Outer Continental Shelf

OCS Report
MMS 88-0005

Oil and Gas Program: Cumulative Effects

U.S. Department of the Interior
Minerals Management Service

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Oil and Gas Program: Cumulative Effects

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U.S. Department of the Interior
Minerals Management Service

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INTRODUCTION

Provisions of the Outer Continental Shelf Lands Act

The principal purpose of the Outer Continental Shelf Lands Act (OCSLA) (43 U.S.C. 1331-1356) is to make the mineral resources of the OCS available for exploration and orderly development, subject to environmental safeguards. More detailed mandates for protection of the environment are contained in the OCSLA Amendments of 1978 (43 U.S.C. 1801-1886). The Amendments provide for extensive coordination and consultation with affected States and local governments (Section 19); require environmental studies in each OCS area before leasing (Section 20); require a study of safety and health regulations (Section 21); establish an oil-spill pollution fund (Title III); and establish a fisherman's contingency fund (Title IV). The purpose of this fund is to compensate fishermen for damage or loss associated with oil and gas exploration, development, or production.

Definition of Cumulative Effects

Section 20(e) of the Amendments instructs the Secretary of the Department of the Interior (DOI) to submit to the Congress annually an assessment of the cumulative effects of the activities conducted under the OCSLA on the human, marine, and coastal environments. This report has been prepared to fulfill this Section 20(e) requirement. It is not an environmental analysis prepared to comply with requirements of the National Environmental Policy Act (NEPA). NEPA analyses, such as lease sale environmental impact statements prepared by the DOI, do consider potential/projected effects and include other non-OCS-related activities in the definition of cumulative effects. The 20(e) requirement is for a yearly analysis of the effects which are known to have occurred as a result of the OCS Oil and Gas Program. Because this is the first cumulative report on the program, the DOI has done a retrospective assessment back to 1954 considering the effect of 33 years of OCS oil and gas activity. Therefore, for the purpose of this report, "cumulative effects" are defined as the total identifiable long-term effects that are attributable to activities authorized under the OCSLA which are in evidence at this point in time and can be quantified or evaluated.

Program Summary

The environmental record for drilling on the OCS is impressive. Of the 7.5 billion barrels (bbl) of oil produced through 1986, it is estimated that only about 350,000 bbl (.005 percent) were spilled. In the past decade only 31,000 bbl, or 0.0009 percent of the total 3,480,657,000 bbl, of crude oil and condensate produced have been spilled. Through 1986, over 24,000 wells were drilled, yet only 1 blowout that resulted in significant amounts of oil reaching shore has occurred--the Santa Barbara, California, blowout in 1969. Today there are no apparent adverse cumulative effects from this blowout. A similar incident from U.S. operations on the OCS is not judged likely to occur again because steps taken since 1969 provide more stringent regulatory requirements to promote safe and pollution-free operations.

There are inherent difficulties in defining and identifying cumulative effects occurring as a result of activities of the OCS Program. These range from the difficulty in documenting effects due to the extreme variability of the natural environment to the inability to isolate the effects of OCS Program activities from the many other factors that effect both the natural and manmade environments. In this cumulative analysis, we have only considered those identifiable long-term impacts that can be quantified or evaluated. Other less quantifiable, or less easily evaluated, effects however, may have occurred and, therefore, would contribute to the overall cumulative effect. What is most important is that the OCS Program is managed to ensure that significant adverse cumulative, as well as adverse individual, impacts rarely occur. Once a significant adverse impact to a resource or activity has been identified as a result of an OCS activity, immediate measures are taken to reduce the severity and duration of the impact and the likelihood of the impact reoccurring. Also, the operating procedures or regulations under which that OCS activity is conducted are reexamined with the intent of developing or instituting additional mitigation. A current example is the concern with the potential effects of platform removal on sea turtles. Once DOI identifies a potentially significant impact from OCS activities on other resources or activities, procedures are amended, and further evaluation studies are begun to understand better the extent of potential impacts and methods to reduce them.

Another reason cumulative effects are difficult to identify is that many potential conflicts are resolved before any oil and gas activities occur. Examples are the agreements with the Department of Defense on joint use of military operating areas. These agreements are enforced through lease stipulations requiring that the relevant military authority is notified before drilling or other activities occur. Other conflicts between seismic vessels and fishing boats have merited special review to minimize impacts. Special lease sale stipulations for Sales 73 and 80 reduced the potential for air quality impacts before any activities took place. Land-use conflicts are generally avoided or resolved because of compliance with local and State controls over siting, involving zoning considerations.

Conclusion

Although temporary and localized impacts have occurred, with the exception of loss of wetlands in Louisiana (see page V-26), the present regulatory system has prevented identifiable significant adverse cumulative impacts on the human, marine, and coastal environments from the OCS Program. When an unforseen problem surfaces, procedures are reassessed, and additional mitigation is implemented to protect special sensitive resources.

I. SUMMARY OF THE OCS OIL AND GAS PROGRAM

This section of the report summarizes exploration, development, and production activities. The Minerals Management Service (MMS) divides the OCS into four Regions: Atlantic, Gulf of Mexico, Pacific, and Alaska. The section is organized by Region, with each planning area being discussed separately except in Alaska where multiple planning areas are combined into three geographic subregions (Gulf of Alaska, Bering Sea, and Arctic). The locations of all current planning areas during the 1982-87 five-year program are shown in figure I-1.

A. Atlantic Region

More detailed information relating to the OCS Program can be found in Atlantic Summary /Index, January - June 1986, MMS 86-0071 (J.D. Wiese, 1986). Figures I-2 and I-3 summarize the levels of geological and geophysical (G&G) exploration activities in the Atlantic Region.

1. North Atlantic Planning Area

Activities through 1986

To date, one OCS lease sale has been held in the North Atlantic Planning Area in 1979. There were 8 exploratory wells drilled on the 63 tracts leased, none of which resulted in commercial discoveries (figures I-4 and I-5). Two Continental Offshore Stratigraphic Test (COST) wells were also drilled in the planning area. There is no current drilling activity.

2. Mid-Atlantic Planning Area

Activities through 1986

There have been five lease sales in the Mid-Atlantic Planning Area since 1976. Exploratory drilling commenced in 1978. There have been 32 exploratory wells and 2 COST wells drilled in this planning area (figures I-4 and I-6). Although five wells yielded shows of natural gas and one yielded shows of oil, there have been no commercial discoveries. There is no current drilling activity.

