Chapter 2
The Role of Offshore Resources

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OVERVIEW

The petroleum and natural gas resources of offshore areas of the United States could be a key additional energy source to help meet U.S energy needs and limit oil import growth in future years. Although plentiful energy supplies and declining world prices have dampened concern about the energy situation, supply and demand trends indicate potential domestic shortfalls and rising oil imports by the end of the century. At present, offshore oil accounts for about 11 percent of total domestic petroleum production and offshore natural gas accounts for about 24 percent of total domestic gas production. The potential for increasing the contribution of offshore areas to U.S. energy supply may be large. Most U.S. offshore acreage remains to be explored, and the search is just beginning in the deepwater and Arctic frontier areas.

Resource recoverability is determined by a combination of geologic, technologic, and economic factors which can change over time. In addition, petroleum resource statistics are confusing because each estimate seems to be the result of different definitions and statistical methods. Given the inaccuracy and uncertainty associated with published resource estimates, they probably should be considered only as indicators of relative ranking among prospective oil and gas producing areas.

Offshore areas are expected to contain 21 to 41 percent of the oil and 25 to 30 percent of the natural gas that is undiscovered and recoverable in the United States. As much as one-third to one-half of the offshore oil may lie under waters 660 to 12,000 feet deep, If onshore and offshore Alaska are considered together, Alaska may contain as much as one-half of the total amount of recoverable oil expected to be found in the United States. About 31 percent of the natural gas expected to occur offshore probably lies in water depths between 660 and 8,200 feet. Gas occurring in the Arctic offshore regions is now considered to be uneconomical to recover.

California, while having a long history of offshore petroleum production, still remains largely unexplored in many areas. Similarly, the Atlantic and Alaskan regions have had only limited exploration, and as yet their Federal offshore areas have no oil or gas production. The Gulf of Mexico region continues to produce about 90 percent of the oil and virtually all of the natural gas produced from submerged lands.

U.S. ENERGY OUTLOOK

Although the United States is now in a period of relative stability as far as energy prices and supplies are concerned, energy trends include slowly increasing demand, declining domestic production, and rising imports to the end of the century. Although oil imports have decreased in the last 5 years, domestic demand is outpacing supply and leading to higher import levels. Low oil and gas prices have reduced incentives to conserve on energy uses and to substitute alternative fuels, Forecasts indicate that imports could reach record highs in the 1990s, increasing U.S. vulnerability to supply disruptions. Against this background, the oil and gas resources of the offshore areas of the United States take on new significance in their potential contribution to future U.S. energy needs.

Energy Demand Trends

U.S. energy demand decreased over the past decade largely because of the increase in the price of oil and natural gas that began in the early 1970s and the resulting energy conservation efforts (see table 2-l). The real increase in the price of both

Table 2-1 .–Energy Demand and Domestic Supply: 1978-83

Energy demand

Year	Oil (MMBD)	Natural gas (TCF)	Coal (MMT)	Nuclear (BkWh)	Hydro (BkWh)	Total (QUADS)
1968	13.4	18.6	509.8	12.5	225.2	60.9
1971	15.2	21.8	501.6	38.1	273.1	67.8
1974	16.7	21.2	558.4	114.0	316.9	72.5
1977	18.4	21.7	625.3	250.9	241.0	76.2
1980	17.0	19.9	702.7	251.1	300.1	75.9
1983	15.2	17.0	736.7	293.7	373.2	70.7

Domestic energy production

Year	Oil (MMBD)	Natural gas (TCF)	Coal (MMT)	Nuclear (BkWh)	Hydro (BkWh)	Total (QUADS)
1968	10.6	18.5	556.7	12.5	225.9	56.7
1971	11.2	20.2	560.9	38.1	269.5	61.2
1974	10.5	20.7	610.0	114.0	304.2	60.8
1977	9.9	19.2	697.2	250.9	223.6	60.1
1980	10.2	19.4	829.7	251.1	279.2	64.7
1983	10.3	16.0	784.9	293.7	332.1	61.2

SOURCE: Energy Information Administration, *1983 Annual Energy Review,* DOE/EIA-0384 (83), Washington, DC, April 1984.

fuels was about 250 percent between 1972 and 1983. In the same period, energy use per unit of gross national product dropped more than 22 percent. In the industrial sector, energy demand declined by 15.5 percent as a result of increased energy efficiency in various industrial processes and a shift to less energy-intensive products. In the residential and commercial sectors, energy demand remained nearly constant due to building insulation efforts and reduced heating and cooling levels. In the transportation sector, driving mileage has been reduced, and fuel consumption has become more efficient since the Corporate Average Fuel Economy (CAFE) standards were put in place.

Today, a combination of stable energy prices and recovery from the 1982-83 economic recession has caused demand to grow once again. Total energy demand in 1984 increased about 7 percent over 1983. Most of the increase is probably to restore demand capacity lost during the recession. There are indications, however, that fuel-use efficiency may be dropping. Driving mileage is up and automobile manufacturers are producing and selling more cars with lower fuel economy. Just as higher prices prompted fuel conservation, it appears that lower petroleum prices may now be encouraging greater energy use.

There is also less incentive to switch from oil and gas to alternative fuel sources. After the oil and gas price increases of the 1970s, demand for alternative fuels grew. Electric utilities, in particular, made greater use of coal and nuclear power in place of oil and natural gas. However, low oil and gas prices have now reduced the economic advantage of using coal, and the future of nuclear power is limited unless changes are made in the technology, management, and regulation of the industry. Low oil prices have halted the development of synthetic fuels made from more abundant resources (e. g., coal, oil shale, heavy oils, tar sands). Similarly, the high capital costs of converting direct renewable energy sources (e. g., solar, wind, wood) has severely limited their potential for replacing oil and gas.

Energy forecasts indicate that overall U.S. energy demand will grow modestly to the end of the century and that oil will remain the largest single energy source. Projections by the Department of Energy (DOE) and the Gas Research Institute (GRI) show energy consumption in the United States growing by about 1 percent per year—less than half the expected growth rate of the gross national product (see table 2-2). The percentage of oil used in relation to total energy use is forecast to be about 35 percent in 2000 as compared to 42

Table 2-2.—U.S. Energy Demand and Supply Forecasts to 2000

Energy source	Demand		Domestic supply		Imports	
	GRI	DOE	GRI	DOE	GRI	DOE
Oil and NGL (MMBD)	16.7	15.2	9.2	8.1	7.5	7.1
Natural gas (TCF)	19.0	18.7	15.9	15.9	3.8	2.8
Coal (MMT)	1,345.0	1,190.0	—	—	—	—
Nuclear (BkWh)	600.0	700.0	—			
Hydro (BkWh)	375.0	375.0	–	-	-	
Other (Quads)	2.9	3.3	—	–	–	–
Total (Quads)	93.3	90.9				

SOURCES: 1984 GRI *Baseline Projection of* U S Energy Supply *and Demand,* 1983-2000, Gas Research Institute, Chicago, IL, October 1984; U.S. Department of Energy, *Energy Projections to the Year* 2010, DOE/PE0029/2. Washington. DC, October 1983

percent today. This decline does not represent any significant replacement of oil, but rather indicates that growth in the electric utility sector will continue to be accommodated partly by coal and nuclear power.

Energy Supply Trends

Despite the large oil and gas price increases of the 1970s, domestic energy production remained virtually level over the past decade (see table 2-1). Growth in the production of coal and nuclear power offset declines in domestic oil and natural gas production, If the contribution of Alaskan crude oil production is removed, domestic oil production declined more than 18 percent between 1974 and 1983. The slight increase in domestic oil production since 1980 is due entirely to production from the Prudhoe Bay Field on Alaska's North Slope. Domestic oil and gas reserves have declined even more rapidly than production, despite enormous increases in resource exploration and development since 1973, and particularly since 1980. According to DOE, proven reserves of economically recoverable oil dropped from 47 billion barrels in 1970 to 35 billion barrels in 1984,

As a result of the recent increase in energy demand, however, domestic energy production increased in 1984 as compared to 1983. Crude oil production grew slightly with increases in Alaskan production, and natural gas output was about 11 percent ahead of 1983. Coal production, which declined between 1981 and 1983, was up sharply as electricity demand rebounded from the recession. Similarly, the production of nuclear-generated electricity was expanded in 1984, as new power plants came on line.

Oil import levels have increased as growth in domestic demand has outpaced domestic oil production. Oil imports decreased after the oil embargo and price increase of 1973, but shortly thereafter grew to an all time high of 9.3 million barrels per day in 1977. Over the next 2 years, Alaskan oil began to flow in significant quantities and U.S. imports of petroleum declined slightly. A second oil price rise in 1979 and cumulative conservation efforts led to declining imports and a record oil import low of 4.9 million barrels per day in 1983. However, in 1984, oil imports once again started to climb and increased about 7 percent over 1983, accounting for about one-third of U.S. petroleum requirements.

The DOE and GRI energy forecasts indicate a continuing decline in the production of domestic oil and natural gas to the year 2000 (see table 2-2). In both forecasts, oil and gas imports are expected to increase substantially, to between 7.1 and 7.5 million barrels of oil per day and 2.8 and 3.8 trillion cubic feet (Tcf) of natural gas per day. There are indications, however, that even the DOE and GRI projections maybe optimistic and that imports may reach higher levels. Continued low energy prices may lead to greater fuel usage, reduced conservation efforts, and limited replacement of oil by alternative fuels. There are also uncertainties about natural gas supplies and the possibility that price controls and a failure to develop unconventional sources may promote substitution of oil for natural gas.

In comparison with the DOE projection of 8.1 million barrels per day and the GRI projection of 9.2 million barrels per day, studies by the Office of Technology Assessment (OTA)[1] and the Congressional Research Service (CRS)[2] forecast even greater declines in domestic production of crude oil. OTA projected that domestic oil and natural gas liquids production would decline to 4 to 7 million barrels per day by 2000. CRS was less pessimistic, but still estimated a decline in production to 7.3 to 8.5 million barrels per day. These production levels indicate that oil imports may range from 7 to as high as 10 million barrels per day in 2000, contributing to high trade deficits and decreases in energy and economic security.

[1]U. S. Congress, Office of Technology Assessment, *World Petroleum Availability: 1980-2000* (Washington, DC: U.S. Government Printing Office, October 1980).

[2]Congressional Research Service, "Domestic Crude Oil Production Projected to the Year 2000 on the Basis of Resource Capability' (July 1984).

