OCS Report
MMS 2007-012

# Estimated Oil and Gas Reserves
## Pacific Outer Continental Shelf

## (January 1, 1999 through December 31, 2003)

MMS Securing Ocean Energy & Economic Value For America

OCS Report
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by
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**U.S. Department of the Interior**
**Minerals Management Service**
**Pacific OCS Region**

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COVER PHOTO: ExxonMobil's Platform Heritage stands in 1,075 feet of water in the western Santa Barbara Channel, about 8 miles offshore. Installed in 1989, this 60-slot platform's first production was from the Pescado field. About 40 wells (including sidetracks and redrills) have been drilled to date in the field, producing from the Monterey Formation heavy oil reservoir and lighter gravity oil sandstone formations, with peak production of 62,000 barrels of oil per day in 1995. Advances in drilling and production technology have allowed ExxonMobil to develop the adjacent Sacate field using extended-reach wells from Platform Heritage. The longest reach Sacate well has 21,277 feet of horizontal displacement. Peak production from the Sacate field was approximately 10,000 barrels of oil per day in 2001. *Photograph by Ralph Vasquez, Minerals Management Service, Camarillo, CA.*

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## Abbreviations

APD..... Application for Permit to Drill
API ..... American Petroleum Institute
°API..... Oil Gravity
bbl..... Barrel of Oil (42 US gallons)
Bcf..... Billion Cubic Feet of Gas
BOE ..... Barrels of Oil Equivalent
bpd ..... Barrels per Day
cf ..... Cubic Feet
CFR ..... Code of Federal Regulations
DPP ..... Development and Production Plan
DSI..... Drilling Shut-In
°F..... Degrees Fahrenheit
GOR ..... Gas-Oil Ratio
Mbbl..... Thousand Barrels of Oil
Mcf ..... Thousand Cubic Feet of Gas
Mcfpd ..... Thousand Cubic Feet of Gas per Day
MMbbl..... Million Barrels of Oil
MMcf ..... Million Cubic Feet of Gas
MMS ..... Minerals Management Service
OCS ..... Outer Continental Shelf
OFR ..... Open File Report
PA ..... Plugged and Abandoned
psia..... Pounds per Square Inch Absolute
RD ..... Redrill
SPE ..... Society of Petroleum Engineers
ST..... Side Track
TR..... Tranquillon Ridge Unit
USGS..... U.S. Geological Survey
WOR ..... Water-Oil Ratio
WPC..... World Petroleum Congress

# Estimated Oil and Gas Reserves
## Pacific Outer Continental Shelf
## (January 1, 1999 through December 31, 2003)

By Harold E. Syms and Armen Voskanian

## Executive Summary

Proved reserves of oil[1] and gas[2] in the Pacific Outer Continental Shelf (OCS), offshore California, are estimated to be 303 million barrels and 987 billion cubic feet, respectively, as of December 31, 2003. These reserves are attributed to 13 fields. Original recoverable oil and gas reserves for these fields are estimated to be 1,388 million barrels and 2,112 billion cubic feet, respectively. Unproved reserves are estimated to be 1,166 million barrels of oil and 490 billion cubic feet of gas, in 12 fields.

Reserve estimates for 18 of the 25 Pacific OCS fields were calculated using individual reservoir volumetric studies. Both decline-curve and volumetric analyses were used for the remaining 7 fields. Over three-fourths of all originally recoverable oil reserves (both proved and unproved) and approximately two-thirds of all originally recoverable gas reserves are attributed to reservoirs in the Monterey Formation. Over three-fourths of remaining oil reserves are contained within fields that have not yet been developed.

Thirteen of the 25 fields were producing at yearend 2003. Oil production during 2003 was approximately 29.7 million barrels, while gas production was about 58.4 billion cubic feet. Through 2003, over 1,085 million barrels of oil and 1,377 billion cubic feet of gas have been produced from 13 fields in the Pacific OCS.

[1] *Oil,* as used in this report, includes crude oil and condensate.
[2] *Gas,* as used in this report, includes associated and nonassociated dry gas.

## Introduction

This report, which in part supersedes OCS Report MMS 2000-063 (Sorensen and others, 2000), presents estimates of original recoverable oil and gas reserves, cumulative production through 2003, and estimates of remaining reserves on a yearly basis from January 1, 1999 through December 31, 2003, for the Pacific Outer Continental Shelf (OCS), offshore California. Detailed reserves estimates are included in this report as part of a Minerals Management Service (MMS) continuing program to provide a current inventory of oil and gas reserves for the Pacific OCS.

Beginning in the 1995 report, (MMS 96-0060) the Pacific OCS Region modified the method of gas reserves computation, allowing us to better account for remaining reserves in fields where significant amounts of gas are reinjected into the producing reservoir. This change affects gas reserves in the Hondo, Pescado, and Point Arguello fields.

The estimates presented here were prepared by petroleum engineers, geologists, and geophysicists from the MMS Pacific OCS Regional Office, Camarillo, California. Previous reserves reports served as a basis for parts of this update.

## 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 (USGS) and MMS, 1989). The Society of Petroleum Engineers (SPE) and World Petroleum Congresses (WPC) have also adopted a standardized set of reserve categories and definitions (SPE and WPC, 1997). The definitions used within this report conform with both these sources. Figure 1 shows how resource and reserve definitions are related.

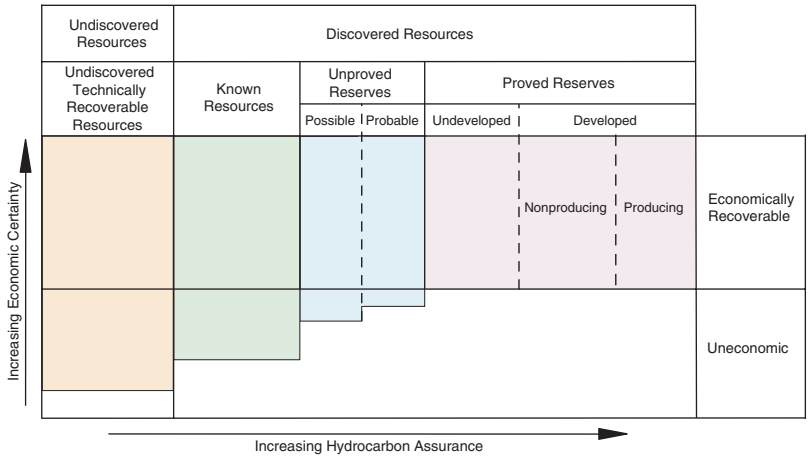



**Figure 1.** MMS petroleum reserves classification (modified from USGS and MMS, 1989; and SPE, 1987).

*Resources*

*Resources* are defined as concentrations of naturally occurring liquid or gaseous hydrocarbons that can conceivably be discovered and recovered. Normal use encompasses both undiscovered and discovered resources.

*Undiscovered Resources*

Resources estimated from broad geologic knowledge or theory and 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 (USGS and MMS, 1989).

Undiscovered resources that are producible with current recovery technology and efficiency, but without any consideration of economic viability, are *undiscovered technically recoverable resources.*

*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 115, Determination of Well Producibility (hereinafter referred to as 30 CFR 250.115), the lease is considered to have *discovered resources*. Discovered resources are those whose location and quantity are known or are estimated from specific geologic 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 and geologic viability. Changing economic conditions and new geologic data and interpretations can result in reclassification of resources.

*Known Resources*

Hydrocarbons associated with reservoirs penetrated by one or more wells that are on leases that are expired or relinquished are identified as *known resources*.

*Reserves*

"*Reserves* are those quantities of petroleum which are anticipated to be commercially recovered from known accumulations from a given date forward. All reserve estimates involve some degree of uncertainty. The uncertainty depends chiefly on the amount of reliable geologic and engineering data available at the time of the estimate and the interpretation of these data. The relative degree of uncertainty may be conveyed by placing reserves into one of two principal classifications, either proved or unproved. Unproved reserves are less certain to be recovered than proved reserves and may be further sub-classified as probable and possible reserves to denote progressively increasing uncertainty in their recoverability." (SPE and WPC, 1997)

*Unproved Reserves*

After a lease qualifies under 30 CFR 250.115, 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 reserves*. "Unproved reserves are based

on geologic and/or engineering data 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 further classified as probable reserves and possible reserves." (SPE and WPC, 1997)

Unproved reserves may be estimated assuming future economic conditions different from those prevailing at the time of the estimate. The effect of possible future improvements in economic conditions and technological developments can be expressed by allocating appropriate quantities of reserves to the probable and possible classifications.

"*Possible reserves* are those unproved reserves which analysis of geological and engineering data suggests are less likely to be recoverable than probable reserves…" "In general, possible reserves may include (1) reserves which, based on geological interpretations, could possibly exist beyond areas classified as probable, (2) reserves in formations that appear to be petroleum bearing based on log and core analysis but may not be productive at commercial rates, (3) incremental reserves attributed to infill drilling that are subject to technical uncertainty, (4) reserves attributed to improved recovery methods when (a) a project or pilot is planned but not in operation and (b) rock, fluid, and reservoir characteristics are such that a reasonable doubt exists that the project will be commercial, and (5) reserves in an area of the formation that appears to be separated from the proved area by faulting and geological interpretation indicates the subject area is structurally lower than the proved area." (SPE and WPC, 1997) After a lease qualifies under 30 CFR 250.115, the reserves associated with the lease are initially classified as *unproved possible*.

"*Probable reserves* are those unproved reserves which analysis of geological and engineering data suggests are more likely than not to be recoverable…" "In general, probable reserves may include (1) reserves anticipated to be proved by normal step-out drilling where sub-surface control is inadequate to classify these reserves as proved, (2) reserves in formations that appear to be productive based on well log characteristics but lack core data or definitive tests and which are not analogous to producing or proved reservoirs in the area, (3) incremental reserves attributable to infill drilling that could have been classified as proved if closer statutory spacing had been approved at the time of the estimate, (4) reserves attributable to improved recovery methods that have been established by repeated commercially successful applications when (a) a project or pilot is planned but not in operation and (b) rock, fluid, and reservoir characteristics appear favorable for commercial application, (5) reserves in an area of the formation that appears to be separated from the proved area by faulting and the geologic interpretation indicates the subject area is structurally higher than the proved area, (6) reserves attributable to a future workover, treatment, re-treatment, change of equipment, or other mechanical procedures, where

such procedure has not been proved successful in wells which exhibit similar behavior in analogous reservoirs, and (7) incremental reserves in proved reservoirs where an alternative interpretation of performance or volumetric data indicates more reserves than can be classified as proved." (SPE and WPC, 1997) Reserves in fields for which a schedule leading to a Development and Production Plan (DPP) has been submitted to the MMS have been classified as *unproved probable*.

*Proved Reserves*

"*Proved reserves* are those quantities of petroleum which, by analysis of geological and engineering data, can be estimated with reasonable certainty to be commercially recoverable, from a given date forward, from known reservoirs and under current economic conditions, operating methods, and government regulations. Proved reserves can be categorized as developed or undeveloped."