3. South Atlantic Planning Area

Activities through 1986

To date, there have been four lease sales held in the South Atlantic Planning Area since 1978. In addition to a preliminary COST well, six exploratory wells have been drilled (figures I-4 and I-7). All wells were reported dry. There is no current drilling activity.

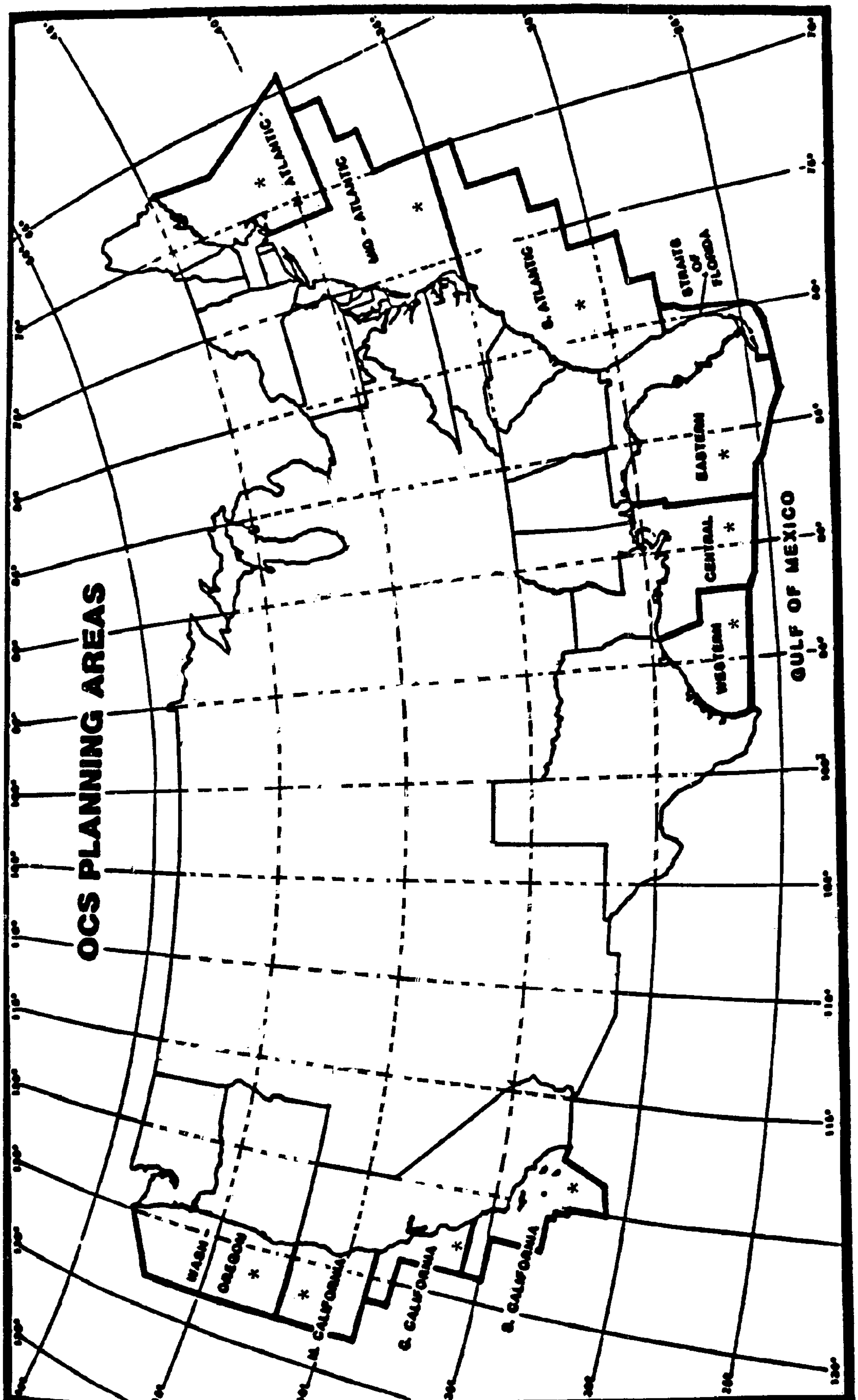

Figure I-1. Outer Continental Shelf Planning Areas, current program, July 1987.
* Indicates planning areas where leasing sales have occurred.