Current energy forecasts underline the importance of the oil and gas resources of the U.S. Outer Continental Shelf (OCS) and the Exclusive Economic Zone (EEZ). Since domestic reserves have been dropping over the last several years, an increasing percentage of our domestic oil production must come from oil reserves as yet undiscovered. Widespread exploration and development of the lower 48 States make large field discoveries in onshore areas of the United States, outside Alaska, somewhat doubtful. In contrast to the overall energy reserve status in the United States, estimated recoverable oil and gas reserves in Federal offshore areas have increased steadily in recent years. However, only a small percentage of total U.S. offshore area has been explored. Offshore resources, particularly those of the unexplored deepwater and Arctic frontier regions, offer the best hope for limiting future U.S. energy import dependence.

RESOURCE PROJECTION PROBLEMS

The U.S. Geological Survey (USGS) estimated in 1981 that 26 to 41 percent of the oil and 25 to 30 percent of the natural gas that is undiscovered and recoverable in the United States would be found offshore within the EEZ. However, that estimate is by no means certain. Published projections of oil and gas reserves and resources are generally incomplete and lack accuracy. There are several reasons for this.

- Projections of oil and gas resources are generally based on averages or aggregated values from independent analyses and expert opinions, which results in widely ranging estimates that are subject to large errors.
- Until an area is sufficiently explored, resource projections are largely inferred from indirect geological information, e.g., seismic records, gravity and magnetic data, and geomorphology, and Continental Offshore Stratigraphic Test (COST) wells.
- Information on oil and gas reserves in existing fields and assessments of resource potential for frontier regions are considered by the petroleum industry to be proprietary and highly sensitive, therefore it is unlikely that precise, detailed information on recoverable reserves and resources from individual firms will be available to Congress, the Department of the Interior, or the public.

The amount of recoverable oil and gas that remains to be discovered beyond the currently estimated reserves will be produced from two sources: 1) extension of known fields through new developments in drilling technology and new techniques for increasing (enhancing) oil and gas recovery from old fields; and 2) new discoveries in unexplored frontier regions and undeveloped areas of proven regions.

Over three-fourths of the oil discovered thus far in the United States is located in ' 'giant' fields of 100 million barrels or more—**e.g.,** the Gulf of Mexico and Prudhoe Bay, Alaska. About 8 percent of the discovered oil is found in fields smaller than 10 million barrels. Therefore, the reliability of discoverable resource projections for the EEZ will depend on how well geologists and petroleum engineers can predict the existence of giant fields

offshore, and how accurately they can evaluate the extent of the recoverable resources that lie therein. [3] When estimates go beyond proved reserves, accuracy rapidly deteriorates with errors of perhaps 50 percent or more.

Comparability Among Estimates

Although resource estimates may be useful to Congress in considering national policies, their value lies primarily in indicating the relative reserve potential from the likely petroleum-bearing basins rather than as estimates of absolute quantities of oil and gas available offshore. The primary use of published resource assessments is for general information.

Published sources have little technical use in either the administration of the offshore leasing program by the Department of the Interior or the formulation of industry leasing strategies. Firms make large investments to develop detailed information on resource prospects in the individual basins of the OCS for the purpose of corporate planning. Good resource information is a major competitive factor among oil and gas firms bidding on offshore tracts, and therefore is considered proprietary. However, it is unlikely that even the industry has ***accurate*** estimates.

Four independent assessments of the oil and gas resources of the OCS are currently available to the public:

1. USGS Circular 860 (1981): ***Estimates of Undiscovered Recoverable Conventional Resources of Oil and Gas in the United States.***
2. National Petroleum Council (1981): ***U.S. Arctic Oil and Gas.***
3. Rand Corporation (1981): ***The Discovery of Significant Oil and Gas Fields in the United States.***
4. Potential Gas Committee (1983): ***Potential Supply of Natural Gas in the United States.***

It is difficult to make area-by-area comparisons of the estimates of undiscovered oil and gas published in the four resource assessments. The difficulty in comparing these estimates arises from: 1) differences in methodologies used in deriving the resource estimates; 2) differences in reporting statistical data, e.g., errors, ranges, and probabilities; 3) inconsistencies in definitions of resources and reserves; 4) differences in technical and economic assumptions in deriving recoverable resource values; 5) the inclusion or exclusion of unconventional resources, e.g., low permeability formations; 6) lack of agreement on boundaries (water depth, international boundaries, etc.) of the resource area being estimated; and the fact that 7) the professional perspectives of the estimators may influence the probabilities assigned to the estimates; and 8) the conditions and assumptions on which the estimates are based are seldom specified in sufficient detail.

Furthermore, several government agencies with varying missions often report resource statistics in different ways to suit their particular purpose. This may result in inconsistencies among government reports and add to the confusion.

Reliability of Estimates

It is difficult to determine the reliability and credibility of the various resource assessments for many of the same reasons. In addition: 1) details of the methods used for estimating resources are not published; 2) data bases and geological information used for the assessments are often considered to be proprietary and confidential; and 3) the process used for deriving resource estimates relies largely on the ‘ ‘expert opinion’ of geologists and petroleum engineers.

While it is not entirely accurate to characterize the collective (averaged) judgment of resource experts as “subjective, the use of ‘opinions’ in lieu of science-based hypotheses and experimental data prevent these expert-derived estimates from being considered wholly ‘ ‘objective.

There can probably, therefore, be no determination as to which resource assessment is the ‘ ‘best’ or ‘ ‘most accurate. In any oil and gas resource assessment, the quantitative volumes should be considered speculative and may or may not accurately reflect the volumes of oil and gas that will or could be ultimately discovered in any single basin or region. Many of the basins with large estimated po-

3M. King Hubbert, ‘ ‘Techniques of Prediction as Applied to the Production of Oil and Gas, ’ *Oil and Gas Supply Modeling, S. I.* Grass (cd,) (Washington, DC: National Bureau of Standards Special Publication 631, May 1982).

tential may prove unproductive; some may yield petroleum recoveries exceeding even the most optimistic estimates. Estimates are made recognizing the uncertainties involved, but are based on the current level of knowledge.

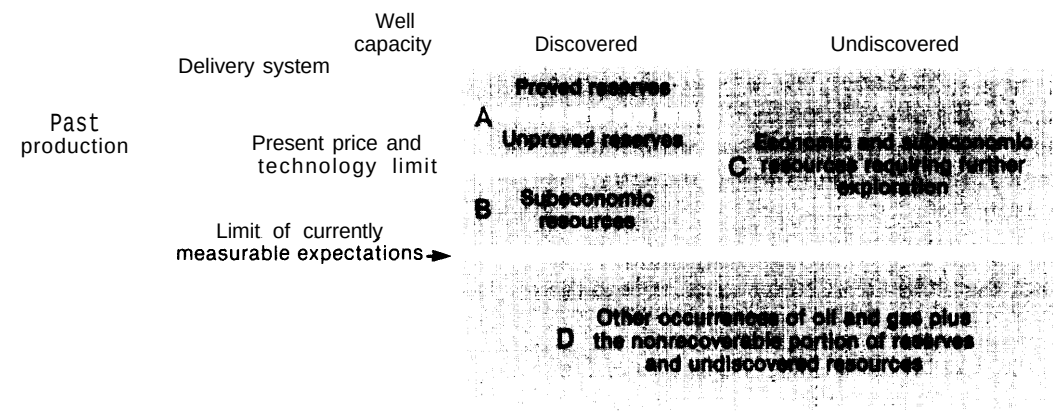
Interpretation of Estimates

Aside from problems of comparability and reliability, there are problems associated with interpreting various estimates. Statistics for potential oil and gas resources are reported using a lexicon that may confuse and befuddle those unfamiliar with petroleum resources. Petroleum reserves and resources are frequently explained, as shown in table 2-3.

In addition, crude oil and natural gas resources are often reported in combined units of "barrels of oil equivalent (BOE). This measure is calculated by converting estimated natural gas and natural gas liquids to oil (product) equivalents based on comparable energy (Btu) units. While BOE resource statistics provide a common unit of measure which is easily communicated and comparable, it can be misleading where natural gas production is not immediately planned.

For example, the National Petroleum Council (NPC) study reports a risked mean of 31 billion BOE in Arctic offshore basins. However, only 57 percent (18 billion barrels) is oil, and the balance is gas and natural gas liquids, In remote regions of the Arctic and in many deepwater areas, natu-

Table 2-3.—Definitions of Reserves and Resources



Reserves: Oil and gas which has already been found and is considered producible under current prices using currently available technology.

Proved *Reserves:* Immediately producible portions of the oil and gas reserves that will flow from wells in developed reservoirs and the quantity of which can be estimated accurately.

Unproved Reserves: Oil and gas that has been discovered but cannot be estimated with as great accuracy and may require additional drilling and development.

Subeconomic Resources: Oil and gas that has been discovered, but in the judgment of the operators cannot be produced under current prices with existing technology. Subeconomic resources are sometimes divided into two portions: First, the unrecoverable, high-cost portion of oil and gas currently left behind in producing reservoirs. Second, oil and gas in other reservoirs that have been found but are not now producing or have been abandoned because they would cost too much to produce due to size or other problems.

Economic and Subeconomic Resources Needing Further Exploration: Oil and gas that remains to be discovered. Exploratory drilling has not proceeded to a point where there is physical evidence of the actual presence of oil and gas. Only expectation exists, and estimates of undiscovered oil and gas are based solely upon geologic and engineering extrapolations.

Other Occurrences: Oil and gas left behind that is not expected under any future circumstances to be worth the effort or cost of production, as well as deposits which are considered too small to find or to produce if found. Other forms of petroleum may be included in this category, e.g., oil shale, tar sands, heavy oils, etc.

SOURCE: John J. Schanz, Jr., "Oil and Gas Resources — Welcome to Uncertainty," In *Resources* (Washington, D. C.: Resources for the Future, March 1978).

ral gas production is not now economically feasible. Therefore, to combine oil and natural gas into a single measure can be misleading to those not familiar with the distinction between oil equivalent resource statistics (which may include unmarketable natural gas) and crude oil resource statistics.

Other Factors

Estimates of potentially recoverable resources will change in response to: 1) oil prices, production costs, and economic conditions; 2) new technological developments that enable more efficient recovery of oil and gas; and 3) new knowledge about resources gained from exploration. For example, the USGS revised its 1975 resource estimates in 1981 to reflect changes in technology (resource estimates were included down to water depths of 7,870 feet in Alaska and 8,200 feet elsewhere); changing economic conditions; and more geological information gained from exploration. As a result, estimates of offshore oil potential decreased slightly even with the additions from the Continental Slope. Offshore oil resources were estimated at 17 to 49 billion barrels in 1975 and decreased to 17 to 44 billion barrels in 1981. Estimates of natural gas increased significantly from 42 to 81 Tcf in 1975 to 72 to 167 Tcf in 1981.