"Establishment of current economic conditions should include relevant historical petroleum prices and associated costs and may involve an averaging period that is consistent with the purpose of the reserve estimate, appropriate contract obligations, corporate procedures, and government regulations involved in reporting these reserves." (SPE and WPC, 1997)

Reserves are classified as *proved undeveloped reserves* when a relatively large expenditure is required to install production/transportation facilities, a commitment by the operator is made, and a timeframe to begin production is established. "Undeveloped reserves are expected to be recovered: (1) from new wells on undrilled acreage, (2) from deepening existing wells to a different reservoir, or (3) where a relatively large expenditure is required to (a) recomplete an existing well or (b) install production or transportation facilities for primary or improved recovery projects." (SPE and WPC, 1997)

"*Developed reserves* are expected to be recovered from existing wells including reserves behind pipe. Improved recovery reserves are considered developed only after the necessary equipment has been installed, or when the costs to do so are relatively minor. Developed reserves may be sub-categorized as producing or non-producing." (SPE and WPC, 1997) This distinction is made at the reservoir level and not at the field level.

Once the first reservoir in a field begins production, the reservoir is considered to contain *proved developed producing reserves.* "Reserves subcategorized as producing are expected to be recovered from completion intervals which are open and producing at the time of the estimate. Improved recovery reserves are considered producing only after the improved recovery project is in operation" (SPE and WPC, 1997). If a reservoir had sustained production during the last year, it is considered to contain proved developed producing 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*. "Reserves subcategorized as non-producing include shut-in and behind-pipe reserves. Shut-in reserves are expected to be recovered from (1) completion intervals which are open at the time of the estimate but which have not started producing, (2) wells which were shut-in for market conditions or pipeline connections, or (3) wells not capable of production for mechanical reasons. Behind-pipe reserves are expected to be recovered from zones in existing wells, which will require additional completion work or future recompletion prior to the start of production." (SPE and WPC, 1997) The reserves classification procedure is shown in figure 2.

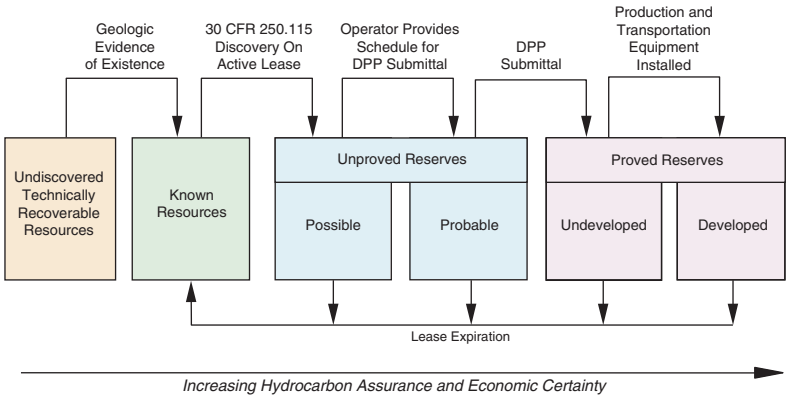



**Figure 2.**
MMS Pacific OCS reserves classification procedure.

*Total reserves* are the sum of proved and unproved reserves.

*Remaining proved reserves* are the quantities of proved reserves currently estimated to be recoverable. Estimates of remaining proved reserves equal proved reserves minus cumulative production.

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*.

The term *production data* means 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 $^{o}$F and 14.73 psia. Continuously measured volumes from production platforms 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.

## MMS Reporting of Reserves and Resource Data and Information

Reserves estimates have been published by the Pacific OCS Region since 1978, presenting end-of-year totals starting with 1976. From 1977 to 1982 the estimates were published as United States Geological Survey (USGS) Open-File reports. The MMS has continued the reporting since 1983 (see appendix A, table A-1). Figure 3 shows the relationship and scope of reserves and resource data studied and published by MMS. The data are progressively aggregated on both a geologic and a geographic basis at each step of the evaluation process (from reservoir level through the region level). The most detailed studies are those done to estimate the reserves of individual fields. These studies are based on analysis at the reservoir level and are used as the basis for all subsequent analyses of discovered and undiscovered resources

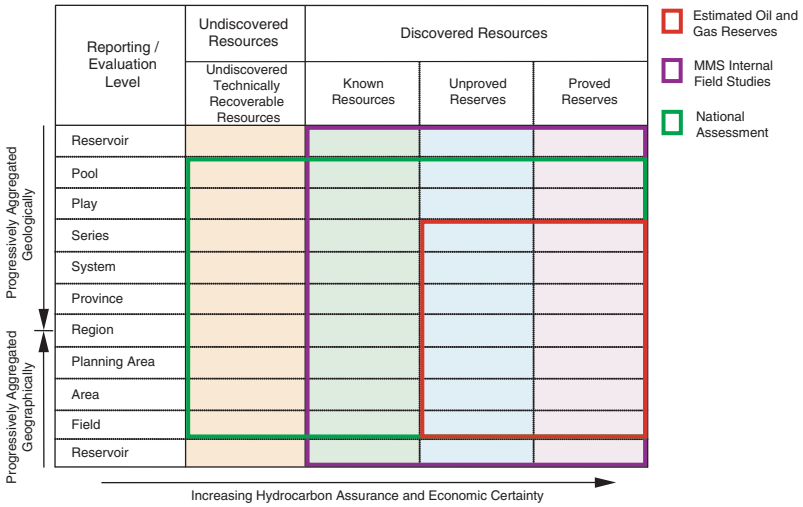



**Figure 3.**
MMS Pacific OCS reserves and resources reporting schema.

This report, *Estimated Oil and Gas Reserves*, presents reserves data at the field level through the series and region level (see figure 3), and as stated above is based on aggregation of MMS internal field studies completed at the reservoir level. The latest report and all previous editions from this series are available at *www.mms.gov/omm/pacific/*.

For information related to undiscovered resources, refer to the MMS OCS Report *MMS 2001-014, Oil and Gas Resources in the Pacific Outer Continental Shelf as of January 1, 1999 An Expanded Update to the 1995 National Assessment of United States Oil and Gas Resources.* This report is also known as the National Assessment and contains estimates of undiscovered resources as well as reserves listed by play, planning area, and region. It is available at MMS's web site, *www.mms.gov/omm/pacific/*.

## Methods Used for Estimating Reserves

For the volumetric calculation of reserves, the amounts of original oil and gas in place are estimated from the bulk volume of the reservoir as mapped using data from wells and seismic profiles. Maps of net oil and gas sand thicknesses are generated with the aid of a computer mapping system, and the results are converted to bulk reservoir volume using the appropriate equations. Rock porosities and the amounts of water, oil, and gas in the pore space are derived from well log interpretations and core analyses. The estimated original amounts of oil and gas in place are converted to standard conditions through analyses of pressure, volume, and temperature relationships and by the use of standard correlations. The amounts of the original oil and gas in place that can be recovered are estimated from information about the reservoir drive mechanism, well spacing, analog field recovery factors, and American Petroleum Institute (API) recovery factor equations (Arps and others, 1967, p. 19-20).

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 cumulative past production to predicted future production.

## Fields Reported

As of December 31, 2003, there are 25 fields in the Pacific OCS that are recognized as containing reserves under MMS's established criteria. One of these fields is a gas field, 19 are oil fields, and 5 are combination oil and gas fields (figure 4).

Thirteen fields were determined to have proved reserves of oil and/or gas. These 13 fields are Point Pedernales, Tranquillon Ridge, Point Arguello, Pescado, Sacate, Hondo, Dos Cuadras, Pitas Point, Carpinteria Offshore, Santa Clara, Sockeye, Hueneme, and Beta (figure 4, fields 6, 7, 11, 20, 21, 23, 29, 30, 31, 33, 34, 36, and 38). All of these fields were producing at yearend 2003. The remaining 12 fields were determined to have unproved oil and gas reserves.

Reserve estimates for 7 of the producing fields were obtained from volumetric calculations and decline-curve analyses: Hondo, Dos Cuadras, Pitas Point, Carpinteria Offshore, Santa Clara, Hueneme, and Beta (figure 4, fields 23, 29, 30, 31, 33, 36, and 38). Individual reservoirs in each field were grouped for volumetric calculations, while decline-curve analyses were made on a reservoir and lease-by-lease basis. The 18 remaining fields (5 producing and 13 nonproducing) were studied on a reservoir-by-reservoir basis, and the reserve estimates were determined solely by the volumetric calculation method.

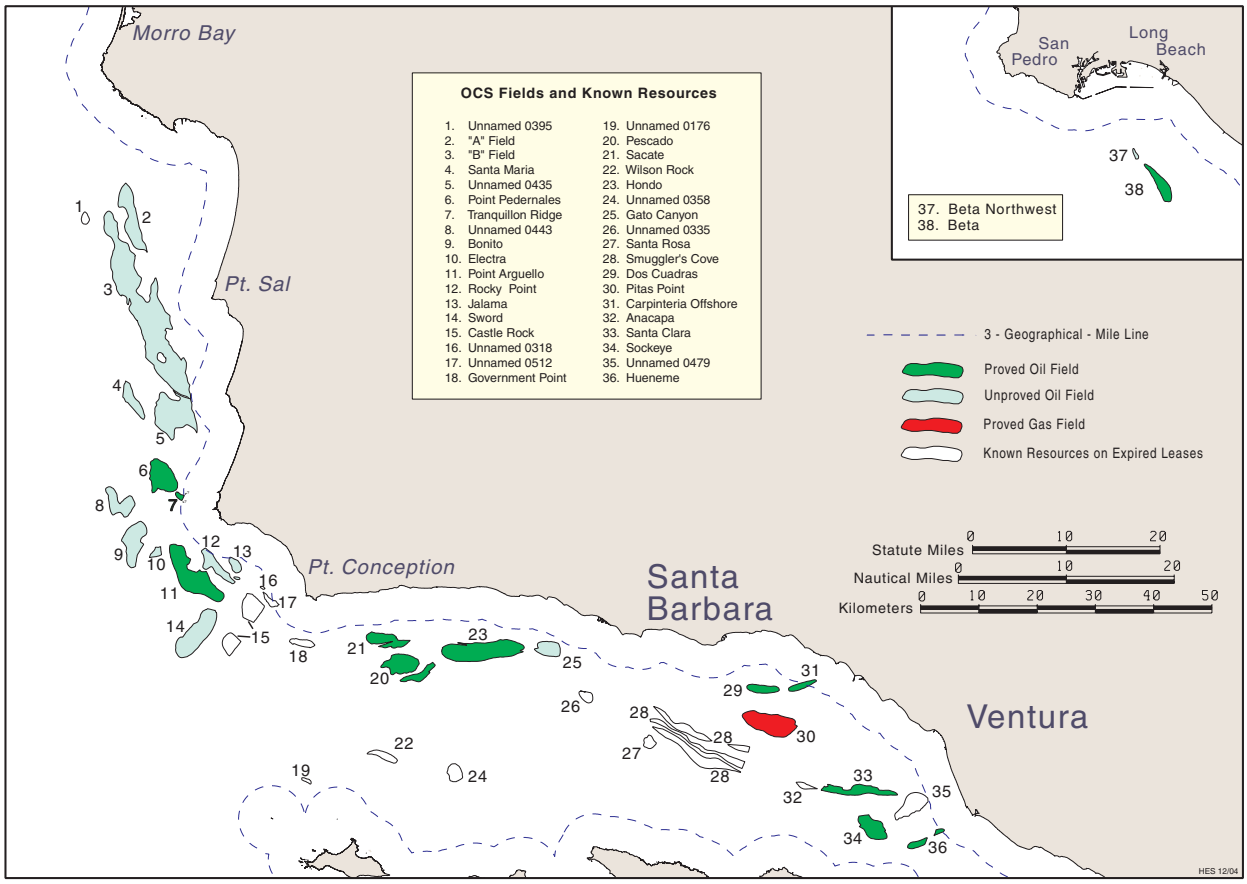



**Figure 4.**
Recognized discoveries of federally controlled oil and gas fields in the Pacific OCS.
(Dashed lines indicate 3-geographic mile boundary between State and Federal waters.)