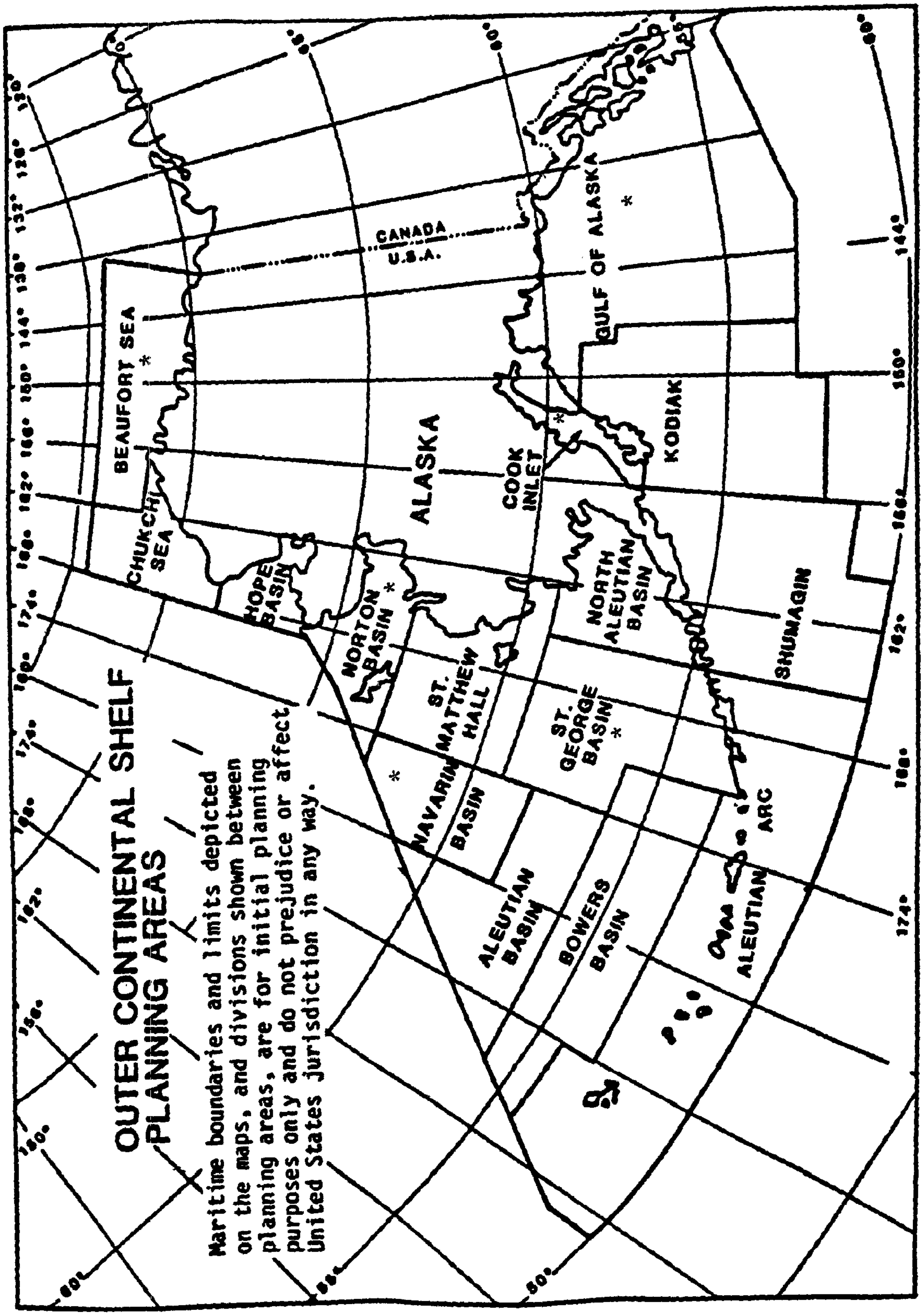

Figure I-1 (continued). Alaska Outer Continental Shelf Planning Areas.
* Indicates planning areas where leasing sales have occurred.

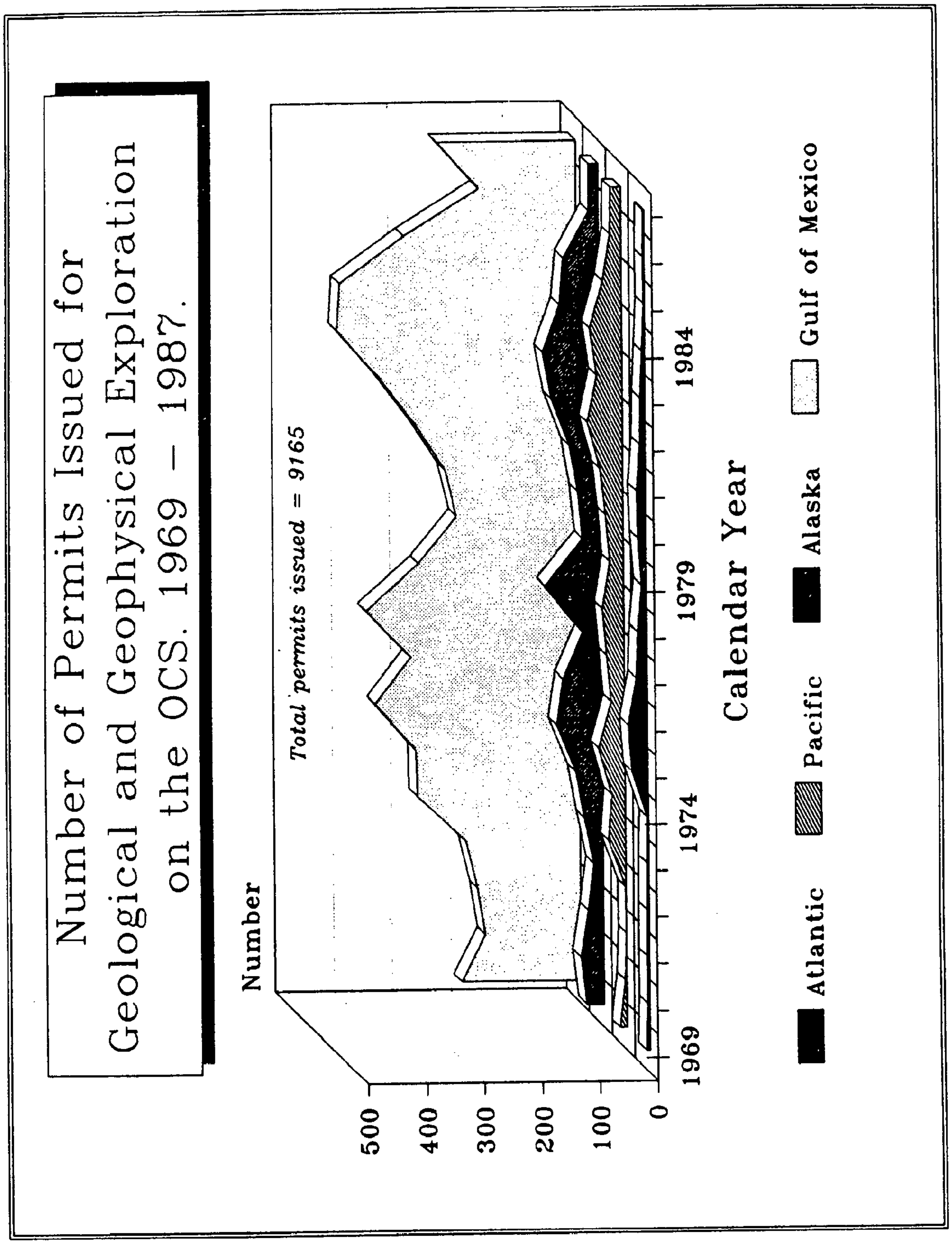

Figure I-2. Numbers of permits issued for geological and geophysical exploration.