U.S. EXCLUSIVE ECONOMIC ZONE

The 200-nautical mile U.S. Exclusive Economic Zone encompasses 1.9 billion acres adjacent to the coasts of the continental United States. * Approximately 1.3 billion acres of the EEZ is underlain by the Continental Shelf, the extension of the continental land mass that was flooded when the oceans rose. Almost half of the U.S. Continental Shelf (815 million acres) lies adjacent to Alaska.

Along most of the U.S. coastline, the Continental Shelf gradually slopes downward (see figure 2-1) until it breaks abruptly at the edge of the Continental Slope where it plunges steeply toward the deep ocean floor. At the transition zone between the deep ocean and the base of the Continental Slope is the Continental Rise, which rises gradually from the Abyssal Plain.[5]

Water depths over the Continental Shelf range to more than 600 feet at the edge of the Continental Slope. Undersea canyons have been cut deeply into the Continental Shelf at the mouths of major rivers, such as the Hudson, the Mississippi, and off the mouth of the Chesapeake Bay, The Continental Slope plunges to depths over 8,250 feet before merging with the Continental Rise. Depths over the Continental Rise range between 11,500 and 20,000 feet.

Much of the Continental Shelf was formed under prehistoric conditions that favored the evolution of petroleum —accumulated organic-rich sediments, extremely high pressures from overlying materials, and high subsurface temperatures. Thirty-four sedimentary basins with oil and gas potential have been identified in the U.S. Continental Shelf. The Department of the Interior recognizes 26 offshore areas with commercial oil and gas potential for purposes of leasing in the OCS. Sediments in some of these basins reach thicknesses of more than 43,000 feet. In addition, portions of the Continental Slope and the Continental Rise are underlain by a great wedge of sediments and ancient buried reefs that may contain petroleum deposits. Deep oceanic basins, particularly the Gulf of Mexico, may also contain petroleum, but because of the water depths much less is known about these prospects. [6]

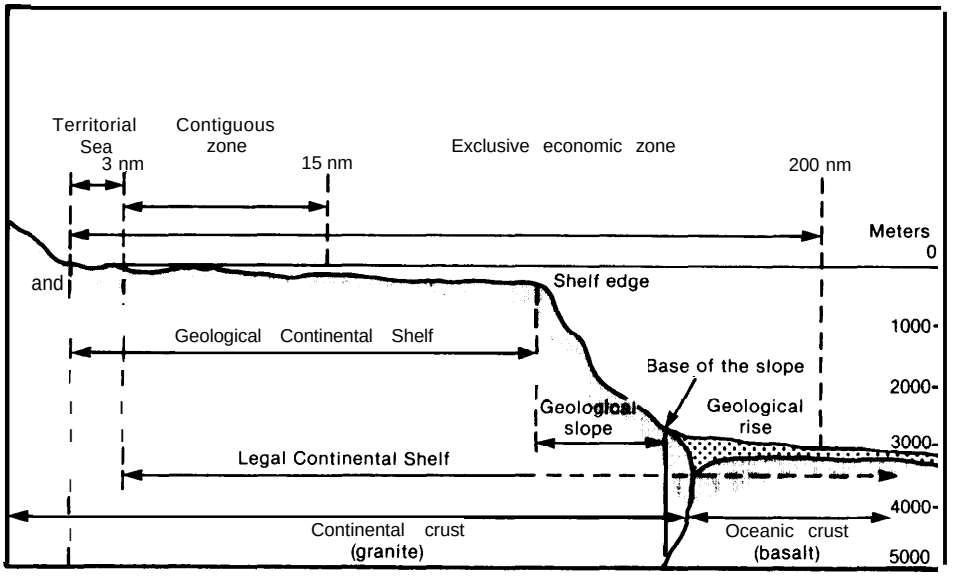
The breadth of the U.S. Continental Margin (Shelf, Slope, and Rise) varies considerably, ranging from a few miles along steep segments of the Pacific Coast to perhaps 500 miles adjacent to parts of Alaska. The establishment of the U.S. EEZ in

[4]Robert W. Smith, "The Maritime Boundaries of the United States, *Geographical Review* (October 1981), p. 395.

[5]One should distinguish between the "geologic Cent inental Shelf and the' 'legal Continental Shell. The former is defined by scientific prim iple of landform, position *and* geological origin The latter is a construct of law imposed by the need for regulating international affairs among coastal nations under the Law of the Sea and international agreements.

[6]H. D. Hedberg, U. D. Moody, and R. M. Hedberg, "Petroleum Prospects of the Deep Offshore, *AAPG Bulletin* 63(3):286-300.

Figure 2-1.— Profile of Physiographic Features of the Geological Continental Margin of the U.S.



SOURCE: Robert D. Hodgson and Robert W. Smith, "The Informal Single Negotiating Text (Committee II): A Geographical Perspective, " Ocean *Development and International Law Journal 3:3*

1983 added about 46 percent more ocean area to that already under the jurisdiction of the United States for the purpose of exploring and developing the living and nonliving resources of the sea. The net effect was to add approximately 600 million acres of seabed to that already claimed for exclusive resource development by the United States offshore the 50 States.

Oil Resources

The two most widely quoted assessments of offshore oil resources are USGS Circular 860 and the NPC study. The NPC study dealt only with Arctic resources and, in general, there is some agreement between the two assessments on Arctic oil potential. Both assessments used an averaging technique (modified Delphi) to aggregate expert opinion of estimates based on "geological analogies, i.e., the prediction of the occurrence of oil in an unexplored area based on similarities between that area and one in which oil is known to exist. [7] However, because the statistical treatment of the data is different in the two assessments, the estimates can not be directly compared.

Resource estimates from USGS Circular 860 are the most widely cited and have been used in the past by the Minerals Management Service (MMS) in general lease sale planning and for public information (see table 2-4). Total offshore oil resources according to the USGS study are about 30 billion barrels, one-third of which is in water depths greater than 660 feet (see figure 2-2). However, as a result of an institutional reorganization, the MMS no longer uses USGS estimates in lease sale planning. Henceforth, MMS will be responsible for developing all offshore resource estimates and has recently revised the estimates of offshore oil and gas (see box). [a]

Deepwater Oil Resources

According to the 1981 USGS estimates, about 40 percent of the recoverable oil expected to be found in the Continental Slope beneath water depths greater than 660 feet is in the Atlantic

[7] Joseph P. Riva, Jr., " 'The Occurrence of Petroleum, *World Petroleum Resources and Reserves* (Boulder, CO: Westview Press, 1983)

[a] Minerals Management Service, *Estimates of Undiscovered Oil and Gas Resources for the Outer Continental Shelf* (personal correspondence, Feb. 4, 1985),

Table 2-4.—Offshore Resource Estimates

	Water depth (meters)	Oil (billion barrels)	Gas (TCF)
Alaska			
Norton Basin	(0-200)	0.2	1.2
St. George Basin	(0-200)	0.4	2.5
Navarin Basin	(0-200)	0.9	5.6
	(200-2500)	0.1	0
North Aleutian Basin	(0-200)	0.2	1.0
Beaufort Sea	(0-200)	7.8	39.3
	(200-2500)	0.8	4.3
Chukchi Sea	(0-200)	3.6	13.8
	(200-2500)	0.2	1.1
Gulf of Mexico			
Central and Western Gulf of Mexico	(0-200)	2.8	42.9
	(200-2500)	2.4	26.1
Eastern Gulf of Mexico	(0-200)	1.2	2.4
	(200-2500)	0.2	0.4
Pacific			
Southern California	(0-200)	1.0	1.3
	(200-2500)	1.4	2.6
Central and Northern California	(0-200)	0.9	1.0
	(200-2500)	1.0	1.3
Washington and Oregon	(0-200)	0.1	0.6
	(200-2500)	0.2	0.8
Atlantic			
North Atlantic	(0-200)	0.4	2.4
	(200-2500)	1.0	3.2
Mid-Atlantic	(0-200)	0.8	5.6
	(200-2500)	2.3	8.6
South Atlantic	(0-200)	0	0.2
	(200-2500)	0.9	3.6

SOURCE: Minerals Management Service, OCS *Summary Reports, 1983,* (based on uSGS *Cicular 860, 1981).*

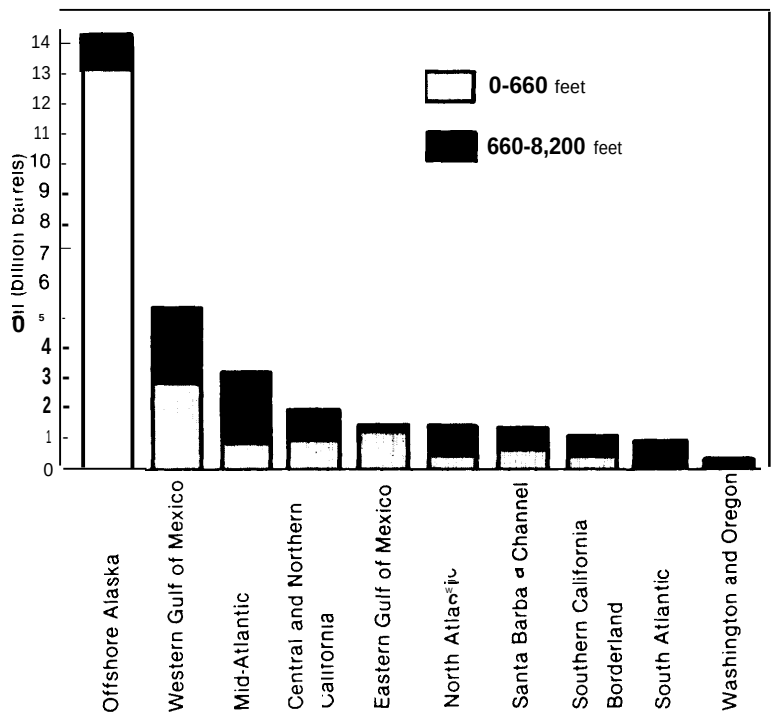
Ocean. Nearly 25 percent of the projected deepwater oil resource is in the Pacific Ocean off California, Oregon, and Washington, and a like amount is expected to be found in deepwater regions of the Gulf of Mexico. Deepwater resources in Alaska are estimated to be about 1.1 billion barrels.

The USGS did not include recoverable oil and gas that may occur in deep ocean regions, e.g., the Gulf of Mexico Oceanic Basin or in extremely deep water in the Pacific Ocean, in its 1981 assessment. It is possible, therefore, that one-third to one-half of U.S. offshore oil resources lie under waters ranging in depth from 660 feet to more than 12,000 feet when the potential of the oceanic basins within the OCS is included.