## Estimated Oil and Gas Reserves

As of December 31, 2003, total original recoverable oil and gas reserves in the Pacific OCS are estimated to be 2,555 million barrels (MMbbl) and 2,601 billion cubic feet (Bcf), respectively. Total remaining reserves are estimated to be 1,469 MMbbl of oil and 1,477 Bcf of gas.

The current aggregated estimates of Pacific OCS oil and gas reserves are shown in table 1, by reserves category, for both original recoverable and remaining reserves. Estimates of the original recoverable and remaining reserves for the 13 producing oil and gas fields are presented in figures 5 and 6.

These estimates have been updated annually as additional information has become available. Past updates have caused both increases and decreases in estimates of original recoverable and remaining oil and gas reserves. Previous reserves estimates for the Pacific OCS are presented in appendix A.

**Table 1.**
Estimated reserves and known resources of oil and gas by reserves category, Pacific OCS, December 31, 2003.

| | Number of Fields | Original Recoverable Reserves | | 2003 Annual Production | | Cumulative Production | | Remaining Reserves | |
|---|---|---|---|---|---|---|---|---|---|
| | | Oil | Gas | Oil | Gas | Oil | Gas | Oil | Gas |
| Proved Developed Reserves | 13 | 1,388 | 2,112 | 30 | 58 | 1,085 | 1,377 | 303 | 987 |
| Unproved Possible Reserves | 12 | 1,166 | 490 | 0 | 0 | 0 | 0 | 1,166 | 490 |
| **Total Reserves** | **25** | **2,555** | **2,601** | **30** | **58** | **1,085** | **1,377** | **1,469** | **1,477** |
| Known Resources | 13 | 149 | 362 | 0 | 0 | 0 | 0 | 149 | 362 |

*Oil in million barrels (MMbbl), Gas in billion cubic feet (Bcf)*

**Figure 5.**
Production and estimated reserves of oil for producing fields, Pacific OCS, December 31, 2003.

| Field | Original Recoverable Reserves | 2003 Production | Cumulative Production | Remaining Reserves |
|---|---|---|---|---|
| Hondo | 316.90 | 7.66 | 250.41 | 66.49 |
| Dos Cuadras | 264.60 | 1.75 | 254.30 | 10.30 |
| Pt Arguello | 208.00 | 4.71 | 163.07 | 44.93 |
| Pescado | 146.59 | 6.33 | 102.92 | 43.67 |
| Beta | 106.80 | 0.99 | 84.80 | 22.00 |
| Pt Pedernales/Tranq. Ridge | 80.00 | 2.32 | 70.32 | 9.68 |
| Carpinteria | 71.40 | 0.66 | 66.82 | 4.58 |
| Sacate | 71.30 | 2.78 | 10.39 | 60.91 |
| Sockeye | 61.83 | 1.73 | 31.48 | 30.35 |
| Santa Clara | 50.06 | 0.74 | 39.92 | 10.15 |
| Hueneme | 10.71 | 0.06 | 10.56 | 0.15 |
| Pitas Point | 0.22 | <0.01 | 0.21 | 0.01 |
| **Total** | **1,388.41** | **29.74** | **1,085.20** | **303.21** |

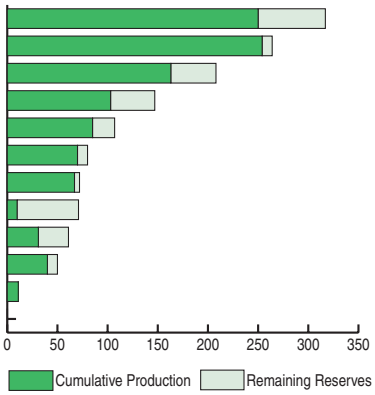
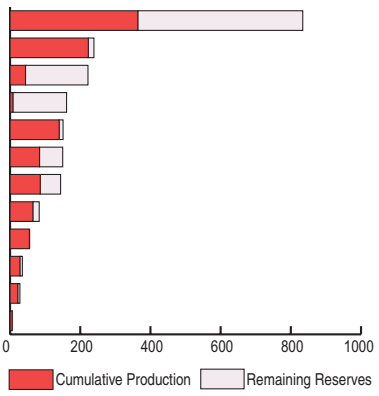



**Figure 6.**
Production and estimated reserves of gas for producing fields, Pacific OCS, December 31, 2003.

| Field | Original Recoverable Reserves | 2003 Production | Cumulative Production | Remaining Reserves |
|---|---|---|---|---|
| Hondo | 834.02 | 28.50 | 504.31 | 470.48 |
| Pitas Point | 239.22 | 1.81 | 222.78 | 16.44 |
| Pescado | 222.32 | 9.90 | 135.62 | 177.99 |
| Sacate | 160.69 | 1.55 | 7.99 | 152.70 |
| Dos Cuadras | 150.50 | 2.34 | 139.80 | 10.70 |
| Sockeye | 150.45 | 1.79 | 84.15 | 66.30 |
| Pt Arguello | 143.84 | 10.08 | 106.73 | 57.94 |
| Santa Clara | 82.33 | 0.57 | 64.83 | 17.50 |
| Carpinteria | 60.00 | 0.45 | 55.36 | 4.64 |
| Beta | 34.40 | 0.31 | 27.87 | 6.53 |
| Pt Pedernales/Tranq. Ridge | 27.50 | 0.91 | 21.86 | 5.64 |
| Hueneme | 6.25 | 0.21 | 5.88 | 0.37 |
| **Total** | **2,111.51** | **58.41** | **1,377.17** | **987.23** |




The current estimate of original recoverable oil reserves has slightly increased, as compared with the most recent previous published estimate. The estimate of original recoverable gas reserves has decreased slightly. As described in appendix C, remaining recoverable gas reserve estimates have been adjusted to reflect the volumes of gas injected back into producing reservoirs.

## Distribution of Reserves

The size distribution of Pacific OCS fields, shown in figure 7, is based on the estimated original recoverable reserves for 19 oil fields, 5 combination oil and gas fields, and 1 gas field. These 25 fields are located in three basins, offshore California. For comparison purposes, gas reserves are expressed in terms of barrels of oil equivalent on the basis of equivalent heating values (5,620 cubic feet of gas has the approximate heating value of 1 bbl of oil), hereinafter referred to as BOE. Developed fields are distinguished from undeveloped fields in this figure.

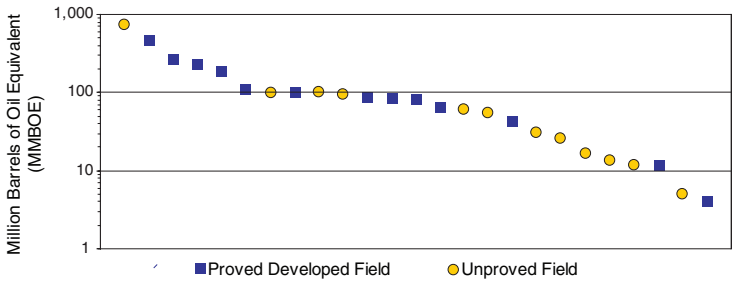



**Figure 7.**
Size distribution of Pacific OCS oil and gas fields.

Approximately one-half of the original recoverable oil reserves and four-fifths of the original gas reserves in the Pacific OCS are attributable to the 13 proved developed fields. These 13 producing fields also contain about one-fifth of the remaining recoverable oil reserves and almost two-thirds of the remaining gas reserves.

Gas reserves in the Pacific OCS are contained in both oil and gas reservoirs. Approximately one-sixth of the original recoverable and remaining gas reserves occur as nonassociated gas contained in natural gas reservoirs. The other five-sixths are associated gas contained within oil reservoirs (figure 8).

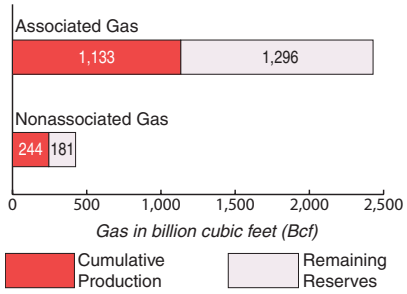



**Figure 8.**
Production and estimated reserves of gas by type of occurrence, Pacific OCS, December 31, 2003.

Oil and gas reserves in the Pacific OCS are further categorized on the basis of the age of the reservoir rocks in which they exist. For this report we have defined three age groups of reservoir rocks: (1) Pre-Monterey, rocks older than the Monterey Formation (early Miocene age and older), (2) Monterey, rocks of the

Monterey Formation (Miocene age), and (3) Post-Monterey, rocks younger than the Monterey Formation (late Miocene age and younger). The distributions of estimated original recoverable and remaining oil and gas reserves by reservoir age group are illustrated in figure 9.

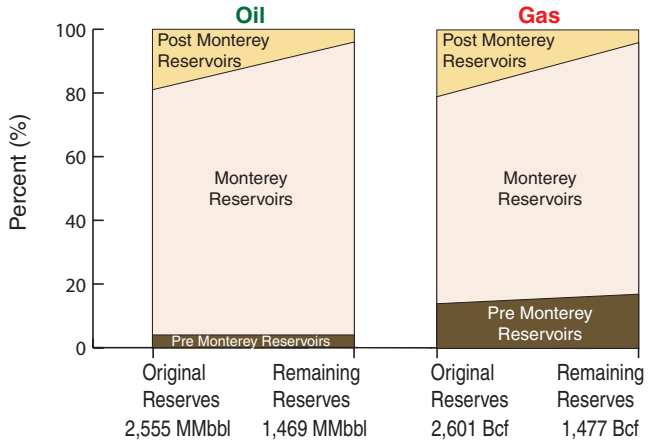



**Figure 9.**
Estimated percentage of original recoverable and remaining oil and gas reserves by reservoir age group, Pacific OCS.

Eight of the 13 producing fields in the Pacific OCS have substantial reserves attributed to the Monterey Formation, as do 11 of the 12 nonproducing fields. In 9 of the 12 nonproducing fields, all identified reserves are attributed to this formation. Over three-quarters of the original recoverable oil reserves and over nine-tenths of the remaining oil reserves are in Monterey Formation reservoirs. The Monterey Formation also contains over three-fourths of all remaining gas reserves in the Pacific OCS.