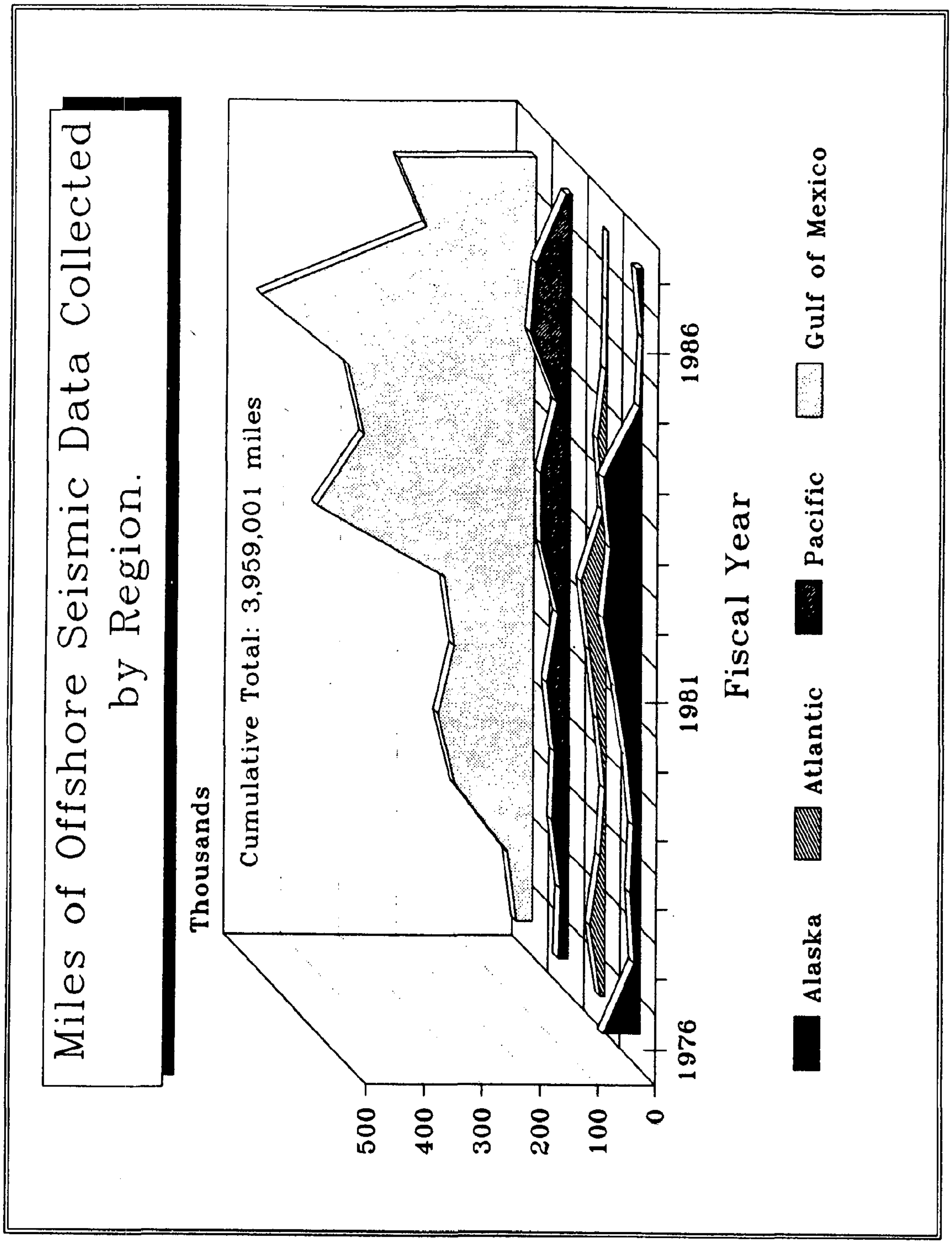

Figure I-3. Miles of offshore seismic data collected by industry (estimated by MMS).

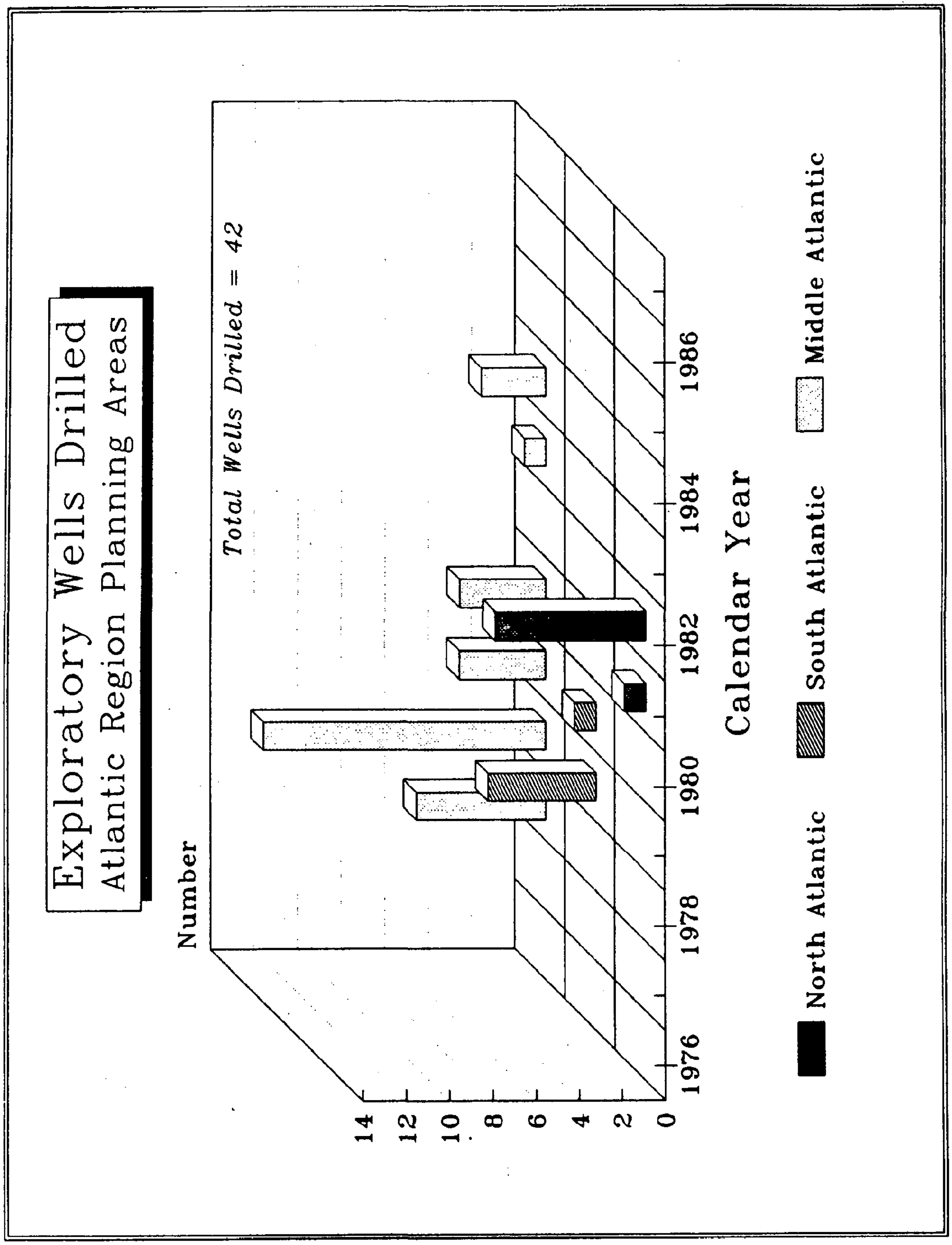

Figure I-4. Atlantic Region Planning Areas - numbers of exploration wells drilled.