Arctic Oil Resources

Resource estimates indicate that Alaska may contain about one-half of the recoverable oil (offshore and onshore) remaining in the United States. The NPC assessment estimates the mean undiscovered recoverable resource in the Arctic to be 18 billion

Figure 2-2.—Oil Resources by Planning Area



SOURCE. Minerals Management Service, OCS *Summary Reports, 1983.*

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Revised *Offshore oil* and Gas Resource Estimates

Planning area	Oil (billion barrels) 1981	1985	% change	Gas (trillion cubic feet) 1981	1985	% change
Alaska:						
Beaufort Sea	7.8	0.89		39.3	3.83	
Navarin Basin	1.0			5.6		
Chukchi Sea	1.6	0.54		13.8	3.02	
St. George Basin	0.4	0.37		2.5	3.47	
Norton Basin	0.2	0,00			0.43	
Other		0.11		2.2	1.42	
Total Alaska	12.2	3.30	-73	84.6	13.85	–78
Atlantic:						
North Atlantic	1.4	0.11		5.6	2.14	
Mid-Atlantic		0.35		14.2	6.02	
South Atlantic	0.9	0.22		3.6	4.04	
Other	-			0.3	0.11	
Total Atlantic	5.4	0.68	-87	23.7	12.31	-48
Gulf of Mexico:						
Western Gulf	5.2			85.4	28.76	
Central Gulf	—	3.72			30.69	
Eastern Gulf		0.41		2.8	2.19	
Total Gulf of Mexico		6.03	- 3	88.2	59.84	-13
Pacific:						
Northern California	0.5	0.25			1.12	
Southern California	2.4			3.9	2.42	
Central California	-	0.36			0.51	
Washington and Oregon	0.3	0.04		1.4	0.85	
Total Pacific		2.19	-31		4.70	-24
Total Offshore	27.0	12.2	-55	162.7	90.5	- 4 4

SOURCE: U.S. Geological Survey, Circular 860, *Estimates* of *Undiscovered Recoverable Conventional Resources* of Oil and *Gas in the* United States (1981). Minerals Management Service, *Estimates of Undiscovered Oil and Gas* Resources *for the Outer Cent/nentu/ Shelf* (personal correspondence, Feb. 4, 1985).

barrels while USGS estimates a resource base of 11 billion barrels of crude oil (see table 2-5).

In terms of undiscovered potentially recoverable oil (based on 1981 technology), according to the NPC, the Beaufort Sea has the greatest resource potential in Alaska with 9.5 billion barrels (USGS estimated 7.8 billion barrels) including both the Continental Shelf and the Slope (see figure 2-3). The Navarin Basin ranks second in resource potential with **2.4** billion barrels (USGS estimated 0.9 billion barrels); third is the Central Chukchi Shelf (NPC estimated 1.7 billion barrels, USGS estimated 0.6 billion barrels); followed by the North Chukchi Shelf and Slope (NPC estimated 1.5 billion barrels, USGS estimated 0.8 billion barrels); and St. George Basin with 1.2 billion barrels (USGS estimated 0.4 billion barrels).

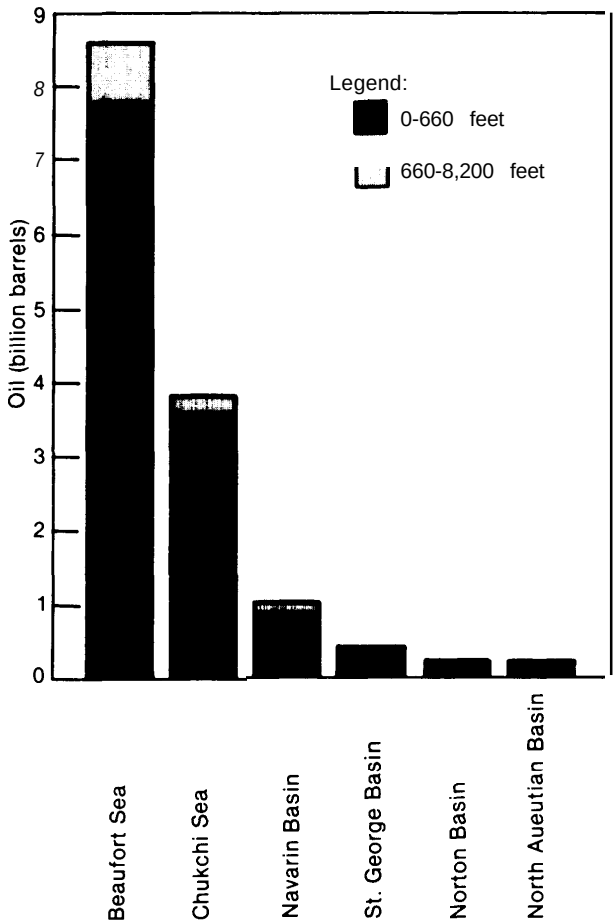
Table 2-5.—Comparison of Estimates of Alaskan Offshore Oil Resources

Oil Resources (billion barrels)

Water depth (meters)	NPC (risked mean) 0-200 M	200-2500 M	USGS (mean) 0-200 M	200-2500 M
Beaufort	8.2			0.8
Navarin	2.3	0.1	0.8	0.1
Central Chukchi	1.7	—	0.6	—
St. George	1.2		0.4	
N. Chukchi	1.2	0.3	0.8	0.2
Bristol	0.6	—	0.2	—
Norton	0.3	—		—
Hope	0.2		0.0	
Zhemchug	0.1	0.0	0.0	0.0
Aleutian	0.0	0.0	0.0	0.0
Umnak Plateau	0.0	—		—
St. Matthew - Hall	0.0	—	0.0	—

SOURCES: National Petroleum Council, *US. Arctic Oil and* Gas, 1981; U.S Geological Survey, Circular 880, 1981

Figure 2-3.—Oil Resources in Alaska Planning Areas



SOURCE: Minerals Management Service, OCS Summary Reports, **1983.**

Natural Gas Resources

The USGS estimates that the OCS contains about 172 Tcf of natural gas. The Potential Gas Committee (PGC), an industry-staffed group operating through the Colorado School of Mines, evaluated the natural gas resources that are expected to occur up to a maximum depth of 3,280 feet. It estimated that the OCS to that depth "probably' contains 35 Tcf of natural gas. (The PGC "probable" estimate is a modal estimate and may be comparable to the statistical mean.) Because the PGC assumed the economic limits of gas production to be about 3,000 feet on the Continental Slope, the USGS and PGC resource estimates for natural gas cannot be compared directly. It appears, however, that the PGC estimates are considerably more conservative than those of the USGS. Although the PGC has historically been optimistic about U.S. onshore natural gas resources, it estimates a probable potential offshore supply of 35 Tcf, a possible supply of 76 Tcf, and a speculative supply of 122 Tcf. Even its most optimistic estimate falls short of the USGS mean estimate of 172 Tcf. In waters 660 feet or less, the PGC estimates the probable occurrence of 32 Tcf of natural gas, while the USGS estimate is about 120 Tcf.

As more geological information is gained from exploratory drilling in frontier regions, natural gas estimates are revised upwards. In 1975, the USGS estimated that the Continental Shelf contained between 42 and 81 Tcf (at the 95 and 5 percent probability levels respectively) of natural gas. When revised in 1981, these estimates were increased to between 72 and 167 Tcf respectively. The upward adjustment resulted from indications of the presence of more gas and less crude oil in exploratory wells in the Atlantic, Gulf of Mexico, and Pacific offshore regions.

The Gulf of Mexico and the Alaskan Arctic are expected to contain nearly 82 percent of the natural gas in the OCS (72 and 70 Tcf respectively), while the Atlantic is estimated to contain 24 Tcf and the Pacific only 8 Tcf (see figure 2-4).

Deepwater Natural Gas Resources

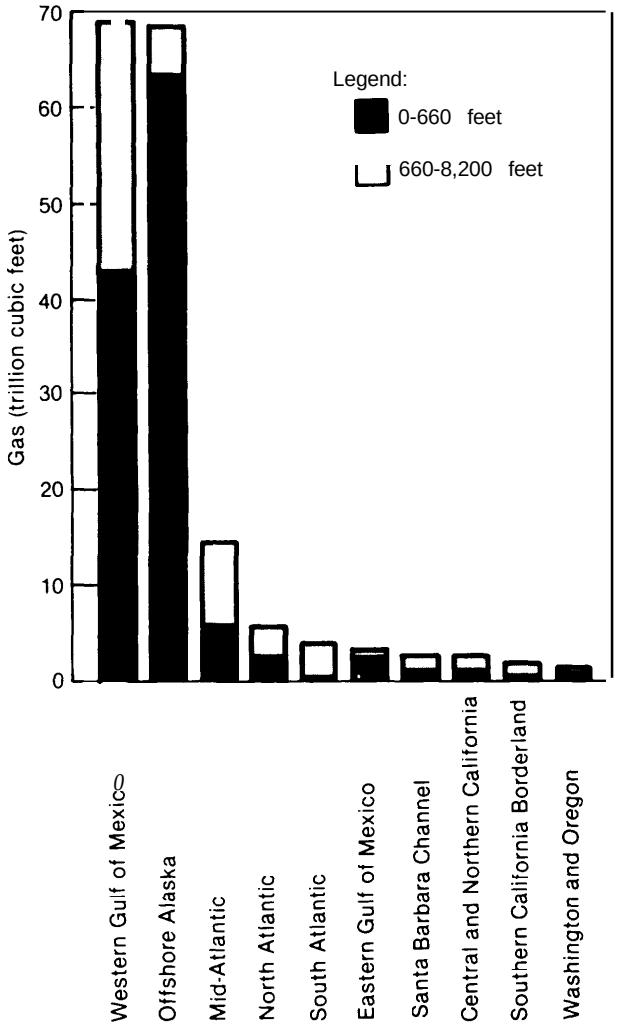
Approximately 31 percent of the natural gas in the OCS is expected to occur in water depths between 660 and 8,200 feet. About half of this (27 Tcf) is in the Gulf of Mexico, while 16 Tcf is in the Atlantic, 6 Tcf in the Arctic, and 5 Tcf in the Pacific.

Arctic Natural Gas Resources

The USGS estimates that 58 Tcf of natural gas may occur in the Arctic. The NPC estimates that 69 Tcf of natural gas may be expected to occur in that region (see table 2-6). The NPC estimate includes natural gas liquids while the USGS estimate does not. If natural gas liquids (2.5 billion barrels) are removed from the NPC estimate, the two assessments of Arctic natural gas potential agree within 20 percent.

Over 90 percent of Alaskan offshore gas lies in depths of less than 660 feet. The remote far north-

Figure 2-4.—Natural Gas Resources by Planning Area



SOURCE: Minerals Management Service, OCS *Summary Reports,* 1983

ern regions of the Beau fort and Chukchi Seas are expected to contain about 78 percent (39 Tcf and 14 Tcf respectively) of the natural gas in the Arctic while the Navarin Basin contains 6 Tcf, St. George Basin 3 Tcf, and the Norton and North Aleutian Basins about 1 Tcf each (see figure 2-5).