The Post-Monterey group includes rocks of the Pico, Puente, "Repetto", "Santa Margarita", and Sisquoc formations, while the Pre-Monterey group includes the Point Sal, Vaqueros, Topanga, Hueneme, Sespe/Alegria, Gaviota, Matilija, Sacate, Juncal (Camino Cielo), and Jalama formations.

## Status of Field Development

As of December 31, 2003, thirteen of the 25 recognized fields in the Pacific OCS were producing: Point Pedernales, Tranquillon Ridge, Point Arguello, Pescado, Sacate, Hondo, Dos Cuadras, Pitas Point, Carpinteria Offshore, Santa Clara, Sockeye, Hueneme, and Beta (figure 4, fields 6, 7, 11, 20, 23, 24, 29, 30, 31, 33, 34, 36, and 38). The Sacate Field became the thirteenth producing field in the Pacific OCS when production began from Platform Heritage in April 1999.

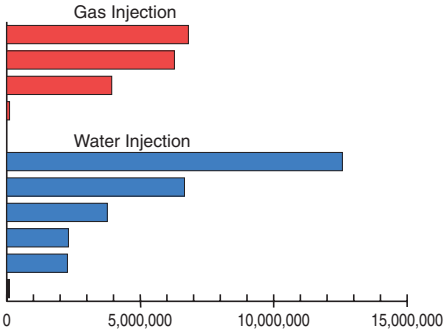
Development drilling occurred at 4 of the 13 producing fields during 2003: Point Arguello, Pescado, Sacate, and Hondo (figure 4, fields 11, 20, 21, and 23).

A summary of Pacific OCS development activities during 1999 through 2003 is presented in appendix B.

Seven producing oil and gas fields in the Pacific OCS are undergoing fluid injection: Point Pedernales, Point Arguello, Pescado, Hondo, Dos Cuadras, Sockeye, and Beta (figure 4, fields 6, 11, 20, 23, 29, 34, and 38). Recovery beyond primary production is occurring or can be anticipated. Four fields—Point Arguello, Pescado, Hondo, and Sockeye (figure 4, fields 11, 20, 23, and 34)—are undergoing gas injection for reservoir pressure maintenance or for relief of high pressure gas in emergency situations. Over one-fourth of the natural gas produced in the region is reinjected. Figure 10 shows water and gas injection volumes and rates for each of the eight fields undergoing injection. Appendix C presents a detailed summary of water and gas injection volumes for the Pacific OCS Region.

**Figure 10.**
Gas and water injection volumes, Pacific OCS, 2003.

| Field | Gas Injection Volume (Mcf) | Water Injection Volume (bbl) |
|---|---|---|
| Hondo | 6,804,881 | - |
| Pt. Arguello | 6,281,909 | - |
| Pescado | 3,933,457 | - |
| Sockeye | 105,431 | - |
| Dos Cuadras | - | 12,574,037 |
| Pt. Pedernales | - | 6,658,872 |
| Beta | - | 3,767,766 |
| Sockeye | - | 2,311,688 |
| Pescado | - | 2,273,719 |
| Hondo | - | 101,572 |
| **Total** | **17,125,678** | **27,687,654** |




## Drilling History and Production Rates

There have been 329 exploratory wells and 928 development wells drilled as of December 31, 2003. For thirteen consecutive years no exploratory wells have been drilled in the Pacific OCS. Fourteen development wells and redrills were drilled during 2003, in four fields. Total footage drilled in these wells exceeded 238,000 feet. Drilled footage by year for all wells in the Pacific OCS is displayed in figure 11. Additional delineation wells are anticipated in many of the Pacific OCS fields as the operators seek to define productive limits and optimize oil and gas recovery.

Annual oil production from the Pacific OCS decreased slightly during 2003, to approximately 29.7 MMbbl of oil. Over 80 percent of the oil was produced from Monterey Formation reservoirs. Most of the other oil production was ob-

tained from reservoirs in rocks younger than the Monterey Formation. Hondo, Pescado, and Point Arguello Fields together accounted for almost two-thirds of the region's oil production. Pacific OCS fields produced about five percent of the national OCS total.

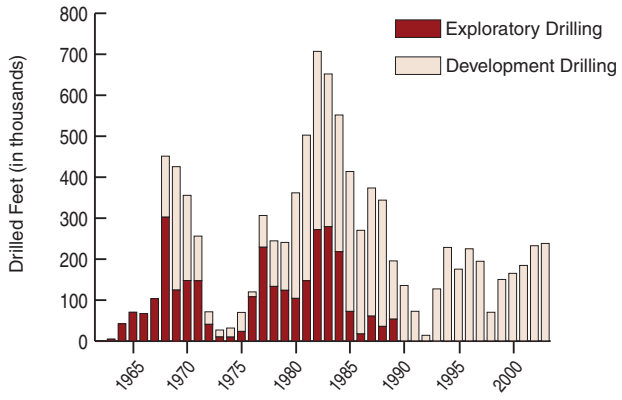



**Figure 11.**
Annual drilled footage for wells in the Pacific OCS.

Gas production from the 13 producing fields decreased during 2003, to approximately 58.4 Bcf by yearend. Approximately nine-tenths of the gas production was associated gas obtained from oil reservoirs, especially those of the Monterey Formation.

Cumulative production reached approximately 1,085 MMbbl of oil and 1,377 Bcf of gas in 2003. About one-half of the oil and gas production in the Pacific OCS to date has been from Post-Monterey aged reservoirs. This proportion will decline, however, as production from Monterey Formation reservoirs continues. Additional oil and gas production volume and rate data for the Pacific OCS are presented in appendix D.

## Oil and Gas Sales Prices, Volumes, and Gravities

During 2003, thirteen of the 25 fields in the Pacific OCS produced oil and gas. Sales volumes of oil and gas produced from these fields totaled 29.7 MMbbl and 31.2 Bcf, respectively. The weighted average sales prices of oil and natural gas during 2003 were $23.85 per barrel and $5.38 per thousand cubic feet, respectively.

Total sales of crude oil from Pacific OCS oil fields during 2003 are shown in figure 12. Hondo Field is the largest field in terms of oil sales volumes. Hondo, Pescado, and Sacate Fields, all in the Santa Ynez Unit accounted for over one-half of all Pacific OCS crude oil sold.

Total sales of natural gas from each field during 2003 are shown in figure 13. Differences between sales volumes and produced gas volumes are due primar-

ily to lease use, flaring, and injection. Pitas Point Field is the only producing gas field in the Pacific OCS, but produced only about 5.5 percent of all Pacific OCS natural gas sold. Hondo Field produces more natural gas than any other single field in the region, accounting for over half of all Pacific OCS natural gas sold.

**Figure 12.**
Oil sales volumes, Pacific OCS, 2003.

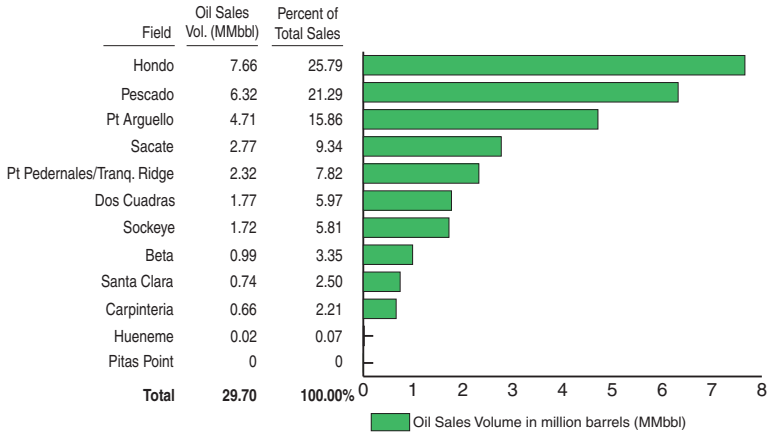
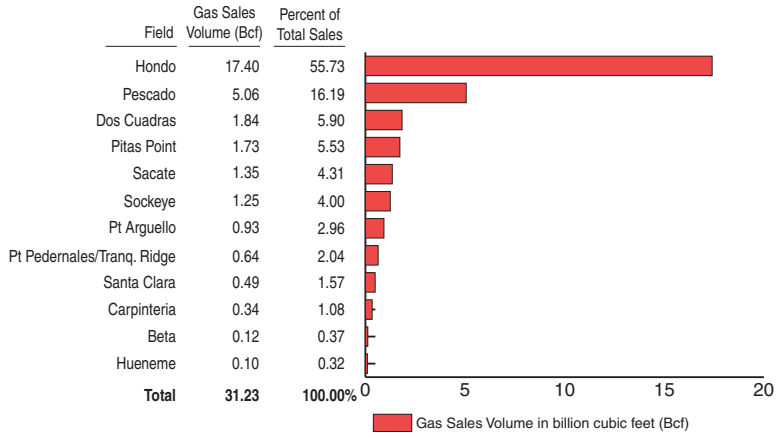



**Figure 13.**
Natural gas sales volumes, Pacific OCS, 2003.




Oil sales gravities range from 12 to 32 °API. Oil produced from some reservoirs, especially those of the Monterey Formation contains substantial quantities of sulfur and metals. These factors have produced lower average prices for Pacific OCS crudes when compared with the U.S. Spot Market (figure 14). On average Pacific OCS oil prices have been about 72 percent of the U.S. Spot Market price.

Average monthly Pacific OCS gas sale prices are shown on figure 15 along with the Henry Hub Price (U.S. Spot Market) and the average U.S. wellhead price. These prices track very closely except for December 2000 through June 2001.

During this time period the price of Pacific OCS natural gas (as well as that of most California natural gas) was 3 to 5 times higher than the national average as a result of manipulation of the California energy market by withholding pipeline transportation capacity to drive-up natural gas prices (California Public Utilities Commission Annual Report Fiscal Year July 1, 2003 - June 30, 2004; California Public Utilities Commission News Release 19325).

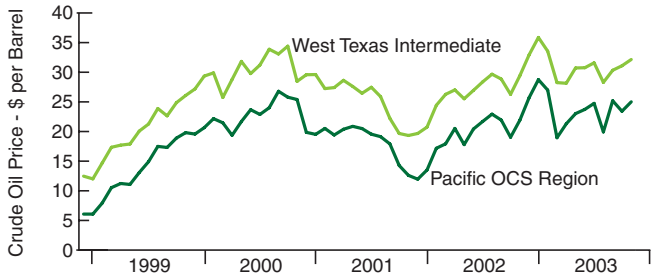



**Figure 14.**
Average monthly crude oil price for Pacific OCS and Standard West Texas Intermediate Crude (U.S. Spot Market).