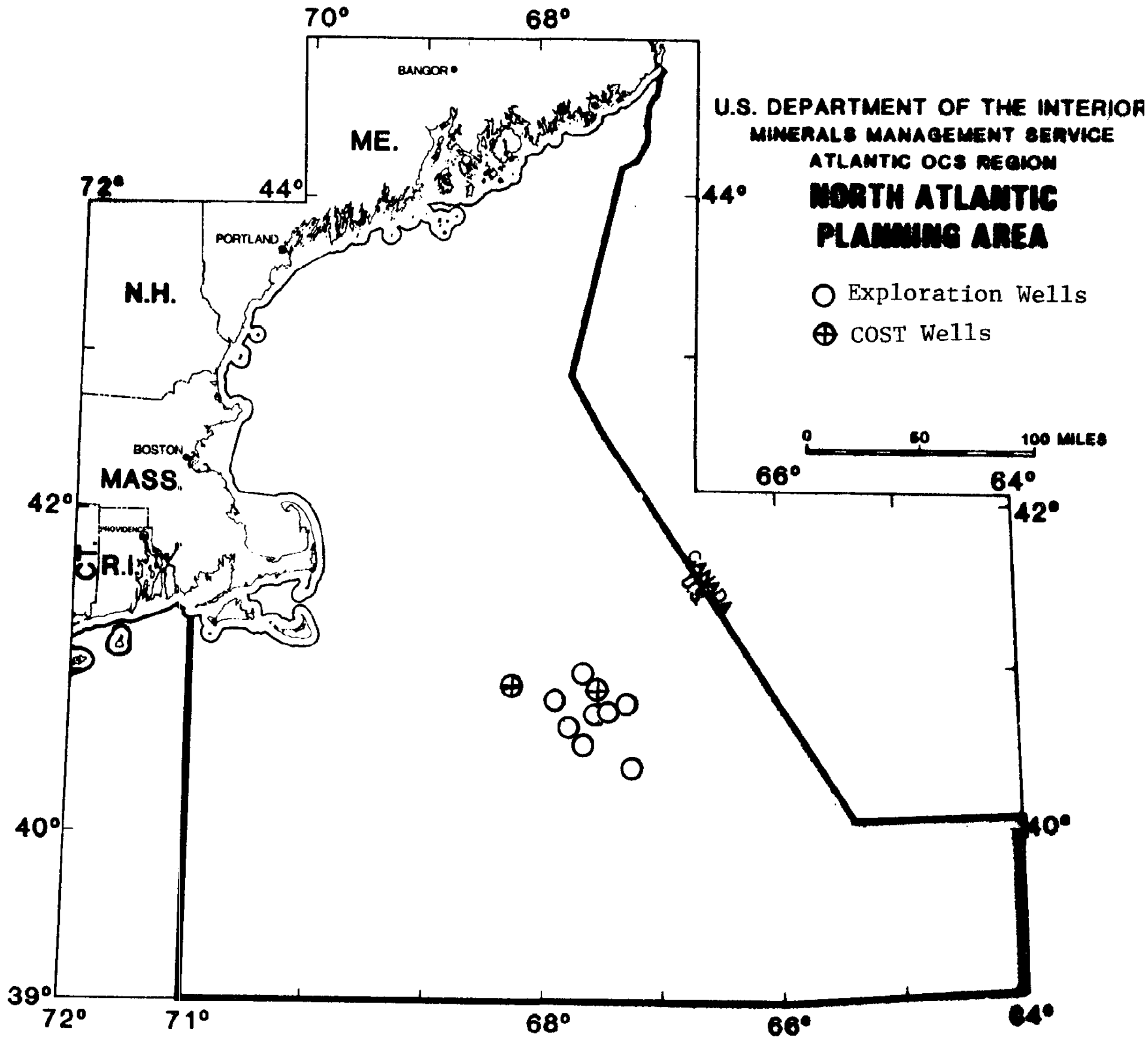

Figure I-5. North Atlantic Planning Area - location of exploration and COST wells.