Resources by Lease Sale Planning Areas

The EEZ is subdivided into 26 planning areas by the Department of the Interior for leasing purposes (see figure 2-6). Each planning area encompasses one or more sedimentary basins that have potential for petroleum resources. Nearly 1.1 billion acres of the total 1.9 billion acres within the OCS are included in the planning areas. However, only about 17 percent of the acreage (179 million acres) in the planning areas is considered to be underlain by "promising geological structures' with significant potential for accumulated oil and natural gas (see table 2-7).

Over half of the acreage(110 million acres) considered to have promising geological structures for oil and gas is adjacent to Alaska. About 15 percent (27 million acres) of the area over promising structures is in planning areas located in the Atlantic Ocean, where exploration activities have failed to confirm the presence of commercial quantities of oil or gas. A similar proportion of the promising geology (25 million acres) lies in the Gulf of Mexico planning areas which historically have produced large quantities of oil and natural gas.

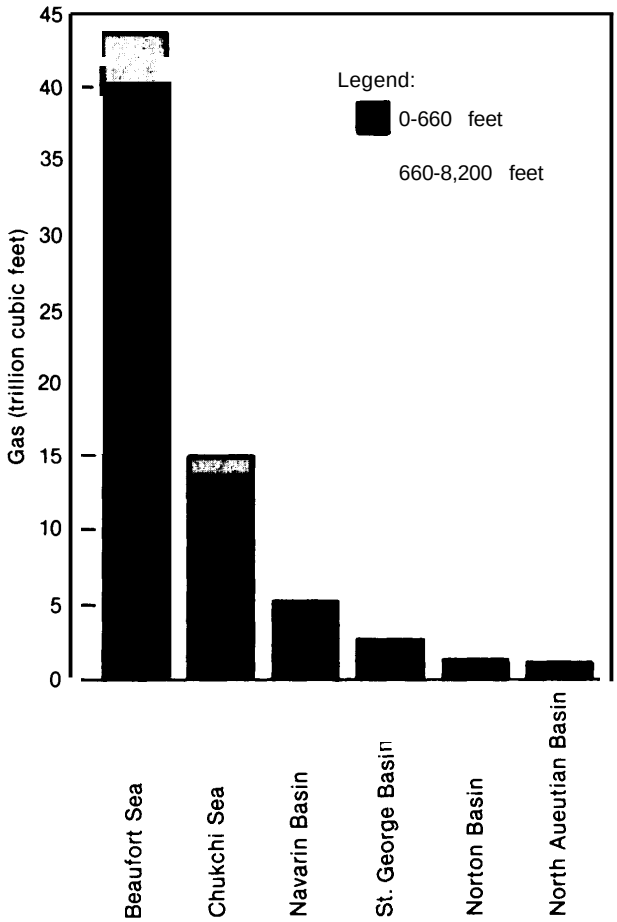
Table 2-6.—Comparison of Estimates of Alaskan Offshore Gas Resources

Gas Resources (trillion cubic feet)

	NPC (risked mean)		USGS (mean)	
Water depth (meters)	0-200 M	200-2500 M	0-200 M	200-2500 M
Beaufort	26.3	6.7	35.0	4.3
Navarin	9.5	<1.0	5.2	0.4
Central Chukchi	9.0	—	3.0	—
St. George	5.6	—	2.3	—
N. Chukchi	5.0	1.7	3.4	1.1
Norton	**3.4**	—	1.2	—
Hope	1.1	—	—	
Bristol. .,	0.3	—	1.0	
St. Matthew - Hall	<1.0	—	0.0	—
Zhemchug	<1.0	<1.0	0.1	0.0
Umnak .,	<1.0	—	0.0	—
Aleutian	<1.0	<1.0	0.0	0.0

SOURCES: National Petroleum Council, U S *Arctic 0il and Gas,* 1981, U.S. Geological Survey, Circular 860, 1981

Figure 2-5.—Natural Gas Resources in Alaska Planning Areas



SOURCE: Minerals Management Service, OCS Summary *Reports,* 1983.

Table 2.7.—Estimates of Offshore Acreage With Hydrocarbon Potential (millions of acres)

Planning area	Geological structures*	Hydrocarbon potential* •
North Atlantic	17.3	**26.0**
South Atlantic	9.4	**63.2**
Eastern Gulf of Mexico	6.0	**58.0**
Central Gulf of Mexico	9.4	**46.0**
Western Gulf of Mexico	9.3	**35.0**
Southern California	9.9	**12.0**
Central and Northern California	7.5	**N/A**
South Alaska (Gulf of Alaska, Kodiak, Cook, Shumagin)	2.0	148.4
North Aleutian Basin	3.2	12.4
St. George Basin	29.2	35.0
Navarin Basin	16.0	28.9
Norton Basin	7.5	8.9
Hope Basin	8.0	N/A
Chukchi Sea	14.0	29.7
Beaufort Sea	30.6	19.1
Total	179.3	**522.6**

'Estimates of the acreage covered by promising geological structures. Department of the Interior, Final Supplement to the Final Environmental Statement, Five-Year Lease Schedule, 1982.

" "Estimates of the acreage having a potential for the generation, migration, and accumulation of hydrocarbons. Minerals Management Service, Resources Assessment Division, 1984.

Gulf of Mexico

The Gulf of Mexico region is the most extensively developed offshore region of the United States. It currently produces over 90 percent of total U.S. offshore oil production and virtually all of the offshore natural gas. The region consists of three lease planning areas: Western Gulf, Central Gulf, and Eastern Gulf. Projections indicate that the Gulf of Mexico will continue to dominate offshore oil and gas production as the industry expands its exploration into the deepwater frontier areas of the Gulf Oceanic Basin.

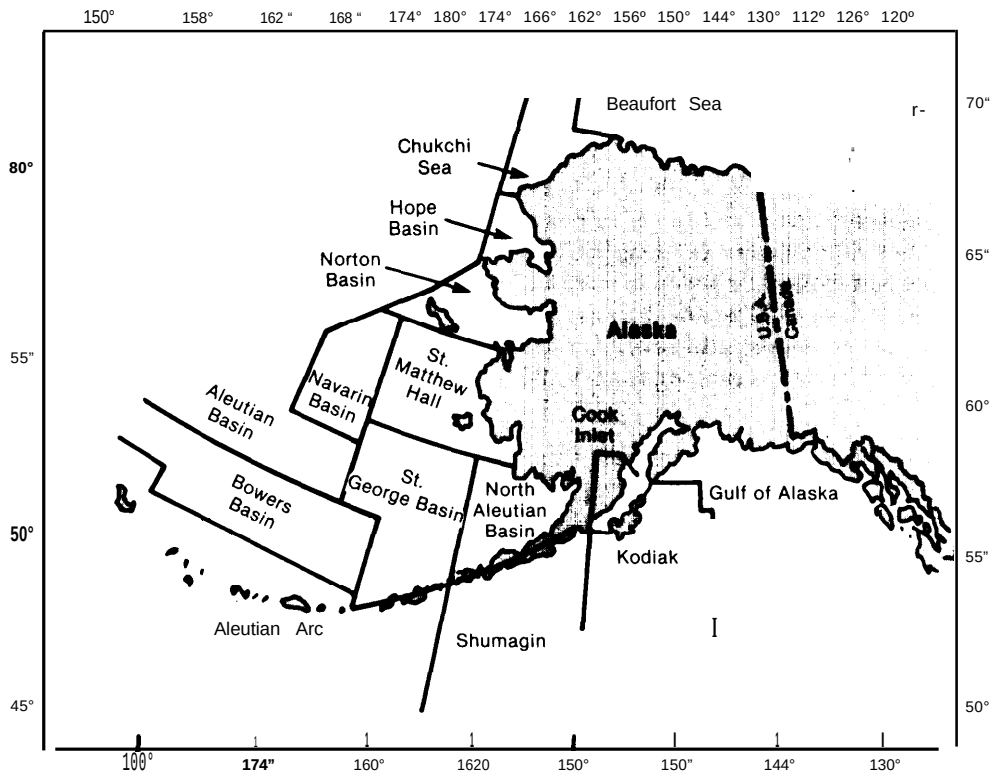
Exploration and development is most advanced in the Central Gulf of Mexico planning area, which lies south of the States of Louisiana and Mississippi. Thus far, little oil and gas activity has taken place in the Eastern Gulf of Mexico planning area adjacent to Alabama and Florida.

Resource estimates. The Central Gulf of Mexico planning area is estimated to contain 3.2 billion barrels of oil and 34 Tcf of natural gas, which is more than half of the total undiscovered economically recoverable oil resources in the Gulf of Mexico region. The Western Gulf of Mexico planning area is expected to be rich in natural gas (26 Tcf), but contains only 2 billion barrels of oil. The Eastern Gulf of Mexico planning area is estimated to contain 1.2 billion barrels of oil and only 1.6 Tcf of natural gas. Remaining oil reserves in the Gulf of Mexico region are estimated to be 3 billion barrels of oil and 40 Tcf of natural gas. [8]

Physical ***and geological characteristics.*** The Continental Shelf in the Gulf of Mexico region slopes gently seaward at an angle of less than one degree It forms a broad plain of relatively shallow water ranging in breadth from 12 miles off the alluvial fan of the Mississippi River to as much as 140 miles off the mouth of the Crystal River in Florida. Th

'Minerals Management Service, *Gulf of* **Mexico** *Summary Repo* (Washington, DC: U.S. Department of the Interior, September 1983 p. 8.

Figure 2-6.—Minerals Management Service Lease Sale Planning Areas



NOTE: Maritime boundaries and limits depicted on the maps, and divisions shown between planning areas, are for initial planning purposes only.

SOURCE: Minerals Management Service.

Continental Slope is relatively steep, ranging between 2 and 45 degrees. Beyond the base of the Continental Slope, the Abyssal Plain of the Gulf of Mexico Oceanic Basin reach depths of up to 12,000 feet at the outer edge of the EEZ. Although the Continental Shelf in the Gulf of Mexico region is extensive, 42 to 68 percent of the acreage within the Gulf of Mexico lease planning areas is in waters deeper than 660 feet (see figure 2-7).

Geological conditions that may occur in the Gulf of Mexico lease planning areas include unstable sediments on the sea floor, active faults, shallow gas accumulations, and underlying karst topography consisting of limestone caverns and voids in the seafloor. The area off the Mississippi Delta and along steeply sloping areas of the Continental Slope may be subject to mass sediment movements.

Leasing ***and exploration.*** The Gulf of Mexico is the most heavily explored and extensively developed offshore petroleum region in the world. The region has been explored for more than 50 years and has been producing oil and natural gas for more than 35 years. Nearly 21,000 wells have been drilled offshore in the Gulf of Mexico, most of them in the Central Gulf of Mexico planning area.