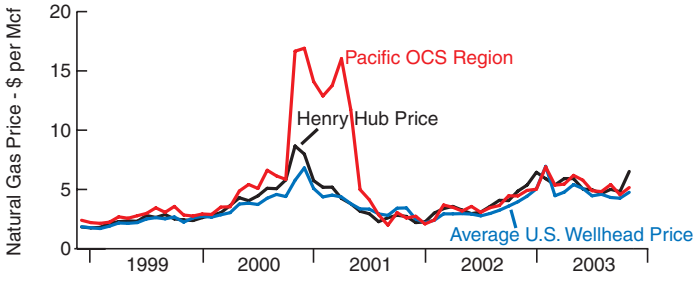



**Figure 15.**
Average monthly natural gas price for Pacific OCS, Henry Hub (U.S. Spot Market), and the average U.S. wellhead price.

## Conclusions

As of December 31, 2003, the total original recoverable reserves in 25 fields in the Pacific OCS, offshore California, are estimated to be 2,555 MMbbl of oil and 2,601 Bcf of gas. The remaining proved reserves in 13 oil and gas fields are estimated to be 303 MMbbl of oil and 987 Bcf of gas. Unproved reserves in 12 oil and gas fields in the Pacific OCS are estimated to be 1,166 MMbbl of oil and 490 Bcf of gas. Less than one-quarter of the remaining oil reserves and about two-thirds of the remaining gas reserves in the Pacific OCS are contained within currently producing fields.

Oil and gas were produced from 22 platforms in 13 fields at yearend 2003. Pacific OCS oil production declined during 2003, when approximately 29.7 MMbbl of oil were produced. Gas production also decreased to about 58.4 Bcf. Approximately nine-tenths of the gas production was associated gas obtained from oil reservoirs, especially those of the Monterey Formation. Through 2003, cumulative production from fields in the Pacific OCS has reached 1,085 MMbbl of oil and 1,377 Bcf of gas since production began in 1968.

Pacific OCS oil sales in 2003 were 29.7 MMbbl and gas sales were 31.2 Bcf. The difference in the gas sales volume from the produced volume is attributed to lease use, flaring, and the injection the gas back into producing reservoirs. The weighted average sales prices of Pacific OCS oil and natural gas during 2003 were $23.85 per barrel and $5.38 per thousand cubic feet (Mcf), respectively.

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## Appendixes: Reserves, Production, and Development Summaries

The following appendixes provide information on estimated oil and gas reserves, oil and gas production volumes and rates, water and gas injection volumes, and annual development activities in the Pacific OCS. This information, obtained primarily from MMS interpretations of geophysical, geological, and other data, form the basis of MMS resource and reserve estimates in the Pacific OCS.

### Appendixes

Appendix A - Annual Estimates of Oil and Gas Reserves..... A-1

Appendix B - Annual Development Activities.....B-1

Appendix C - Annual Water and Gas Injection..... C-1

Appendix D - Annual and Cumulative Oil and Gas Production ..... D-1

# Appendix A - Annual Estimates of Oil and Gas Reserves

The first oil field extending into Federal waters in the Pacific OCS was the Carpinteria Offshore Field (report figure 4, field 31) discovered in 1965. Estimates of original recoverable oil and gas reserves in the region have increased since that time, primarily due to the discovery of new oil and gas fields, and secondarily due to the reevaluation of known fields. Estimates of remaining reserves have generally increased as well, for the same reasons. The continued production of oil and gas, following the cessation of leasing and exploratory drilling, has initiated a downward trend in estimates of remaining reserves.

## Estimates of Original Recoverable Reserves

The MMS has developed yearly estimates of the reserves of Pacific OCS oil and gas fields since 1976. These estimates are shown in figure A-1 for oil, figure A-2 for gas, and table A-1.

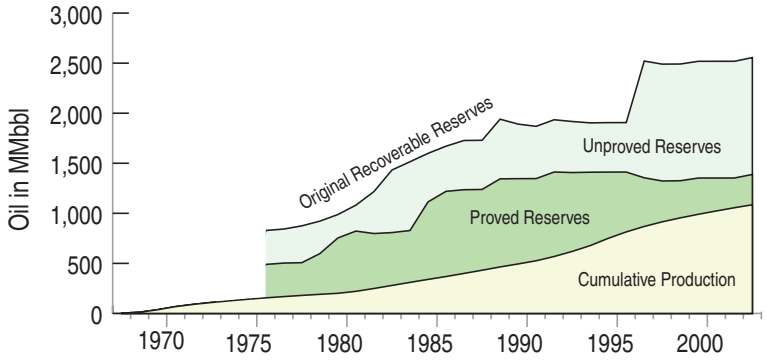



**Figure A-1.**
Annual estimates of oil reserves and cumulative production from the Pacific OCS.

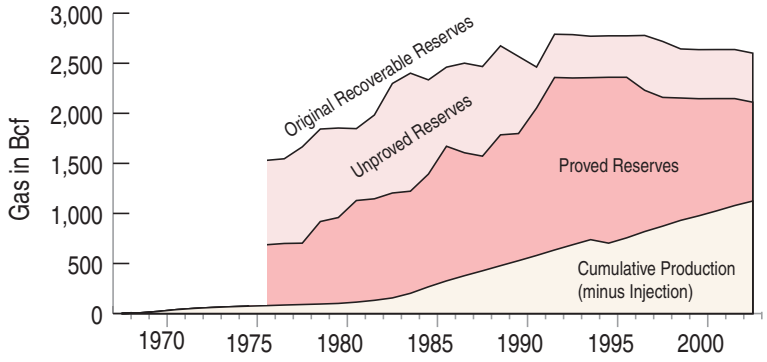



**Figure A-2.**
Annual estimates of gas reserves and cumulative production minus injection from the Pacific OCS.

The Original Recoverable Reserves shown in these figures and in table A-1 consists of three components: (1) Cumulative Production, (2) Remaining Proved Reserves, and (3) Remaining Unproved Reserves. The gas case is more complicated since the gross production volume must be adjusted downward to account for the significant amount of gas that is reinjected into Pacific OCS reservoirs (see appendix D).

The cessation of both leasing and exploratory drilling in the Pacific OCS has made the reevaluation of known fields the only factor that continues to change estimates of original recoverable oil and gas reserves.

**Table A-1.**
Annual estimates of reserves and known resources with source publication numbers.

| | | Original Recoverable Reserves | | Remaining Proved Reserves | | Remaining Unproved Reserves | | Known Resources on Expired Leases | |
|---|---|---|---|---|---|---|---|---|---|
| | MMS Publication | | | | | | | | |
| Year | Number | Oil | Gas | Oil | Gas | Oil | Gas | Oil | Gas |
| 1976 | OFR 78-384 | 829 | 1,530 | 334 | 608 | 339 | 843 | 0 | 0 |
| 1977 | OFR 79-345 | 843 | 1,546 | 335 | 615 | 340 | 846 | 0 | 0 |
| 1978 | OFR 80-477 | 875 | 1,665 | 327 | 613 | 368 | 962 | 0 | 0 |
| 1979 | OFR 80-1042 | 921 | 1,843 | 407 | 824 | 324 | 924 | 3 | 3 |
| 1980 | OFR 81-623 | 988 | 1,853 | 553 | 858 | 234 | 894 | 3 | 3 |
| 1981 | OFR 82-37 | 1,082 | 1,847 | 602 | 1,015 | 259 | 718 | 3 | 3 |
| 1982 | OFR 83-559 | 1,217 | 1,983 | 549 | 1,014 | 419 | 837 | 3 | 3 |
| 1983 | MMS 84-0024 | 1,433 | 2,298 | 528 | 1,048 | 625 | 1,094 | 3 | 3 |
| 1984 | MMS 85-0041 | 1,515 | 2,401 | 518 | 1,020 | 687 | 1,179 | 21 | 21 |
| 1985 | MMS 86-0066 | 1,599 | 2,334 | 774 | 1,126 | 485 | 941 | 27 | 27 |
| 1986 | MMS 87-0045 | 1,670 | 2,461 | 851 | 1,345 | 451 | 790 | 39 | 39 |
| 1987 | MMS 88-0047 | 1,727 | 2,501 | 836 | 1,228 | 492 | 895 | 47 | 49 |
| 1988 | MMS 89-0085 | 1,729 | 2,467 | 807 | 1,145 | 491 | 895 | 47 | 49 |
| 1989 | MMS 90-0086 | 1,940 | 2,674 | 880 | 1,307 | 596 | 889 | 47 | 49 |
| 1990 | MMS 91-0087 | 1,891 | 2,568 | 852 | 1,270 | 545 | 770 | 96 | 147 |
| 1991 | MMS 92-0073 | 1,869 | 2,462 | 821 | 1,473 | 522 | 409 | 121 | 332 |
| 1992 | MMS 94-0008 | 1,935 | 2,790 | 844 | 1,723 | 522 | 432 | 121 | 332 |
| 1993 | MMS 94-0059 | 1,917 | 2,786 | 788 | 1,666 | 510 | 433 | 132 | 343 |
| 1994 | MMS 95-0062 | 1,904 | 2,770 | 733 | 1,618 | 493 | 414 | 149 | 362 |
| 1995 | MMS 96-0060 | 1,906 | 2,774 | 662 | 1,657 | 494 | 414 | 149 | 362 |
| 1996 | MMS 98-0001 | 1,906 | 2,774 | 598 | 1,604 | 494 | 414 | 149 | 362 |
| 1997 | MMS 99-0023 | 2,521 | 2,778 | 486 | 1,411 | 1,166 | 548 | 149 | 362 |
| 1998 | MMS 2000-0063 | 2,490 | 2,718 | 408 | 1,286 | 1,166 | 559 | 149 | 362 |
| 1999 | MMS 2007-012 | 2,491 | 2,643 | 371 | 1,222 | 1,166 | 490 | 149 | 362 |
| 2000 | MMS 2007-012 | 2,518 | 2,636 | 362 | 1,170 | 1,166 | 490 | 149 | 362 |
| 2001 | MMS 2007-012 | 2,518 | 2,637 | 329 | 1,121 | 1,166 | 490 | 149 | 362 |
| 2002 | MMS 2007-012 | 2,518 | 2,637 | 297 | 1,068 | 1,166 | 490 | 149 | 362 |
| 2003 | MMS 2007-012 | 2,555 | 2,601 | 303 | 987 | 1,166 | 490 | 149 | 362 |

*Oil in million barrels (MMbbl), Natural Gas in billion cubic feet (Bcf).*

## Estimates of Remaining Reserves

Three of the 25 known fields in the Pacific OCS (Hondo, Pescado, and Sacate) have been ranked among the top 50 U.S. oil fields in terms of remaining proved oil reserves, and the Hondo field was in the top 20. These 3 fields contain over one-half of the remaining proved oil reserves and over three-quarters of the remaining proved gas reserves in the region.

Historically, the average volumes of oil and gas produced annually in the Pacific OCS have been about 1 percent of current estimated original recoverable oil and gas reserves. Such production rates have not caused extreme annual variations between estimated original recoverable reserves and remaining reserves. As a result, annual estimates of remaining oil and gas reserves have generally increased or decreased in step with the annual estimates of original recoverable reserves (figures A-1 and A-2). However, the divergence between original recoverable reserves and remaining reserves increased since about 1992 as production rates in the Pacific OCS reached record-setting levels.