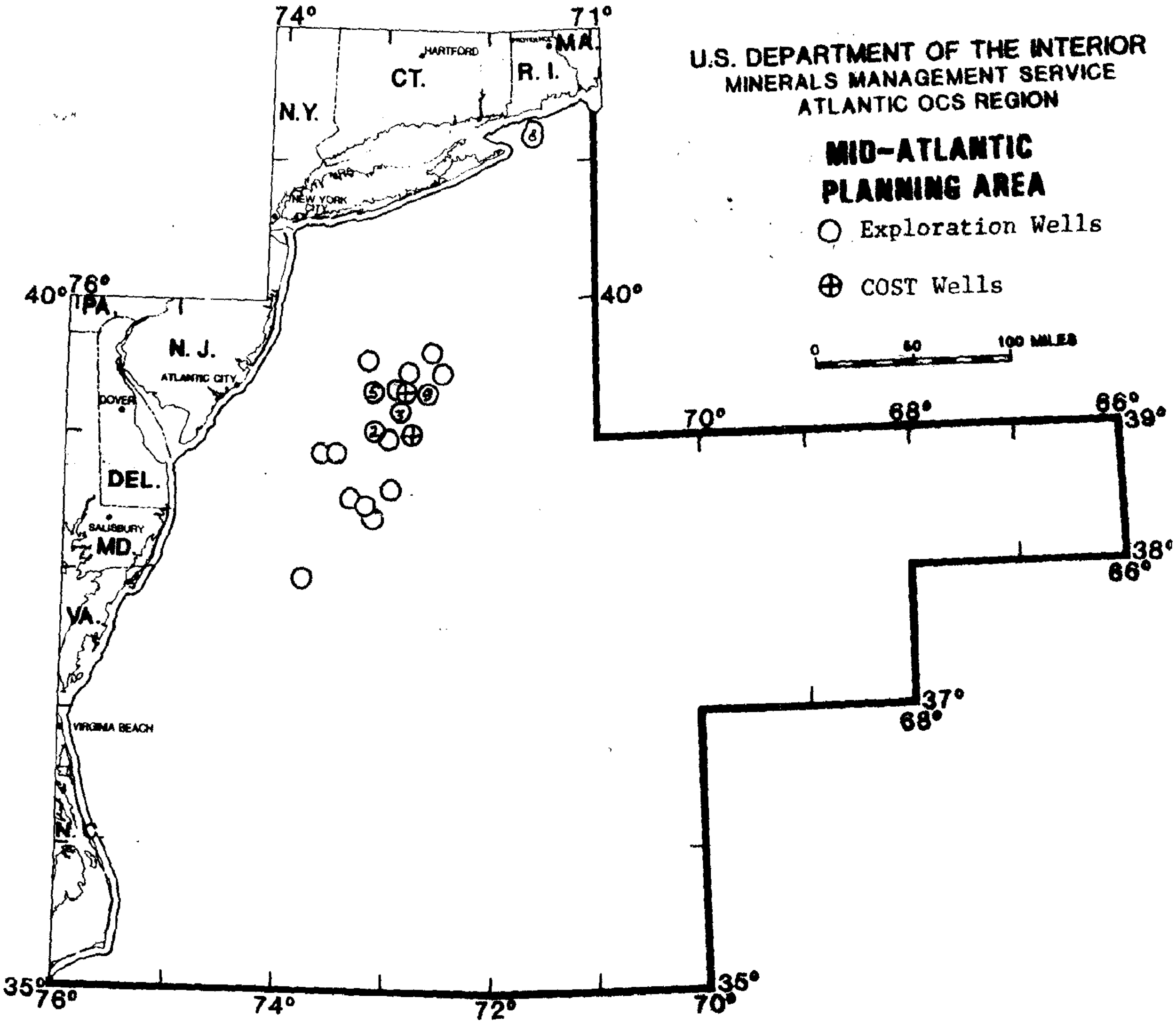

Figure I-6. Mid-Atlantic Planning Area - location of exploration and COST wells.

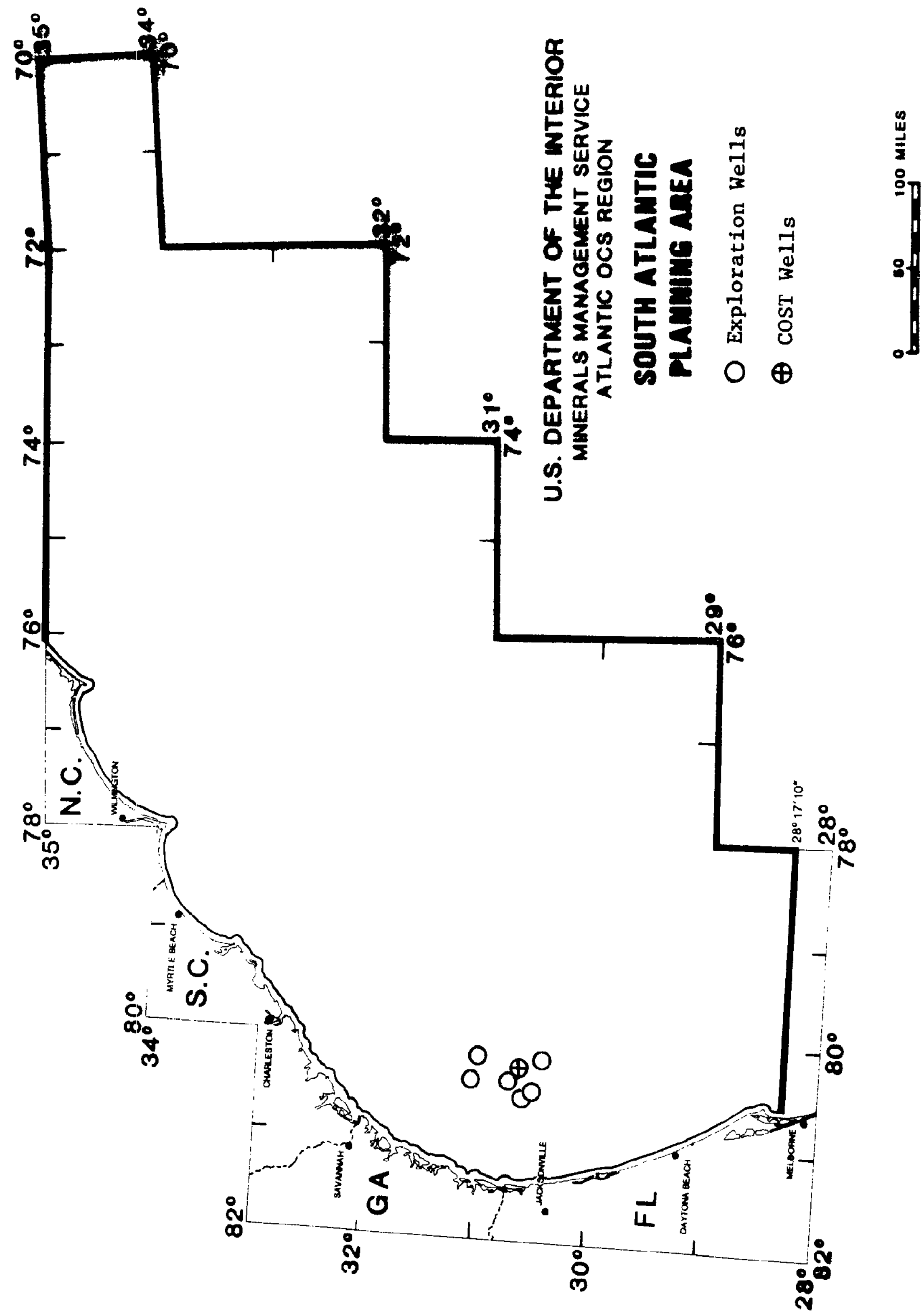

Figure I-7. South Atlantic Planning Area - location of exploration and COST wells.

B. Gulf of Mexico Region

The 1938 discovery of the Creole field, 1 1/2 miles (mi) from the Louisiana coast, marked the beginning of offshore oil and gas activities in the Gulf of Mexico (GOM). Figures I-2 and I-3 summarize the levels of G&G exploration activities in the GOM Region.

Figures I-8 and I-9 show the numbers of exploration and production wells drilled by year in each of the three planning areas. More detailed information relating to the OCS Program can be found in Gulf of Mexico Summary Report/Index (November 1984 - June 1986), MMS 86-0084 (S. P. Risotto and J. H. Collins, 1986).