While exploration in the historically productive areas of the Central and Western Gulf of Mexico planning areas continues at a high level, the offshore industry's interest in deepwater tracts has also increased. The deepest exploratory well in the Gulf of Mexico was drilled in 1980 in the Mississippi Canyon in 2,210 feet of water, and several other wells have been drilled in waters ranging from 1,500 to 1,835 feet.

Several tracts leased in the Atwater Valley sector of the Central Gulf of Mexico planning area are in waters of 3,500 feet and deeper, and one block in the Port Isabel area of the Western Gulf of Mexico is in 3,500 feet of water.[10] Industry interest in deepwater tracts is centered on the area referred to as the "flexure play, a sloping deepwater site that rapidly descends at the edge of the Continental Shelf.

Development, production, and reserves. Crude oil production from the Gulf of Mexico region was about 310 million barrels in 1983, and natural gas production was approximately 3.9 billion cubic feet. Between 1972 and 1980, oil production in the Gulf of Mexico declined each year (see figure 2-8). This trend was reversed in 1981 and oil and condensate production is now at pre-1977 levels. The rebound in Gulf of Mexico oil production is considered to bean anomaly, however, and oil production is expected to soon resume its previous decline. Gas production may have reached its peak in 1981 and is also expected to begin a noticeable decline. At the beginning of 1984, Gulf of Mexico oil reserves were estimated at 3.4 billion barrels and natural gas at 43.7 Tcf.[11]

Atlantic

The Atlantic region, while one of the most geologically studied oceanic regions in the world, is considered to be a frontier region for oil and natural gas exploration. The region consists of four lease planning areas: North Atlantic, Mid-Atlantic, South Atlantic, and Florida Straits. There is no commercial crude oil or natural gas production from the Atlantic region, and no reserve estimates are available.

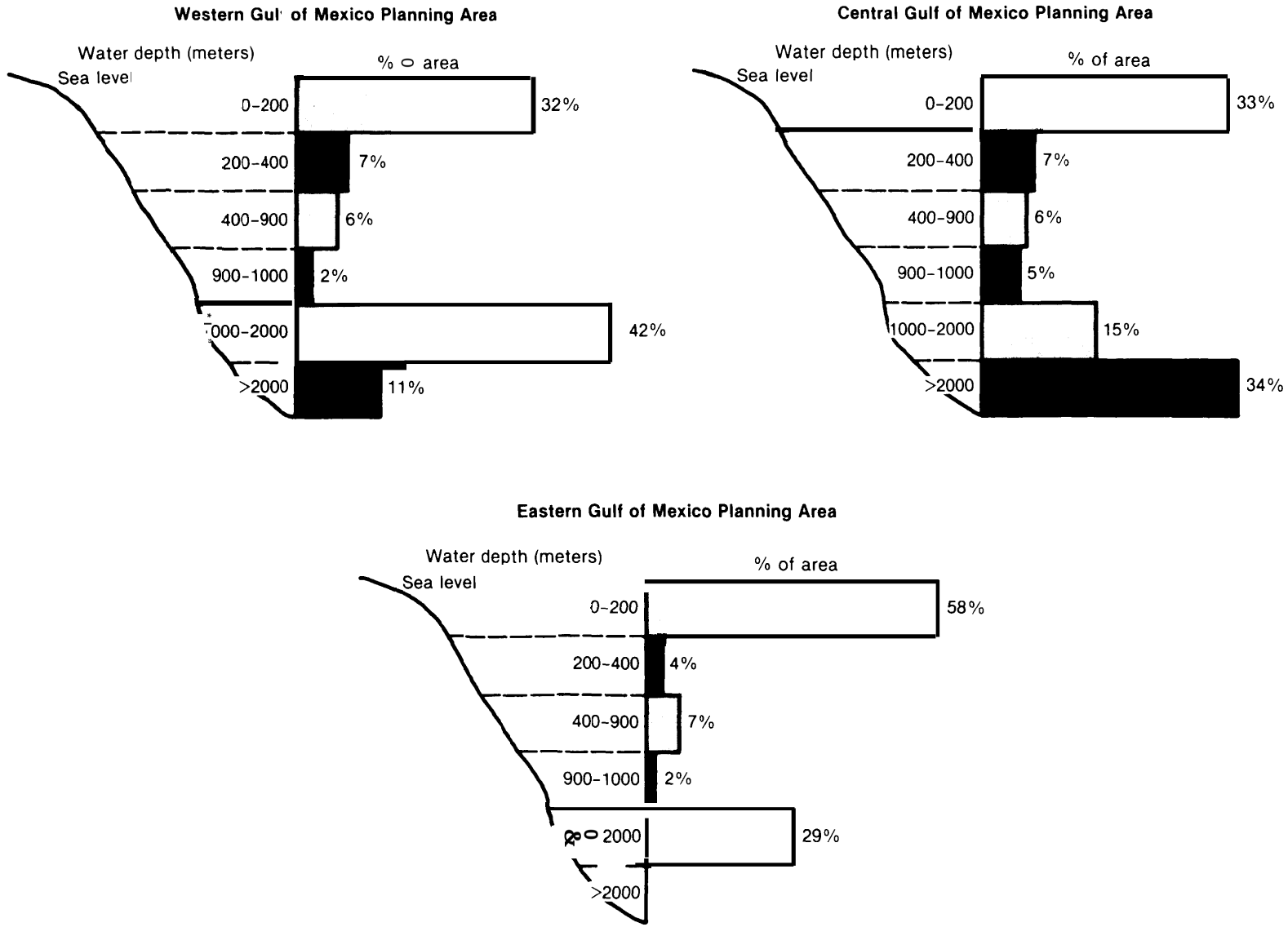
Resource estimates. Over three-quarters of the Atlantic region's undiscovered economically recoverable crude oil resources (4. 2 billion barrels) and about two-thirds of its natural gas (15.4 Tcf) lie in water depths of 660 to 8,200 feet. Total undiscovered recoverable resources in the three lease planning areas of the Atlantic region are estimated to be 5.4 billion barrels of oil and 23.6 Tcf of natural gas.

Nearly 60 percent of the oil (3.1 billion barrels) and natural gas (14.6 Tcf) within the entire Atlantic region is expected to occur in the Mid-Atlantic planning area, between two-thirds and three-quarters of it in water depths between 660 and 8,200 feet. The North Atlantic planning area is estimated to contain 1.4 billion barrels of crude oil and 5.6 Tcf of natural gas, while the South Atlantic area is estimated to contain only 900 million barrels of crude oil—all in waters ranging in depth from 660 to 8,250 feet—and 3.8 Tcf of natural gas.

[10] Data Offshore Services, *Supplement to the Ocean Construction Report* (Houston, TX: Offshore Data Services, July 23, 1984).

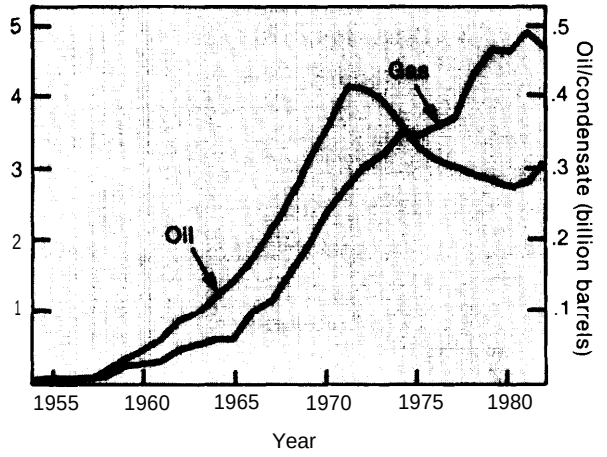
[11] Minerals Management Service, *Federal Offshore Statistics* (Washington, DC: U.S. Department of the Interior, 1984).

Figure 2-7.—Distribution of Gulf of Mexico Planning Areas by Water Depth



SOURCE: Office of Assessment.

Figure 2-8.—Trends in Gulf of Mexico Oil and Gas Production



SOURCE: Minerals Management Service, Gulf of Mexico *Summary Report,* 1983.

Physical and geological characteristics. The Continental Shelf in the Atlantic region varies in width from 14 miles off Cape Hatteras to 200 miles off the coast of New England. From the break at the edge of the Continental Shelf to the base of the Continental Slope, water depths plunge to between 6,560 and 9,840 feet. From the base of the Continental Slope, the Continental Rise extends gradually seaward to depths of 16,405 feet in the Abyssal Plain of the oceanic basin at the outer edge of the EEZ.

The major geological feature of the North Atlantic lease planning area is the Georges Bank plateau on the eastern edge of the Continental Shelf off Cape Cod. About 58 percent of the waters within the North Atlantic planning area are 660 feet or less, and 35 percent are 6,560 feet or deeper (see figure 2-9).

Deep canyons intersect the Continental Slope in the Atlantic region. The Baltimore Canyon Trough is a major physiographic feature of the Mid-Atlantic planning area, extending 300 miles from northeast to southwest. It appears likely that the area of greatest hydrocarbon potential in the Atlantic region is located in the deeper waters of the Continental Slope of the Mid-Atlantic planning area, where a possible extension of Mexico's Reforma-Chiapas oil-bearing reef complex may be buried under mile-deep ocean sediment. Seventy-eight percent of the area within the Mid-Atlantic lease planning area is overlain by waters deeper than 6,560 feet.

The South Atlantic area is dominated by the Blake Plateau, a broad gently sloping segment of the Continental Shelf off Florida and Georgia, and the Carolina Trough, a steep sloping segment of the Continental Slope trending from northeast to southwest off North and South Carolina. Over two-thirds of the South Atlantic lease planning area is in water depths of 6,560 feet or deeper.

Geological conditions that may affect oil and natural gas development in the Atlantic region include: shallow recent faults, shallow gas deposits, mass movement of sediments, filled channels, erosion and scour, sand waves, faults present below the unconsolidated sedimentary section, and gas-charged sediments.[12] The northerly flowing Gulf Stream also may affect exploration and development of oil and gas in areas influenced by its currents.

Leasing ***and exploration.*** The first Atlantic region sale was held in the Mid-Atlantic lease planning area in 1976, Exploration in the Atlantic region peaked in 1979. Since that time, the disappointing results of earlier tests coupled with general economic conditions and worldwide petroleum markets has slowed the pace of the offshore industry's exploration efforts.

