and 677 development wells spudded by yearend. Drilled footage by year for all exploratory and development wells in the Pacific OCS is displayed in figure 8. Table 5 shows the yearend summary of the borehole status for all development 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	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	29,674,099	339,886,500	63,523,094	265,021,153
1986	28,779,968	368,666,468	58,003,369	323,024,522
1987	31,284,618	399,951,086	54,874,298	377,898,820
1988	31,529,776	431,480,862	49,132,759	427,031,579

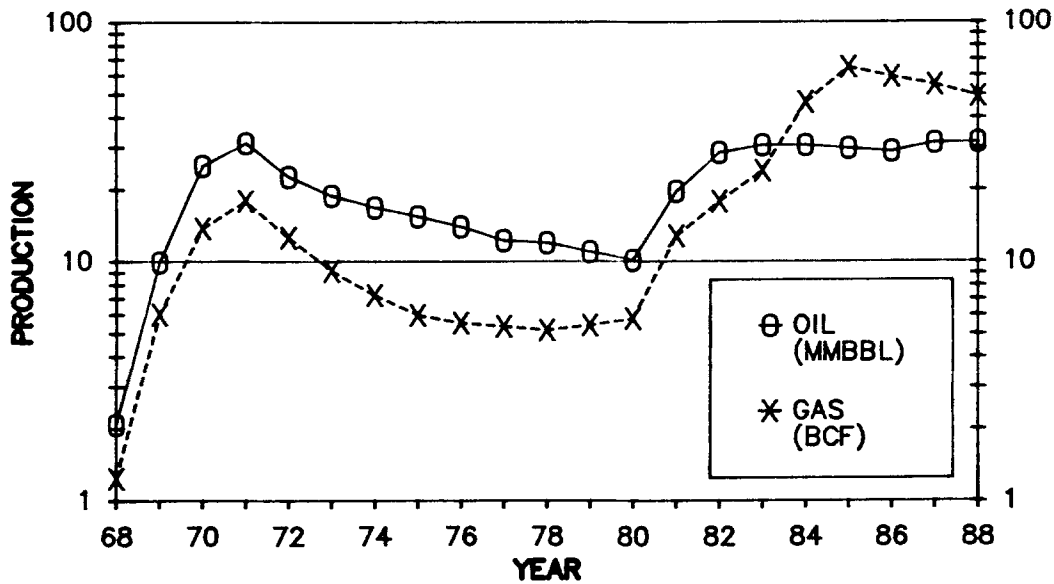


Figure 7. Annual production rates for the Pacific OCS.

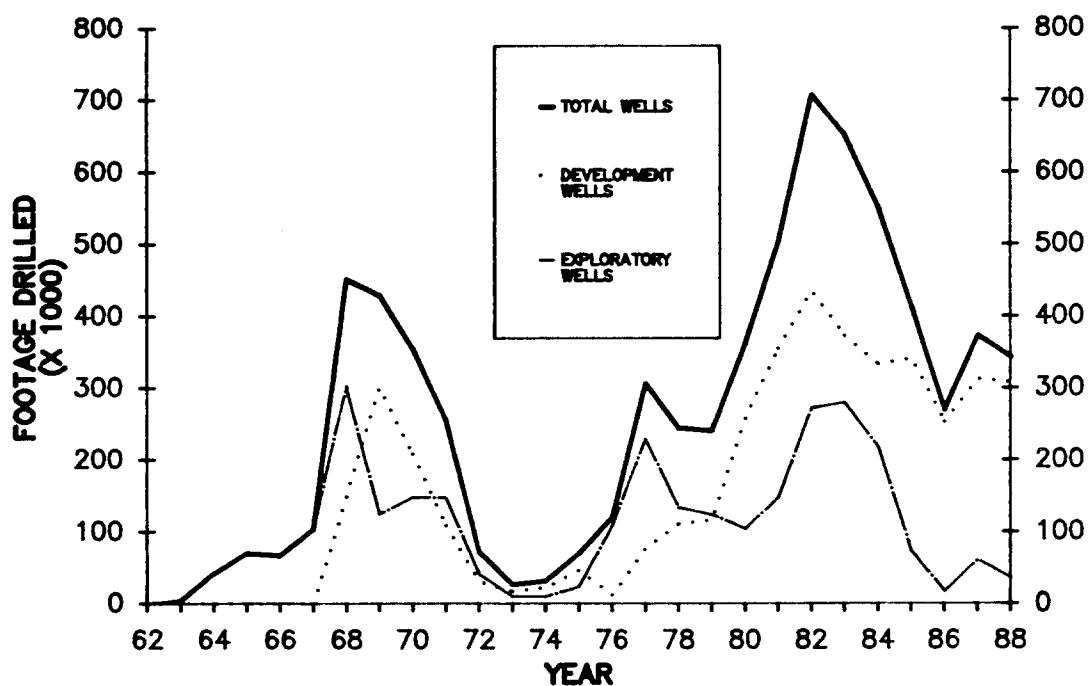


Figure 8. Annual drilled footage for wells in the Pacific OCS.