# Appendix B - Annual Development Activities

The pace of development activities in the Pacific OCS was at a low but relatively constant level from 1999 to 2003. A total of 26 new wells and 36 redrills/sidetracks were drilled during this time period (figure B-1). Additional work was also completed at each of the producing fields consisting primarily of routine maintenance, and well workovers such as reperforations, acid simulation, and pump changes. Listed below are development activities for each of the Pacific OCS producing fields.

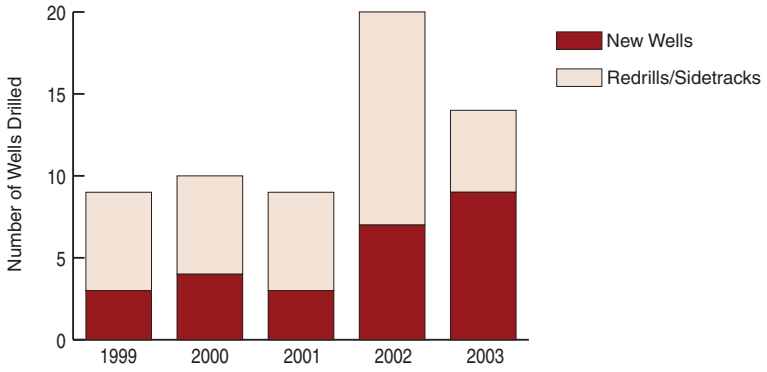



**Figure B-1.**
Wells and redrills/sidetracks drilled in the Pacific OCS.

## Field Activities

*Beta Field*

The Beta Field is the only producing Pacific OCS field in the Los Angeles Basin. There were no new development wells drilled during 1999 to 2003. In 1999 Platform Eureka was shut down due to pipeline failure and 4,100 barrels of oil production per day was lost as a result of that incident. This shutdown continued for the entire period of this report.

Waterflood operations continued in Leases OCS-P 0300 and 0301 with the operator maximizing the process by managing injection/withdrawal volume balancing. Pump changes were the most common type of workovers performed in the Beta field.

Annual oil production declined by 44 percent from 1,771,370 bbl in 1999 to 993,911 barrels in 2003. Annual gas production declined by 59 percent from 760,885 Mcf in 1999 to 313,692 Mcf in 2003. Most of the decline in production is due to the shut down of Platform Eureka.

*Carpinteria Offshore Field*

No new development wells were drilled in the Carpinteria Offshore Field during 1999-2003; however, there were numerous well workovers such as pump changes. In addition there was significant maintenance performed on platforms Hogan and Houchin during 2003.

In 2002 and 2003 the operator of platforms Hogan and Houchin completed a 3-D geological modeling study of the field to identify potential bypassed zones of oil. The operator is planning a major redrilling program similar to one completed in 1998.

Annual oil production declined by 22 percent from 840,757 bbl in 1999 to 656,550 bbl in 2003. During this time period annual gas production declined by 19 percent from 554,871 Mcf to 448,889 Mcf.

*Dos Cuadras Field*

There were three new wells drilled with one considered successful in an effort to redevelop the Dos Cuadras Field and produce bypassed oil reserves. In addition, several shut-in wells were returned to production after gravel pack repairs. Numerous other recompletions, workovers and pump changes were performed during this time period.

Annual oil production declined by 28 percent from 2,430,418 bbl in 1999 to 1,751,815 bbl in 2003. During this time period annual gas production declined by 8 percent from 2,546,514 Mcf to 2,338,899 Mcf.

*Hondo Field*

The development of Hondo Field continued with the drilling of eight new wells and 13 sidetracked wells with the primary objective of producing the remaining Monterey oil column by water drive and eliminating the existing gas cap. Bypassed oil in the Monterey South Fault Block was identified, and evaluation of sandstone targets was started.

During 2002 a pilot water injection project was initiated to supplement the natural aquifer. In 2003 a comprehensive integrated reservoir/geologic field study was initiated to quantify and determine the distribution of remaining reserves and to develop optimal depletion strategies.

Annual oil production declined by 37 percent from 12,194,642 bbl in 1999 to 7,664,524 bbl in 2003. Annual gas production declined by 26 percent from 38,284,266 Mcf to 28,495,318 during this time period.

*Hueneme Field*

There were no new development wells drilled in the Hueneme Field. Only routine maintenance and minor well workovers were performed.

Annual oil production declined by 68 percent from 182,889 bbl in 1999 to 59,076 bbl in 2003. Annual gas production declined by 18 percent from 253,287 Mcf to 207,323 Mcf during this time period.

*Pescado Field*

In 1999 the operator initiated testing the feasibility of aquifer augmentation through waterflooding, and in 2000 initiated a pilot water injection project with a goal of allowing additional gas sales and shrinking of the gas cap sufficiently to restore oil production in updip wells. This project proved successful and has added substantially to the gas sales volume.

During 2002 a geologic field study was completed and the development continued with the drilling of three new wells and two sidetrack wells. The operator commenced evaluating the sandstone reservoirs, which contain high gravity oil that can be used as diluent to lift the heavier Monterey Reservoir oil.

Annual oil production declined by 28 percent from 8,756,809 bbl in 1999 to 6,328,788 bbl in 2003. Annual gas production declined by 48 percent from 19,085,872 Mcf to 9,901,298 Mcf during this time period.

*Pitas Point Field*

Pitas Point Field is the only producing gas field in the Pacific OCS. During this period there were three wells sidetracked, along with other workovers including reperforations and recompletions.

Water production and/or sand influx have become sufficiently excessive and expensive to handle or remediate. Gas lift has been applied to some wells to assist in lifting water and sustaining recovery from sands that otherwise would load-up and kill the wells. Evaluations were made to optimize the lift system in wells to continually unload water from wellbores.

Annual gas production declined by 63 percent from 4,901,386 Mcf in 1999 to 1,809,607 Mcf in 2003. Annual condensate production declined by 62 percent from 2,152 bbl to 816 bbl during this time period.

*Point Arguello Field*

As of November, 1999 Arguello Inc. was designated as operator of the Point Arguello Field. ChevronTexaco was the previous operator. The new operator commenced a 3-D reservoir model study to guide redevelopment. This study included seismic reprocessing and interpretation for the entire field. The seismic/geologic interpretation was subsequently completed and field development opportunities were identified.

During the 1999 to 2003 time period 15 redrills/sidetrack wells were drilled in the Point Arguello Field. In addition numerous acid stimulation jobs were per-

formed to maximize Monterey Reservoir well productivity. During 2000 plans were developed to bring excess sweetened gas to shore for sales to be used to generate electricity utilizing the onshore Gaviota co-generation turbines. Gas sales commenced for generation of electric power in 2001.

Annual oil production declined by 35 percent from 7,294,370 bbl in 1999 to 4,708,031 bbl in 2003. Annual gas production increased by 64 percent from 6,140,448 Mcf to 10,077,220 Mcf during this time period. This increase was due primarily to recycling of injected gas.

*Point Pedernales Field / Tranquillon Ridge Field*

There were no new development wells or redrills in Point Pedernales and Tranquillon Ridge fields during 1999 to 2003. In 1999 a water injection pilot plan was initiated as the onshore Lompoc water disposal facility was nearly filled to capacity. Water injection will also provide reservoir pressure support, increasing ultimate recovery of oil. Water handling is one of the key economic factors of the Point Pedernales Field. Routine maintenance and workovers occurred during the report period.

Annual oil production declined by 26 percent from 3,144,937 bbl in 1999 to 2,321,684 bbl in 2003. Annual gas production declined by 34 percent from 1,375,406 Mcf to 907,321 Mcf during this time period.

*Rocky Point Field*

Although development had not yet commenced at the Rocky Point Field, interpretation of reprocessed 3-D seismic data enabled the operator to construct a detailed plan for the development of the portion of the field which encompasses eastern half of Lease P-OCS 0451. During 2003 the operator acquired all necessary discretionary permits and approvals for the commencement of production.

*Sacate Field*

In 1999 development of the Sacate Field commenced with the drilling of one new well. Production stabilized at about 4,000 BOPD using gas lift, and this well broke the record for Offshore USA extended reach with a 18,688 feet horizontal section. During the 1999 to 2003 time period a total of 11 production wells were drilled to develop the field.

Annual oil production increased from 258,647 bbl in 1999 (partial year) to 2,776,060 bbl in 2003. Annual gas production increased from 654,161 Mcf to 1,552,009 Mcf during this time period.

*Santa Clara Field*

There were no wells drilled in the Santa Clara Field during this time period. However, recompletions, pump changes, and other routine maintenance and

workovers occurred. The operator formulated plans to resume water injection in a subsequent year.

Annual oil production declined by 27 percent from 1,009,142 bbl in 1999 to 741,509 bbl in 2003. Annual gas production declined by 31 percent from 818,055 Mcf to 566,137 Mcf during this time period.

*Sockeye Field*

In 1999 the operator reprocessed the 3-D seismic data and commenced a reservoir characterization study of the Sockeye Field. This study was completed in 2003. One new well and three sidetracks were drilled, along with several recompletions to develop the various reservoirs of the Sockeye Field. In 2000 the operator planned and initiated a successful waterflood in the Upper Topanga reservoir.

Annual oil production increased by 24 percent from 1,394,401 bbl in 1999 to 1,733,875 bbl in 2003. Annual gas production declined by 63 percent from 4,818,758 Mcf to 1,791,947 Mcf during this time period.

# Appendix C - Annual Water and Gas Injection Volumes

This appendix presents annual volumes of natural gas and water injected into reservoirs of the Pacific OCS. Both of these fluids are injected into reservoirs to increase the amount of oil ultimately recovered. The MMS has been keeping records of fluid injection in the Pacific OCS since January 1985.

Water injection is commonly called waterflooding. By injecting water into a hydrocarbon reservoir, additional quantities of oil that have been left behind after primary production can be recovered. Water from injection wells tends to carry or sweep oil to adjacent production wells. Waterflooding requires wells specifically configured for water injection (either drilled specifically for that purpose or converted from former production wells), as well as the ability to remove water and oil from production wells drilled adjacent to the injection wells. The efficiency or ability of waterflooding to increase the ultimate production of oil from a reservoir varies considerably, and is dependent on the geology, and on fluid and other reservoir properties of the oil being produced.

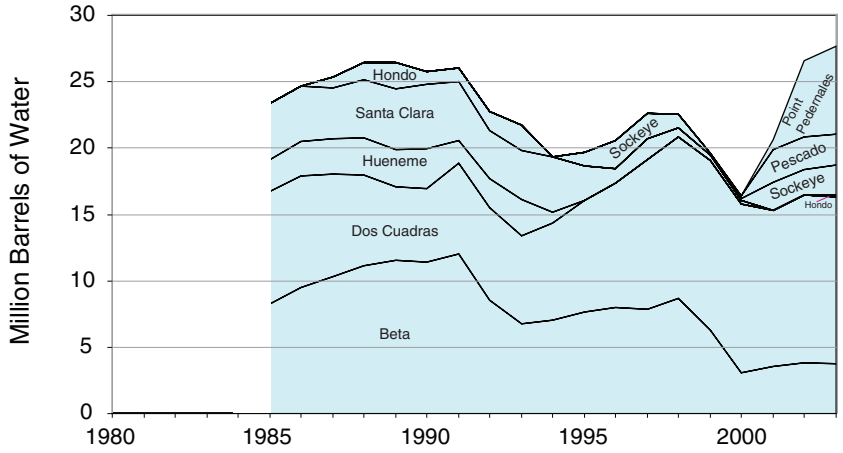
Table C-1 and figure C-1 show the annual volume in barrels of water injected into Pacific OCS reservoirs both by field and total OCS.