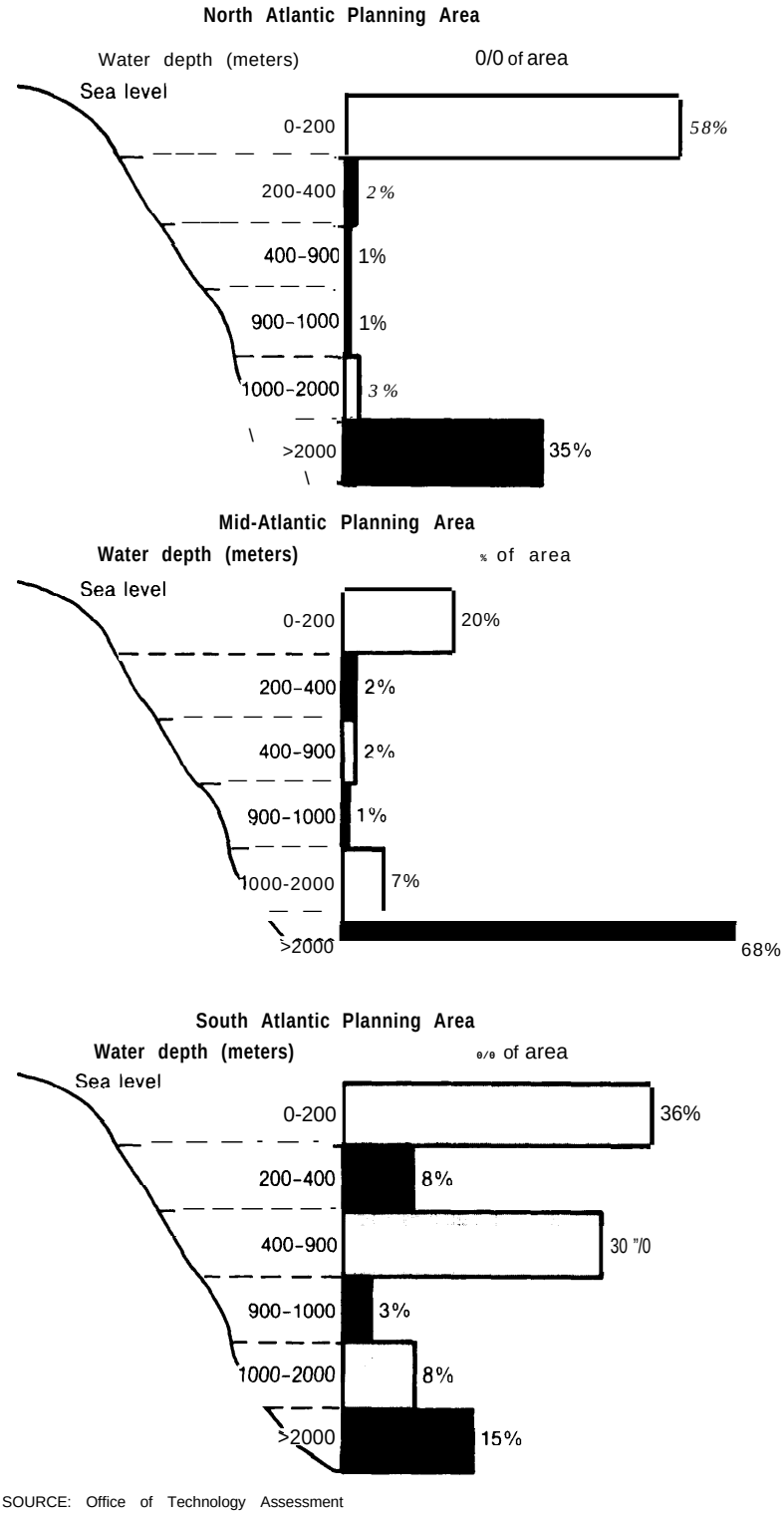
Pacific

The Pacific region is considered the cradle of the offshore oil and gas industry in the United States. In the 1890s, numerous shallow wells were drilled from wooden piers along southern California beaches. From these piers, the offshore petroleum industry ventured onto offshore platforms and expanded its operations to the Gulf of Mexico. It was not until 1950, however, that oil and gas production from offshore platforms in State waters began in the Pacific region. It was also off southern California in the Santa Barbara area where the most serious offshore well blowout occurred in 1969. The impression that the Santa Barbara blowout made on the public continues to influence the Federal offshore leasing program, although a similar incident has not occurred again in the United States.

Four lease sale planning areas are located in the Pacific region: Southern California, Central California, Northern California, and Washington and

[12] Minerals Managment Service, *Mid Atlantic Summary Report* (Washington, DC: U.S. Department of the Interior, 1983), p. 6.

Figure 2-9.— Distribution of Atlantic Planning Areas by Water Depth



SOURCE: Office of Technology Assessment

Oregon. A large proportion (over 90 percent) of the area within the lease sale planning areas in the Pacific region is in water depths of more than 660 feet. Eleven sedimentary basins with potential for containing hydrocarbons are located in the Pacific region. The Santa Maria, Santa Barbara Channel, and Borderland basins in southern California are nearly geographically contiguous and offer the highest potential for petroleum development.

Oil and gas development in the Pacific region is concentrated in the Southern California area. Production from this area makes California the second ranking oil producing State and third ranking in natural gas production from the Federal Outer Continental Shelf. The most frequent oil and gas discoveries in the Pacific region have been mostly small fields of 100 million barrels or less. However, 80 percent of the combined reserves of oil and natural gas occur in larger fields ranging up to 400 million barrels.

Resource estimates. Total undiscovered economically recoverable crude oil resources are estimated to be about 4.6 billion barrels for all Pacific planning regions. Over half (2.4 billion barrels) is expected to occur in the Southern California Borderlands and Santa Barbara Channel lease planning areas. The largest proportion of crude oil is estimated to be located in the Central and Northern California lease planning area (1.9 billion barrels). Only **300** million barrels are estimated to exist in the Washington and Oregon area.

Total undiscovered economically recoverable natural gas resources (7.6 Tcf) are expected to be similarly distributed among the lease planning areas, with the most (2. 5 Tcf) located in the Santa Barbara Channel, and a nearly like amount (2.3 Tcf) in the Central and Northern California lease planning areas. Approximately 60 percent of crude oil and natural gas within the Pacific region lease planning areas is expected to occur in water depths of 660 to 8,200 feet.

Physical and geological characteristics. The breadth of the Continental Shelf in the Pacific region ranges from about 25 to 30 miles off Point Conception in California to over 100 miles off San Diego. The Continental Slope plunges to depths between 1,300 and 9,750 feet at the base of the Slope. Depths in the Abyssal Plain beyond the Continental Rise within the EEZ may reach depths of about 14,675 feet off Washington and Oregon. Seventy six percent of the area in the Central and Northern lease planning areas and 48 percent of the area in the Southern California Borderland lease planning area are in water depths of 6,560 feet or more (see figure 2-10). Depths in the Santa Barbara Channel may reach 2,050 feet.[13]

Of the offshore areas in the Pacific region that have been explored for oil and gas, the Santa Barbara Channel and the Santa Maria basin have been most productive. In both instances, onshore oil and gas development adjacent to Point Conception and Point Arguello preceded petroleum discoveries offshore. The Point Arguello field within the Santa Maria basin is considered the largest field yet discovered in the U.S. Outer Continental Shelf. Its potential is rated at 300 to 500 million barrels.

The Pacific region lies along an axis of known seismic activity, and the potential for earthquakes is the major engineering factor affecting design of offshore platforms and underwater pipelines. Other hazards may exist in the form of subsidence, seafloor erosion, shallow gas deposits, and mass sediment movements.

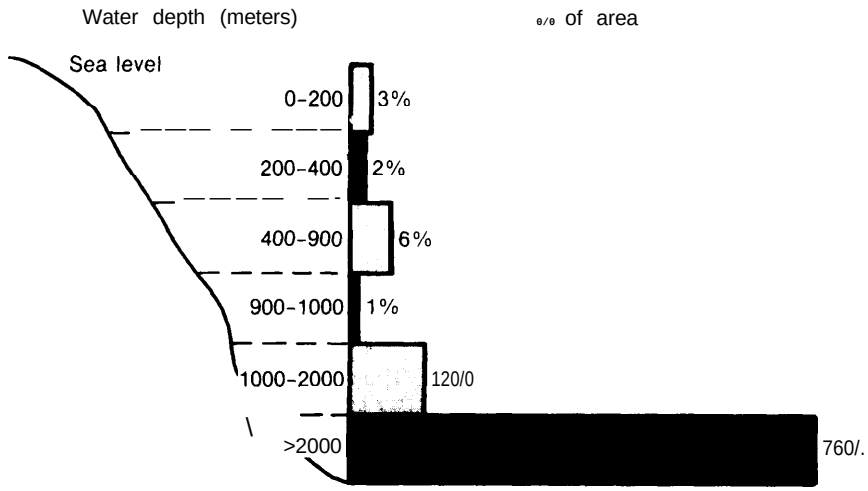
Leasing and exploration. Oil and natural gas leasing in the Pacific region began in 1963 in the Central California lease planning area. A total of 14 oil and gas fields have been identified in the Pacific region. Two of these are natural gas fields; six are oil fields; and six are a combination of oil and gas. Oil has been discovered at wells in waters ranging from 1,097 to 1,544 feet deep off Point Arguello in southern California, but most of the oil discovered is heavy crude which may require development of special lift technologies to produce from those depths economically .14 Exxon is planning to install a production platform (Hondo "B") in 1,200 feet of water in the Santa Ynez unit in 1987.

Development, production, and reserves. Crude oil production from the Pacific region peaked at 31 million barrels in 1971 and decreased to 10.2 million barrels in 1980. Pacific crude oil production

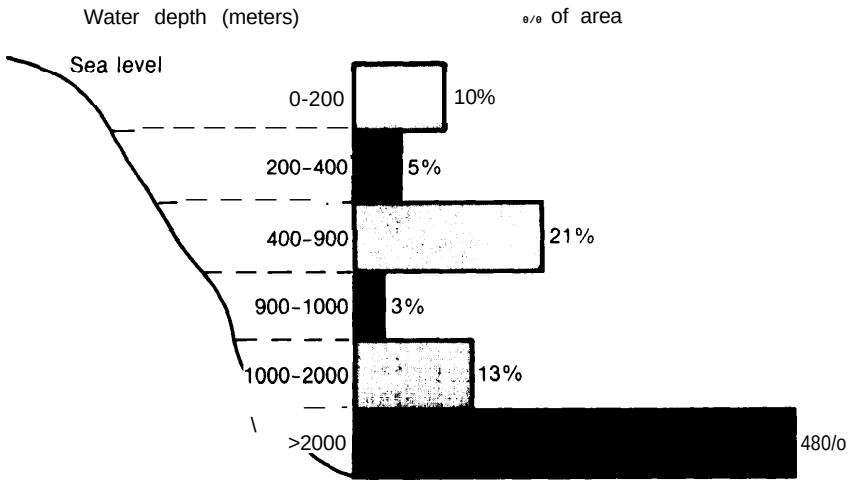
[13]Minerals *Management* Service, *Pacific Summary Report (Washington, DC: U.S. Department of the Interior, 1983), p. 9.*

I+ Oil *and* Gas *Journal* ''Offshore Southern California' (Jan. 9, 1984), p. 58.