1. Eastern Gulf of Mexico Planning Area

Activities through 1986

To date, the eastern GOM is the only planning area in the Gulf of Mexico without commercial discoveries. There have been 6 lease sales in the planning area and 34 wells drilled. No commercial wells have been drilled yet in the eastern GOM. Figure I-10 shows leases on which exploratory drilling has occurred.

2. Central Gulf of Mexico Planning Area

Activities through 1986

To date, there have been 43 sales held in the central GOM. The central GOM is the most active area in the entire OCS, having had 20,796 boreholes drilled. The combined total number of platforms installed, together with those in the western GOM, stands at 3,425, of which 680 are manned platforms. Figure I-11 shows the areas of current production.

Between 1974 and 1983, an average of 230 G&G exploration permits were issued annually for work in the central GOM. Within the GOM Region, industry has shown the greatest interest in central GOM leases.

3. Western Gulf of Mexico Planning Area

Activities through 1986

To date, in the western GOM, 26 lease sales have been held, and 3,081 boreholes have been drilled. This is the second most active area in the entire OCS. The combined total number of platforms installed, together with those in the central GOM stands at 3,425, of which 680 are manned platforms. Figure I-12 shows the areas of current production.

Between 1974 and 1983, an average of 108 G&G exploration permits were issued annually for activity in the western GOM.

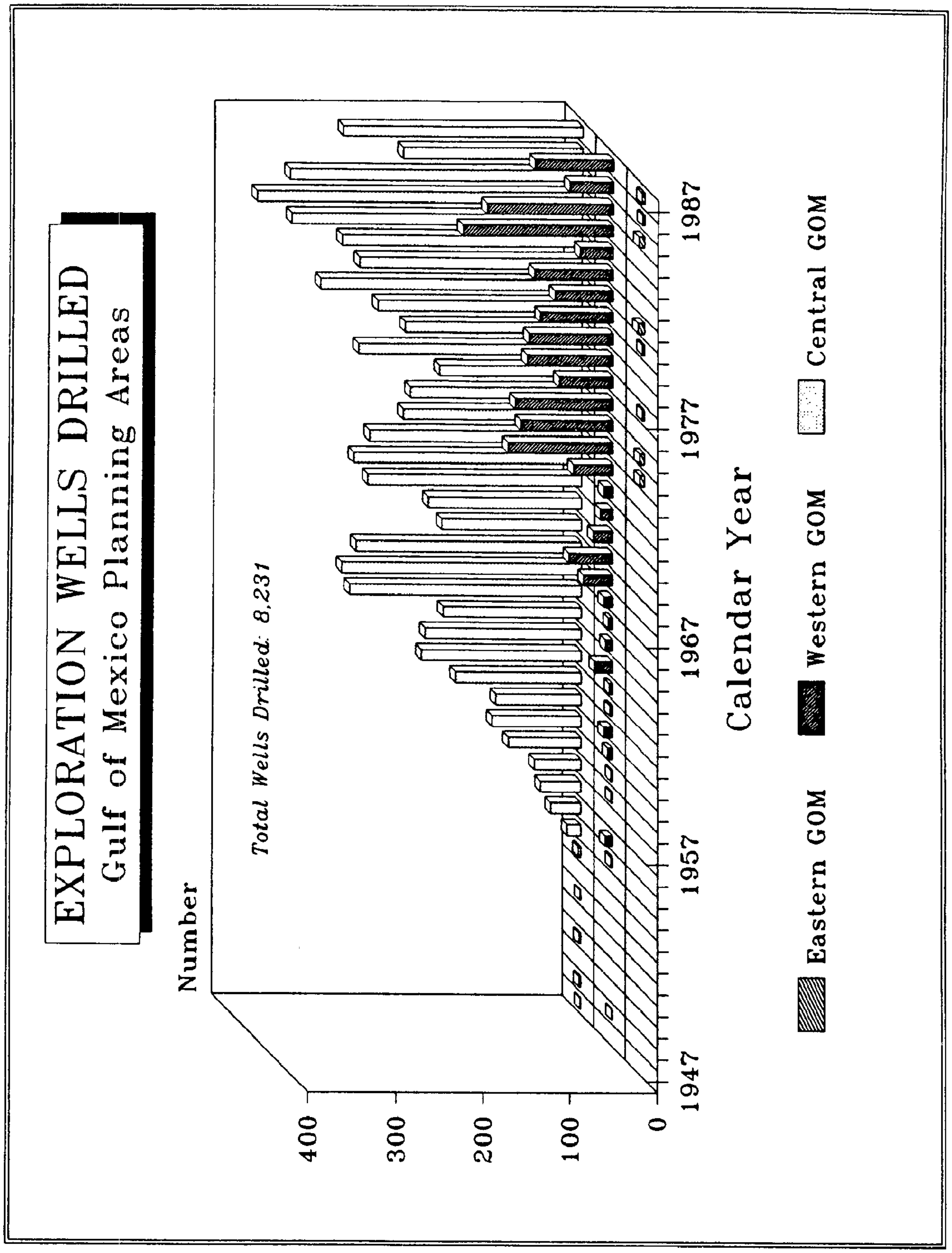

Figure I-8. Gulf of Mexico Region Planning Areas - exploration wells.