**Table C-1.** Annual volume of water injected into Pacific OCS reservoirs.

| Year | Beta | Dos Cuadras | Hueneme | Santa Clara | Hondo | Sockeye | Pescado | Point Pedernales | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 1985 | 8,279,240 | 8,439,148 | 2,405,710 | 4,243,288 | 0 | 0 | 0 | 0 | 23,367,386 |
| 1986 | 9,468,982 | 8,455,830 | 2,573,699 | 4,142,789 | 0 | 0 | 0 | 0 | 24,641,300 |
| 1987 | 10,333,774 | 7,691,027 | 2,693,332 | 3,793,889 | 833,736 | 0 | 0 | 0 | 25,345,758 |
| 1988 | 11,138,301 | 6,848,754 | 2,777,882 | 4,384,128 | 1,312,820 | 0 | 0 | 0 | 26,461,885 |
| 1989 | 11,527,434 | 5,590,276 | 2,764,107 | 4,559,106 | 1,981,544 | 0 | 0 | 0 | 26,422,467 |
| 1990 | 11,419,914 | 5,532,018 | 2,982,373 | 4,865,851 | 966,019 | 0 | 0 | 0 | 25,766,175 |
| 1991 | 12,026,503 | 6,865,071 | 1,672,432 | 4,479,329 | 1,020,939 | 0 | 0 | 0 | 26,064,274 |
| 1992 | 8,533,251 | 6,956,135 | 2,243,916 | 3,599,003 | 1,439,668 | 0 | 0 | 0 | 22,771,973 |
| 1993 | 6,749,234 | 6,629,661 | 2,764,160 | 3,648,134 | 1,927,953 | 0 | 0 | 0 | 21,719,142 |
| 1994 | 7,010,855 | 7,367,790 | 760,920 | 4,170,182 | 13,044 | 0 | 0 | 0 | 19,322,791 |
| 1995 | 7,631,528 | 8,405,289 | 6,709 | 2,580,215 | 0 | 1,064,911 | 0 | 0 | 19,688,652 |
| 1996 | 7,995,149 | 9,389,752 | 0 | 1,088,889 | 0 | 2,080,778 | 0 | 0 | 20,554,568 |
| 1997 | 7,862,579 | 11,247,945 | 0 | 1,566,017 | 0 | 1,938,313 | 0 | 0 | 22,614,854 |
| 1998 | 8,661,200 | 12,155,617 | 0 | 722,368 | 0 | 1,033,682 | 0 | 0 | 22,572,867 |
| 1999 | 6,269,588 | 12,808,941 | 0 | 414,739 | 0 | 119,645 | 0 | 0 | 19,612,913 |
| 2000 | 3,108,285 | 12,651,211 | 0 | 328,139 | 0 | 119,342 | 170,430 | 0 | 16,377,407 |
| 2001 | 3,554,558 | 11,760,124 | 0 | 9,005 | 0 | 2,075,736 | 2,479,997 | 785,966 | 20,665,386 |
| 2002 | 3,860,548 | 12,618,831 | 0 | 0 | 0 | 1,902,697 | 2,482,616 | 5,742,363 | 26,607,055 |
| 2003 | 3,767,766 | 12,574,037 | 0 | 0 | 101,572 | 2,311,688 | 2,273,719 | 6,658,872 | 27,687,654 |

*No Injection Data available prior to January 1, 1985*

**Figure C-1.**
Annual volume of water injected into Pacific OCS reservoirs.
*No injection data is available prior to January 1, 1985*




Gas injection is also a secondary recovery method whereby injected gas helps maintain higher reservoir pressure, thus increasing the recovery of oil. In addition to injecting gas back into the reservoir, it can also be injected downhole into the production wells in a technique called gas lift. This lowers the pressure within the wellbore allowing more efficient recovery, especially of heavier, more viscous oil.

Figure C-2 and table C-2 show the annual volume of natural gas in thousands of cubic feet (Mcf) injected into Pacific OCS reservoirs both by field and total OCS. Figure C-3 shows the percentage of Pacific OCS natural gas production that is injected back into reservoirs.

**Figure C-2.**
Annual volume of natural gas injected into Pacific OCS reservoirs.
*No injection data is available prior to January 1, 1985*

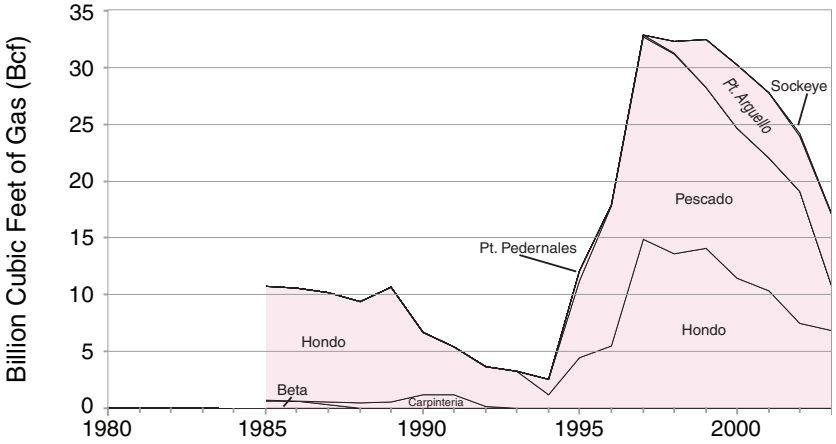



**Figure C-3.**
Percentage of produced natural gas injected into Pacific OCS reservoirs.

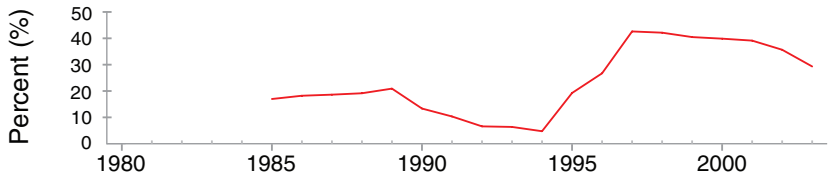


**Table C-2.**
Annual volumes of natural gas injected into Pacific OCS reservoirs.

| Year | Beta | Carpinteria | Hondo | Pescado | Point Pedernales | Point Arguello | Sockeye | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 1985 | 660,298 | 54,240 | 10,062,342 | 0 | 0 | 0 | 0 | 10,776,880 |
| 1986 | 630,430 | 12,634 | 9,919,502 | 0 | 0 | 0 | 0 | 10,562,566 |
| 1987 | 357,325 | 181,094 | 9,663,760 | 0 | 0 | 0 | 0 | 10,202,179 |
| 1988 | 374 | 444,630 | 8,948,117 | 0 | 0 | 0 | 0 | 9,393,121 |
| 1989 | 0 | 586,184 | 10,055,917 | 0 | 0 | 0 | 0 | 10,642,101 |
| 1990 | 0 | 1,211,109 | 5,459,910 | 0 | 0 | 0 | 0 | 6,671,019 |
| 1991 | 0 | 1,192,083 | 4,238,600 | 0 | 0 | 0 | 0 | 5,430,683 |
| 1992 | 0 | 133,722 | 3,505,596 | 0 | 0 | 0 | 0 | 3,639,318 |
| 1993 | 0 | 8,949 | 3,283,688 | 6,330 | 0 | 0 | 0 | 3,298,967 |
| 1994 | 0 | 24,175 | 1,142,925 | 1,370,570 | 0 | 0 | 0 | 2,537,670 |
| 1995 | 0 | 28,878 | 4,403,143 | 6,793,340 | 837,861 | 0 | 0 | 12,063,222 |
| 1996 | 0 | 18,616 | 5,470,530 | 12,341,417 | 74,468 | 0 | 0 | 17,905,031 |
| 1997 | 0 | 4,568 | 14,847,445 | 17,839,533 | 140,895 | 34 | 0 | 32,832,475 |
| 1998 | 0 | 0 | 13,601,400 | 17,584,797 | 84,401 | 1,021,833 | 0 | 32,292,431 |
| 1999 | 0 | 0 | 14,046,083 | 14,176,183 | 19,114 | 4,209,385 | 0 | 32,450,765 |
| 2000 | 0 | 0 | 11,419,795 | 13,254,559 | 2,362 | 5,566,824 | 0 | 30,243,540 |
| 2001 | 0 | 0 | 10,363,473 | 11,645,207 | 0 | 5,765,722 | 0 | 27,774,402 |
| 2002 | 0 | 0 | 7,499,592 | 11,598,621 | 0 | 4,865,167 | 180,637 | 24,144,017 |
| 2003 | 0 | 0 | 6,804,881 | 3,933,457 | 0 | 6,281,909 | 105,431 | 17,125,678 |

*No Injection Data available prior to January 1, 1985*

During 2003 nearly 30 percent of all gas produced was injected back into Pacific OCS reservoirs. Once injected, the majority of this gas is available to be produced again. This makes accounting for gas reserves much more complex than for oil reserves. Unlike oil production, natural gas production cannot be simply subtracted from reserves to give remaining reserves. Also, due to reservoir conditions not all the gas injected back into Pacific OCS reservoirs is returned to the reserves category (i.e., to be produced again). Based on knowledge of the behavior of similar reservoirs, about 70 - 80 percent of the gas reinjected into Pacific OCS reservoirs is available to be produced again, and thus added back to the remaining reserves category.

# Appendix D - Annual and Cumulative Oil, Gas, and Water Production

Oil and gas production from the Pacific OCS began in June 1968 from the Carpinteria Offshore Field. By December 31, 2003, twelve additional fields were producing oil and gas. Peak oil production from the Pacific OCS occurred in 1995 when over 72 million barrels were produced. Peak gas production occurred four years later in 1999 when over 80 billion cubic feet of natural gas of gas were produced. Through December 31, 2003, approximately 1,085 MMbbl of oil and 1,377 Bcf of gas have been produced from 13 fields. Cumulative production of oil equals about 58 percent of the original recoverable reserves, and 78 percent of the original proved reserves. After adjusting gas volumes for injection, cumulative gas production is about 43 percent of the original recoverable reserves, and 53 percent of the original proved reserves.

## Annual Production

Annual production from the Pacific OCS Region is shown in figure D-1 and table D-1. The gas-oil ratio or GOR is shown in figure D-2. This represents the amount of gas produced in cubic feet per barrel of oil produced.