Figure 2-10.— Distribution of Pacific Planning Areas by Water Depth
Central and Northern California Planning Areas



Southern California Planning Area



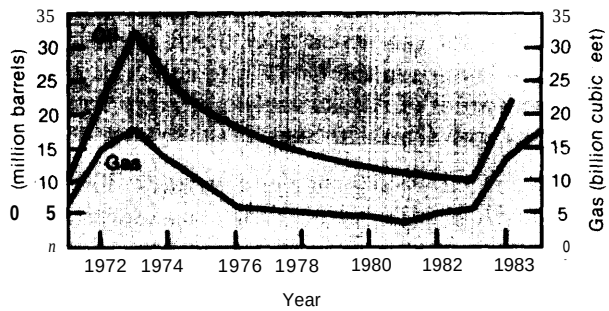
SOURCE: Off Ice of Technology Assessment

rose to over 28 million barrels in 1983 (see figure 2-1 1). Natural gas production followed a similar trend, peaking in 1971 at 15.7 billion cubic feet while decreasing to 2.9 billion cubic feet in 1979, and rebounding to nearly 18 billion cubic feet by 1983. Due to new discoveries, original reserve estimates for crude oil increased to 1.2 billion barrels in 1983 and natural gas to 2 Tcf.

Alaska

The Alaska region is remote, its operating conditions are hostile, exploration and production costs

Figure 2-il.—Trends in Pacific Region Oil and Gas Production



SOURCE: *Minerals Management Service, Pacific Summary Report, 1983,*

are high, and its potential for oil and gas resources enormous. There is currently no oil or gas produced from Federal offshore lands in the Alaska region.

About 4 billion barrels of crude oil have been produced thus far from State offshore leases in the Cook Inlet since before 1954. In addition, onshore discoveries at the North Slope (Prudhoe Bay and Kuparuk fields) indicate that there may be 10 billion barrels of recoverable crude oil and 35 Tcf of natural gas directly adjacent to offshore areas in the Beaufort Sea. The occurrence of these petroleum resources on State lands which are adjacent to the Federal Outer Continental Shelf is considered to be an encouraging indication that vast petroleum resources may occur offshore.

The Alaska region consists of 15 lease sale planning areas: 1) Gulf of Alaska; 2) Kodiak; 3) Lower Cook Inlet-Shelikof Strait; 4) Shumagin; 5) North Aleutian Basin; 6) St. George Basin; 7) Navarin Basin; 8) St. Matthew Hall; 9) Norton Basin; 10) Bowers Basin; 11) Aleutian Basin; 12) Aleutian Arc; 13) Hope Basin; 14) Chukchi Sea; and 15) Beaufort Sea. Planning areas 1 through 4 are in the Gulf of Alaska subregion; 5 through 12 are in the Bering Sea subregion; and 13 through 15 are in the Arctic subregion. This assessment considers the Bering Sea subregion and the Arctic subregion—the offshore subregions north of the Aleutian Islands—as the ' 'Arctic' for the purpose of assessing Arctic technology.

Resource estimates. The Beaufort Sea lease sale planning area is estimated to contain about 70 percent of the undiscovered economically recoverable crude oil and natural gas (8 billion barrels and 39 Tcf expected to be found in the subregions north of the Aleutian Islands. The Chukchi Sea planning area, which lies to the west of the Beaufort Sea, is expected to contain about 4 billion barrels of crude oil and about 14 Tcf of natural gas. In total, over 80 percent of the crude oil and 76 perecent of the natural gas which may occur north of the Aleutian Islands in the Arctic and sub-Arctic lease planning areas of Alaska are expected to be in the Beaufort and Chukchi Seas.

Physical and geological characteristics. The Continental Shelf adjacent to Alaska represents about one-half the total U.S. Continental Shelf. Breadth of the Alaskan Continental Shelf varies significantly, from as narrow as 8 miles at the eastern end of the Gulf of Alaska to perhaps as wide as 500 miles or more in the northwest Chukchi Sea.

The Continental Slope adjacent to Alaska drops steeply to the abyssal depths. South of the Aleutian Islands, the Slope plunges between 16,400 and 19,680 feet in the Aleutian Trench. Depths in the Abyssal Plain of the Gulf of Alaska range to about 13,120 feet. Maximum depths in the Navarin Basin lie between 11,480 and 12,790 feet, while the maximum depths in the Arctic Ocean within the U.S. EEZ are about 7,870 feet.

Over 80 percent of the area within the Navarin Basin lease sale planning area is in water depths of about 660 feet or less while about 83 percent of the area in the Beaufort Sea planning area is in waters 66 feet or less (see figure 2-12).

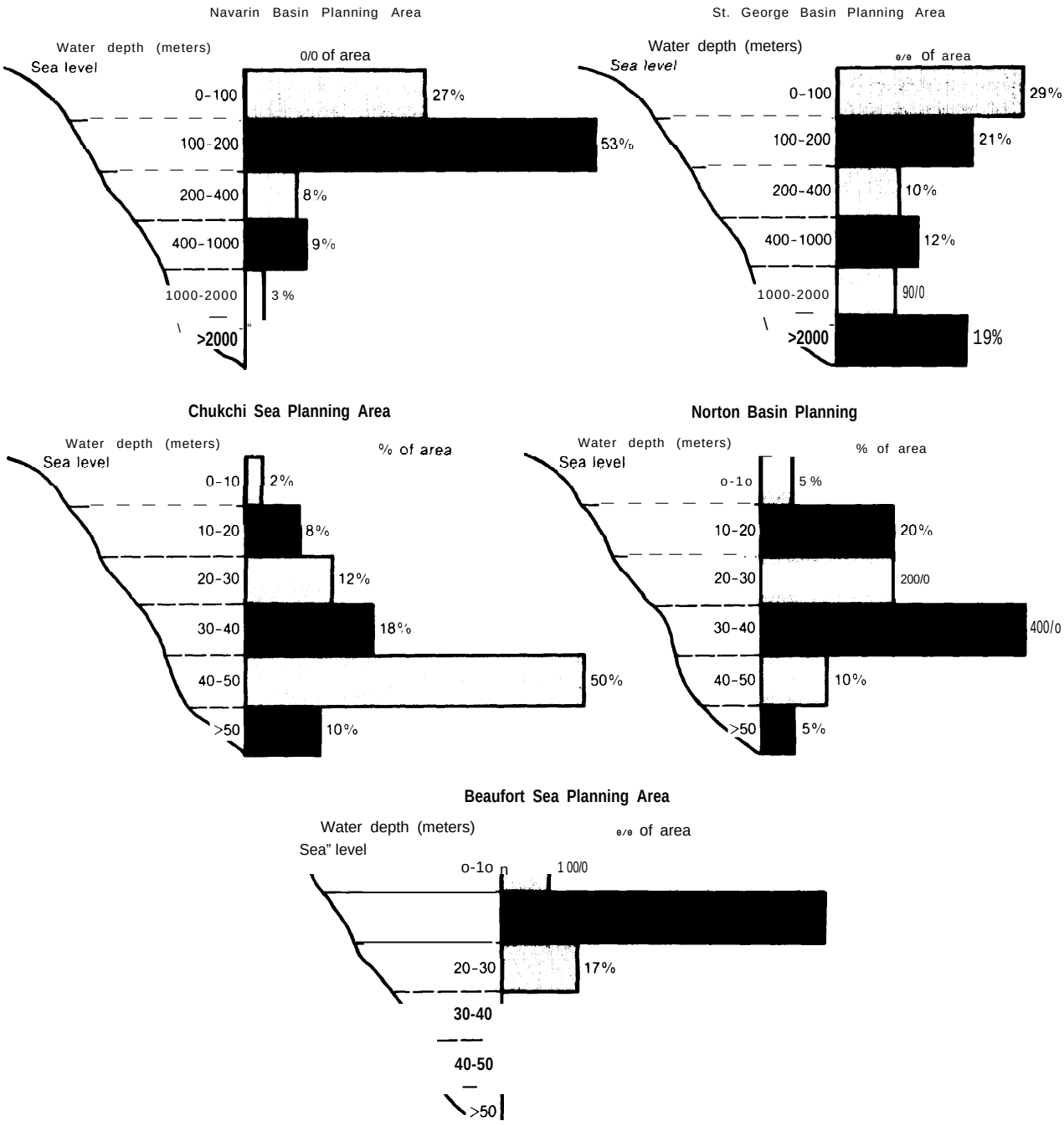
The southern Alaskan lease sale planning areas along the Alaskan peninsula and the Aleutian Islands are in seismically active areas where earthquakes and possible tsunamis must be considered in designing oil and gas exploration and production systems. Sediment instability, which may result in sediment slides and slumping in areas seaward of about 160 to 213 feet, may occur in the Alaska region. In the Bering Sea, faulting, shallow gas-charged sediments, and sediment erosion and transport are geological factors that must be considered in offshore engineering design.[15]

Leasing and exploration. The first oil and gas lease sale in Federal waters off Alaska was in the Gulf of Alaska in 1976. Since that time, about 3.8 million acres have been leased in Alaskan waters, This represents more leased acreage than any other offshore region, with the exception of the Gulf of Mexico.

Exploration efforts in the Yakataga area of the Gulf of Alaska, which began in 1976, resulted in 11 dry holes. Since that time, the industry has shown less interest in exploration in that area. Eight exploratory wells drilled in the Lower Cook Inlet planning area between 1978 and 1980 also yielded dry holes, and no further exploration has taken place.

[15] Minerals *Management Service, Bering Sea Summary Report* **(Washington, DC: U.S. Department of the Interior, 1983),** p. *33.*

Figure 2-12.— Distribution of Alaskan Planning Areas by Water Depth



SOURCE: Office of Technology Assessment.

In the Bering Sea subregion, six deep stratigraphic test wells have been drilled. Exploration has recently commenced in the St. George Basin and Norton Sound planning areas. Planning for exploration in the Navarin Basin lease planning area is currently underway.

Exploration in the Arctic subregion has shown mixed results. The disappointment of the failure of Sohio Alaska Petroleum Company's Mukluk exploration well, which reportedly cost $140 million, is offset by the Shell commercial discovery at Seal Island in the Beaufort Sea planning area (joint Federal-State lease) near the Prudhoe Bay onshore field. The next exploration well in the Beaufort Sea will be at Exxon's Antares site about 45 miles northwest of the Mukluk site.