Table 5. Summary of development well borehole status.

PLATFORM NAME	POW	PGW	OSI	GSI	GIW	WIW	WDW	WSW	SUSP*	PA	TOTAL	ACT
A	42	0	5	0	0	2	1	0	0	15	65	0
B	39	0	5	0	0	4	0	0	0	19	67	0
C	21	0	2	0	0	4	0	0	0	0	27	0
Edith	5	0	13	0	0	0	0	0	2	1	21	0
Ellen	29	0	2	0	2	22	1	3	0	7	66	0
Eureka	28	0	2	0	0	12	1	0	0	1	44	0
Gail	4	1	0	0	0	0	0	0	0	0	5	1
Gilda	39	2	4	1	0	12	0	0	0	4	62	0
Gina	6	0	0	1	0	5	0	0	0	2	14	0
Grace	16	2	5	1	0	0	0	0	3	7	34	0
Habitat	0	10	0	5	0	0	0	0	2	0	17	0
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	5	0	0	0	0	0	1	0	6	1
Hillhouse	42	0	3	0	0	1	0	0	0	4	50	0
Hogan	17	0	14	0	2	0	3	0	0	14	50	1
Hondo	23	0	0	0	2	1	1	0	0	8	35	0
Houchin	25	0	7	0	0	0	0	0	1	10	43	0
Irene	8	0	3	0	0	0	0	0	1	0	12	0
Total	366	15	88	8	6	63	7	3	24	94	674	3

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 age groups of reservoir rocks are (1) Post-Monterey - rocks younger than the Monterey Formation (late Miocene and younger), (2) Monterey - rocks in the Monterey Formation (Miocene), and (3) Pre-Monterey - rocks older than the Monterey Formation (early Miocene and older). The distribution of reserves is illustrated in table 6 and figure 9.

Table 6. Formations within each reservoir age group.

Reservoir Age Group	Formations	Reserves*	Estimated Ultimate Production*
Post-Monterey	Pico, Puente, Repetto, Santa Margarita, Sisquoc	204 MMBBL	570 MMBBL
Monterey	Monterey	1,261 MMBBL	1,386 MMBBL
Pre-Monterey	Camino Cielo, Gaviota, Cretaceous, Hueneme, Jalama, Matilija, Point Sal, Sacate, Sespe/Alegria, Topanga, Vaqueros	173 MMBBL	184 MMBBL

* Barrels of oil equivalent.

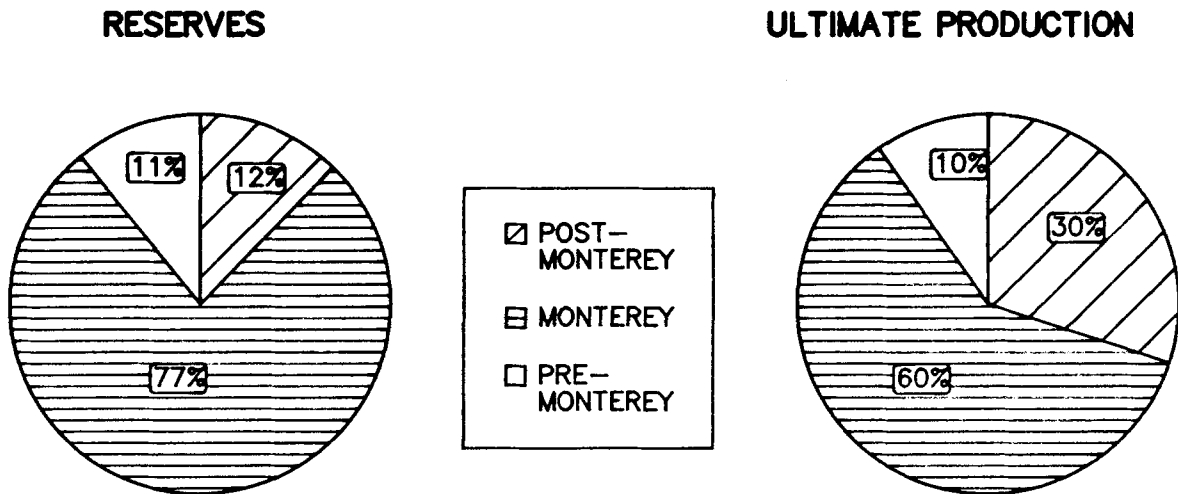


Figure 9. Reserves and estimated ultimate production by reservoir age group.