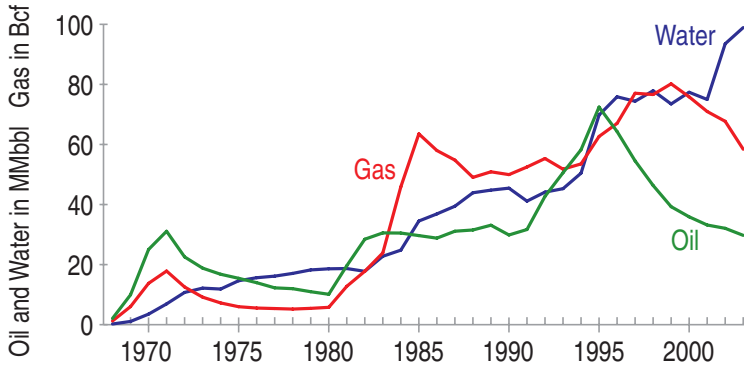



**Figure D-1.**
Annual production for the Pacific OCS.

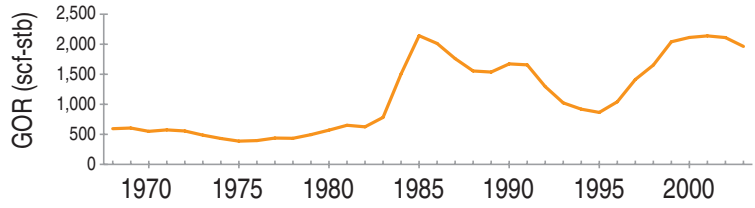



**Figure D-2.**
Gas-oil ratio (GOR) for the Pacific OCS.

Oil production was 29.7 million barrels during 2003, representing an average annual decline of about 7.4 percent from the 1995 peak. Gas production during 2003 was 58.4 billion cubic feet. This represents an average annual decline of about 6.8 percent from the 1999 peak. During 2003 there were 22 producing platforms in 13 fields in the Pacific OCS.

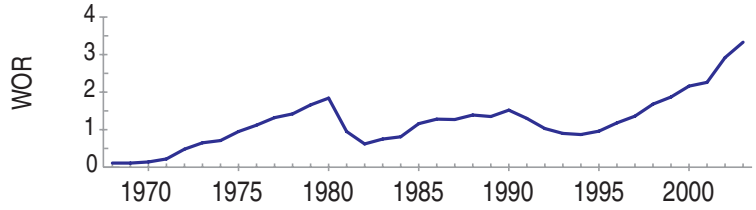
**Table D-1.** Annual and cumulative production for the Pacific OCS.

| Year | Annual Oil | Cumulative Oil | Annual Gas | Cumulative Gas | Annual Water | Cumulative Water | GOR | WOR |
|---|---|---|---|---|---|---|---|---|
| 1968 | 2,074,135 | 2,074,135 | 1,232,537 | 1,232,537 | 223,710 | 223,710 | 594 | 0.11 |
| 1969 | 9,942,733 | 12,016,868 | 6,016,485 | 7,249,022 | 1,072,477 | 1,296,187 | 605 | 0.11 |
| 1970 | 25,034,377 | 37,051,245 | 13,756,711 | 21,005,733 | 3,506,487 | 4,802,674 | 550 | 0.14 |
| 1971 | 31,103,681 | 68,154,926 | 17,853,055 | 38,858,788 | 6,915,276 | 11,717,950 | 574 | 0.22 |
| 1972 | 22,562,566 | 90,717,492 | 12,546,915 | 51,405,703 | 10,733,873 | 22,451,823 | 556 | 0.48 |
| 1973 | 18,818,026 | 109,535,518 | 9,157,714 | 60,563,417 | 12,167,333 | 34,619,156 | 487 | 0.65 |
| 1974 | 16,784,100 | 126,319,618 | 7,234,937 | 67,798,354 | 11,859,023 | 46,478,179 | 431 | 0.71 |
| 1975 | 15,434,507 | 141,754,125 | 5,978,959 | 73,777,313 | 14,630,940 | 61,109,119 | 387 | 0.95 |
| 1976 | 13,977,436 | 155,731,561 | 5,533,258 | 79,310,571 | 15,631,203 | 76,740,322 | 396 | 1.12 |
| 1977 | 12,258,013 | 167,989,574 | 5,366,181 | 84,676,752 | 16,157,737 | 92,898,059 | 438 | 1.32 |
| 1978 | 11,979,674 | 179,969,248 | 5,193,985 | 89,870,737 | 17,069,003 | 109,967,062 | 434 | 1.42 |
| 1979 | 10,971,013 | 190,940,261 | 5,430,689 | 95,301,426 | 18,230,747 | 128,197,809 | 495 | 1.66 |
| 1980 | 10,118,614 | 201,058,875 | 5,771,792 | 101,073,218 | 18,598,412 | 146,796,221 | 570 | 1.84 |
| 1981 | 19,616,136 | 220,675,011 | 12,769,019 | 113,842,237 | 18,687,567 | 165,483,788 | 651 | 0.95 |
| 1982 | 28,445,384 | 249,120,395 | 17,778,999 | 131,621,236 | 17,762,813 | 183,246,601 | 625 | 0.62 |
| 1983 | 30,550,954 | 279,671,349 | 23,886,062 | 155,507,298 | 22,771,102 | 206,017,703 | 782 | 0.75 |
| 1984 | 30,502,329 | 310,173,678 | 45,906,548 | 201,413,846 | 24,812,474 | 230,830,177 | 1,505 | 0.81 |
| 1985 | 29,657,291 | 339,830,969 | 63,521,850 | 264,935,696 | 34,506,598 | 265,336,775 | 2,142 | 1.16 |
| 1986 | 28,809,869 | 368,640,838 | 57,988,982 | 322,924,678 | 36,876,518 | 302,213,293 | 2,013 | 1.28 |
| 1987 | 31,110,377 | 399,751,215 | 54,797,967 | 377,722,645 | 39,436,718 | 341,650,011 | 1,761 | 1.27 |
| 1988 | 31,529,166 | 431,280,381 | 49,043,212 | 426,765,857 | 43,919,111 | 385,569,122 | 1,555 | 1.39 |
| 1989 | 33,112,019 | 464,392,400 | 50,896,259 | 477,662,116 | 44,793,399 | 430,362,521 | 1,537 | 1.35 |
| 1990 | 29,863,262 | 494,255,662 | 49,962,004 | 527,624,120 | 45,453,348 | 475,815,869 | 1,673 | 1.52 |
| 1991 | 31,682,004 | 525,937,666 | 52,497,516 | 580,121,636 | 41,132,773 | 516,948,642 | 1,657 | 1.30 |
| 1992 | 42,718,880 | 568,656,546 | 55,323,296 | 635,444,932 | 44,135,016 | 561,083,658 | 1,295 | 1.03 |
| 1993 | 50,586,863 | 619,243,409 | 51,781,188 | 687,226,120 | 45,274,037 | 606,357,695 | 1,024 | 0.90 |
| 1994 | 58,253,234 | 677,496,643 | 53,525,891 | 740,752,011 | 50,440,039 | 656,797,734 | 919 | 0.87 |
| 1995 | 72,450,243 | 749,946,886 | 62,666,960 | 803,418,971 | 69,798,374 | 726,596,108 | 865 | 0.96 |
| 1996 | 64,317,156 | 814,264,042 | 67,007,541 | 870,426,512 | 75,868,635 | 802,464,743 | 1,042 | 1.18 |
| 1997 | 54,542,748 | 868,806,790 | 77,052,233 | 947,478,745 | 74,388,860 | 876,853,603 | 1,413 | 1.36 |
| 1998 | 46,353,653 | 915,160,443 | 76,628,525 | 1,024,107,270 | 77,887,129 | 954,740,732 | 1,653 | 1.68 |
| 1999 | 39,284,153 | 954,444,596 | 80,193,909 | 1,104,301,179 | 73,482,897 | 1,028,223,629 | 2,041 | 1.87 |
| 2000 | 35,904,823 | 990,349,419 | 75,852,459 | 1,180,153,638 | 77,381,554 | 1,105,605,183 | 2,113 | 2.16 |
| 2001 | 33,181,608 | 1,023,531,027 | 70,971,635 | 1,251,125,273 | 74,983,218 | 1,180,588,401 | 2,139 | 2.26 |
| 2002 | 32,077,686 | 1,055,608,713 | 67,702,610 | 1,318,827,883 | 93,520,841 | 1,274,109,242 | 2,111 | 2.92 |
| 2003 | 29,736,639 | 1,085,345,352 | 58,409,660 | 1,377,237,543 | 98,916,059 | 1,373,025,301 | 1,964 | 3.33 |

*Oil and Water production in barrels, Natural Gas production in thousands of cubic feet (Mcf).*

During 2003, over 98.9 million barrels of water were produced as a by-product along with the oil and gas (figure D-1 and table D-1). Water production increased by an average of 8.7 percent per year from 1999 to 2003. Figure D-3 shows the ratio of the volume of water produced per volume of oil. This measure is called the water-oil ratio or WOR. Commonly in mature producing fields such as those of the Pacific OCS, the WOR increases with time.

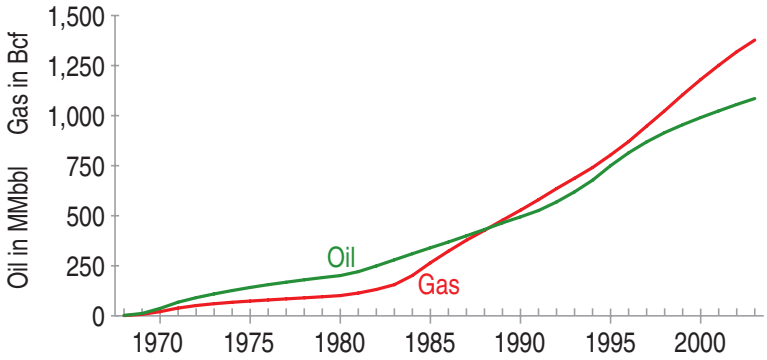
**Figure D-3.**
Water -oil ratio (WOR) for the Pacific OCS.




## Cumulative Production

Cumulative production exceeded 1,085 MMbbl of oil and 1,377 Bcf of gas in 2003 (figure D-4 and table D-1). The amount of oil produced to date exceeds 78 percent of the proved original recoverable reserves and 42 percent of the total original recoverable reserves. The net cumulative gas production when adjusted to reflect gas injection is about 43 percent of the original recoverable reserves.

**Figure D-4.**
Cumulative production for the Pacific OCS.




The Dos Cuadras Field has produced more oil than any other field in the Pacific OCS, with the Hondo Field a close second. Almost one-half of the cumulative oil production can be attributed to these two fields. Dos Cuadras, Hondo, Point Arguello, and Beta Fields have contributed about three-fourths of all Pacific OCS oil produced to date.

Gas production from Hondo Field far exceeds that from any other field in the region, accounting for about 37 percent of the region's total cumulative production. Pitas Point Field, the only producing gas field in the Pacific OCS, cur-

rently ranks second in terms of cumulative gas production. The combined total gas production from the two fields amounts to over one-half of the cumulative gas production from the region. Hondo, Pitas Point, Dos Cuadras, and Pescado Fields have produced about three-fourths of the natural gas obtained from Pacific OCS fields.


**The Department of the Interior Mission**

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 sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; 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 ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.


**The Minerals Management Service Mission**

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.