Conclusions

As of December 31, 1988, the remaining recoverable proved reserves in 13 known oil and gas fields in the Pacific OCS are estimated at 988 million barrels of oil and 1,572 billion cubic feet of gas. Remaining recoverable unproved reserves in 11 known oil and gas fields in the Pacific OCS are estimated to be 310 million barrels of oil and 468 billion cubic feet of gas. Because of the change in the method of reporting reserve estimates no comparison with estimates completed in previous years can be made. Reserves as of December 31, 1988, as reported in previous years, are presented in the Appendix to provide a transition to the new reserve definitions.

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Appendix

Because of changes in reserves definitions, all fields in the Pacific OCS, off the coast of California, have changed categories. Prior to this report, reserves were presented as demonstrated reserves as defined in Minerals Management Service OCS Report MMS 88-0047. Table A1 presents how the reserves would have been reported if there had been no change in reserve definitions.

Previous reserve estimates are shown in table A2 by year and publication. Annual estimates of demonstrated reserves for known fields is shown in figure A1. Table A1, table A2 and figure A1 are presented only as a reference to previous years reports. The current estimates of demonstrated gas reserves and ultimate production are lower than those for the preceding year. For oil estimates, demonstrated reserves are lower while ultimate production is higher than the corresponding estimates for December 31, 1987.

Table A1. Ultimate production and demonstrated oil and gas reserves for 24 fields, Pacific OCS, December 31, 1988.

Production and Reserves	Oil (MMBBL)	Gas (BCF)
Ultimate production:		
Estimated as of 12/31/88 (MMS 89-0085)..	1,729	2,467
Estimated as of 12/31/87 (MMS 88-0047)..	1,727	2,501
Change.....	+02	-34
Cumulative production:		
Through 1988.....	431	427
Through 1987.....	399	378
Demonstrated reserves:		
Estimated as of 12/31/88 (MMS 89-0085)..	1,298	2,040
Estimated as of 12/31/87 (MMS 88-0047)..	1,328	2,123
Change.....	-30	-83

Table A2. Annual estimates of demonstrated reserves with publication numbers.

YEAR	PUBLICATION	DEMONSTRATED RESERVES	
		OIL (MMBBL)	GAS (BCF)
1976	OFR 78-384	673	1,451
1977	OFR 79-345	675	1,461
1978	OFR 80-477	695	1,575
1979	OFR 80-1042	730	1,750
1980	OFR 81-623	787	1,752
1981	OFR 82-37	861	1,733
1982	OFR 83-559	968	1,851
1983	MMS 84-0024	1,153	2,141
1984	MMS 85-0041	1,205	2,198
1985	MMS 86-0066	1,259	2,067
1986	MMS 87-0045	1,302	2,135
1987	MMS 88-0047	1,328	2,123
1988	MMS 89-0085	1,298	2,040

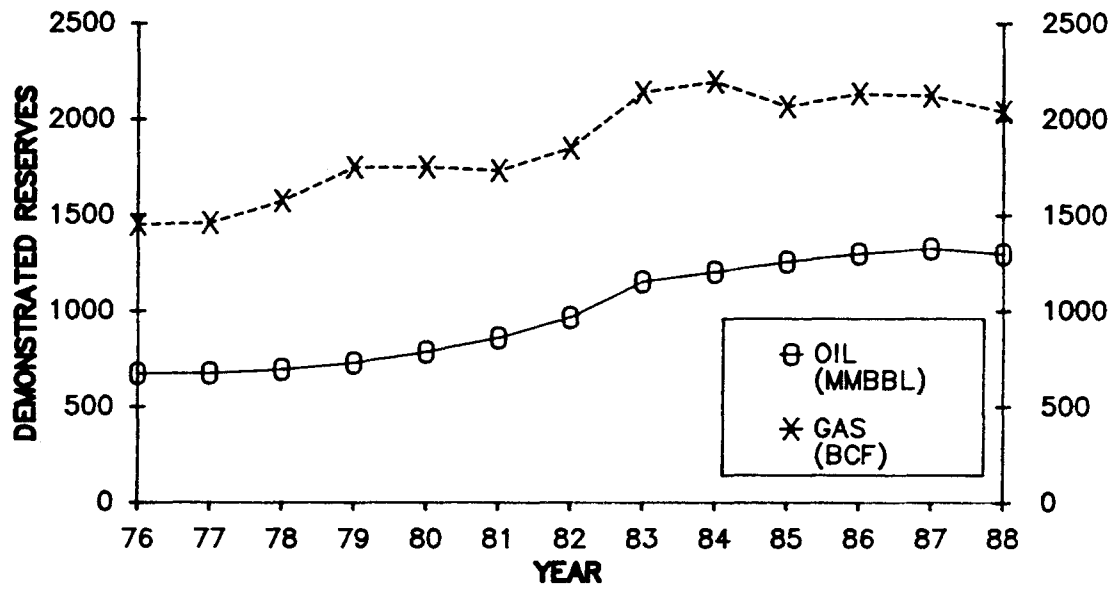


Figure A1. Annual estimates of demonstrated reserves from known fields.

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.