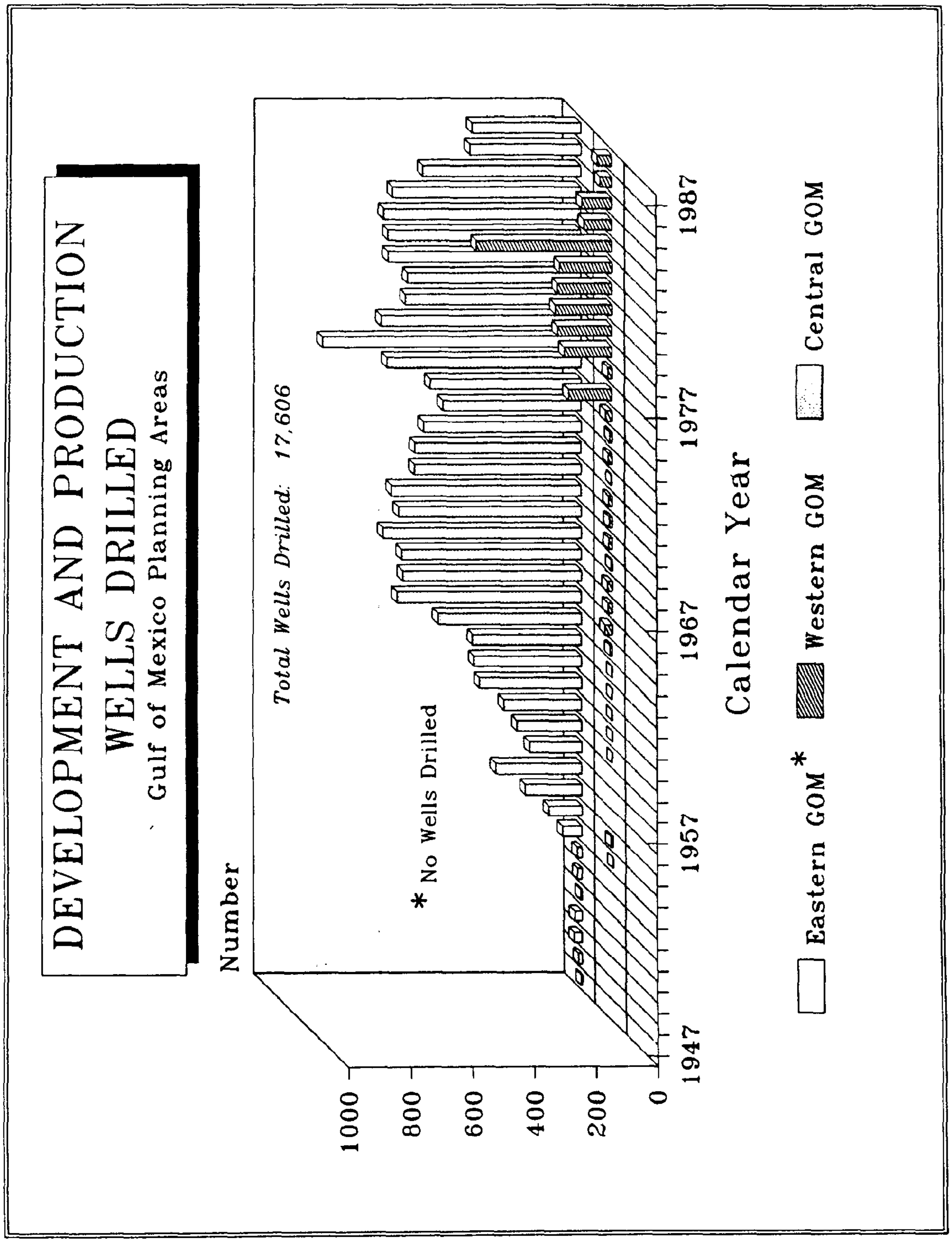

Figure I-9. Gulf of Mexico Region Planning Areas - development and production wells.

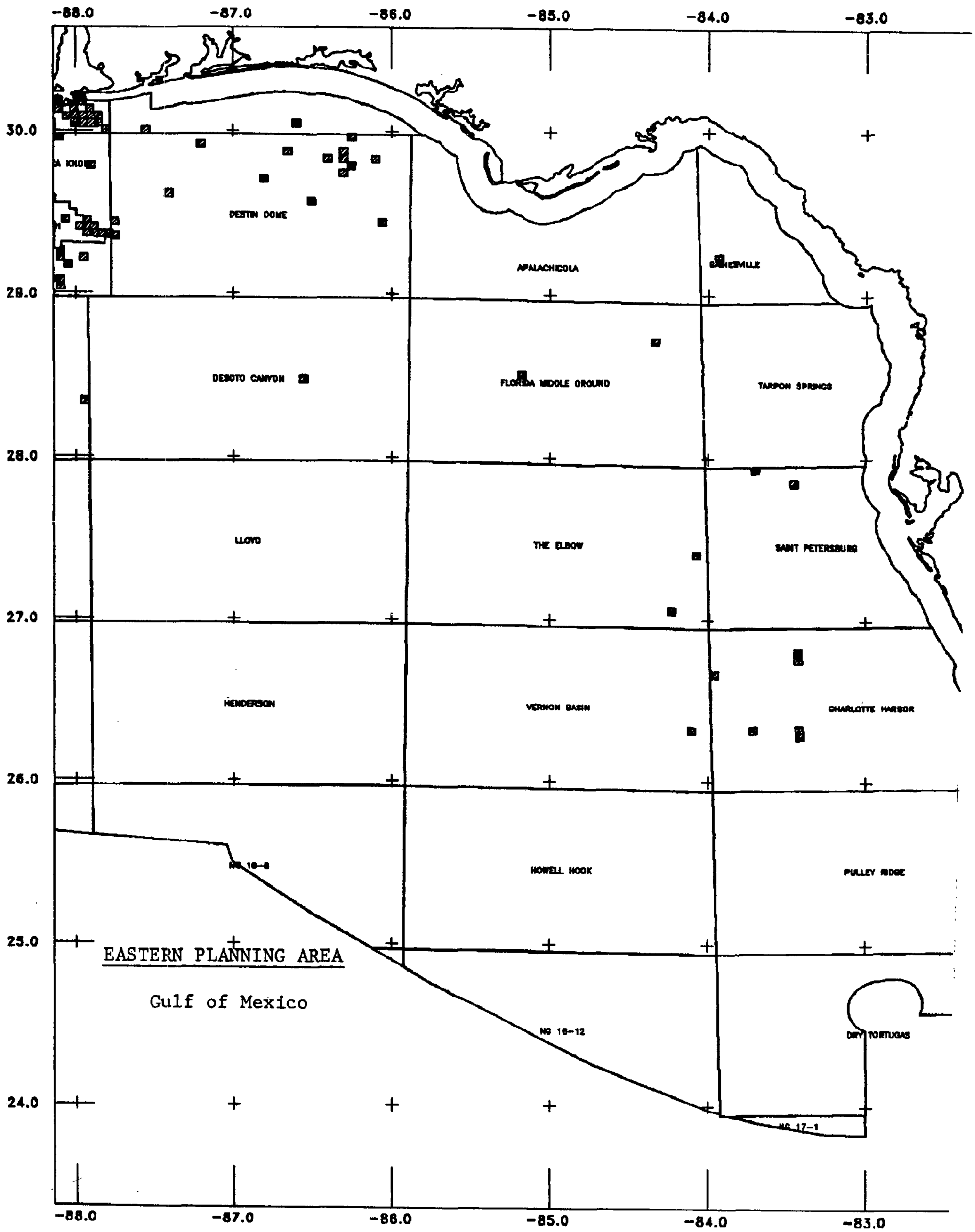

Figure I-10. Eastern Gulf of Mexico Planning Area - location of exploration drilling (shaded).

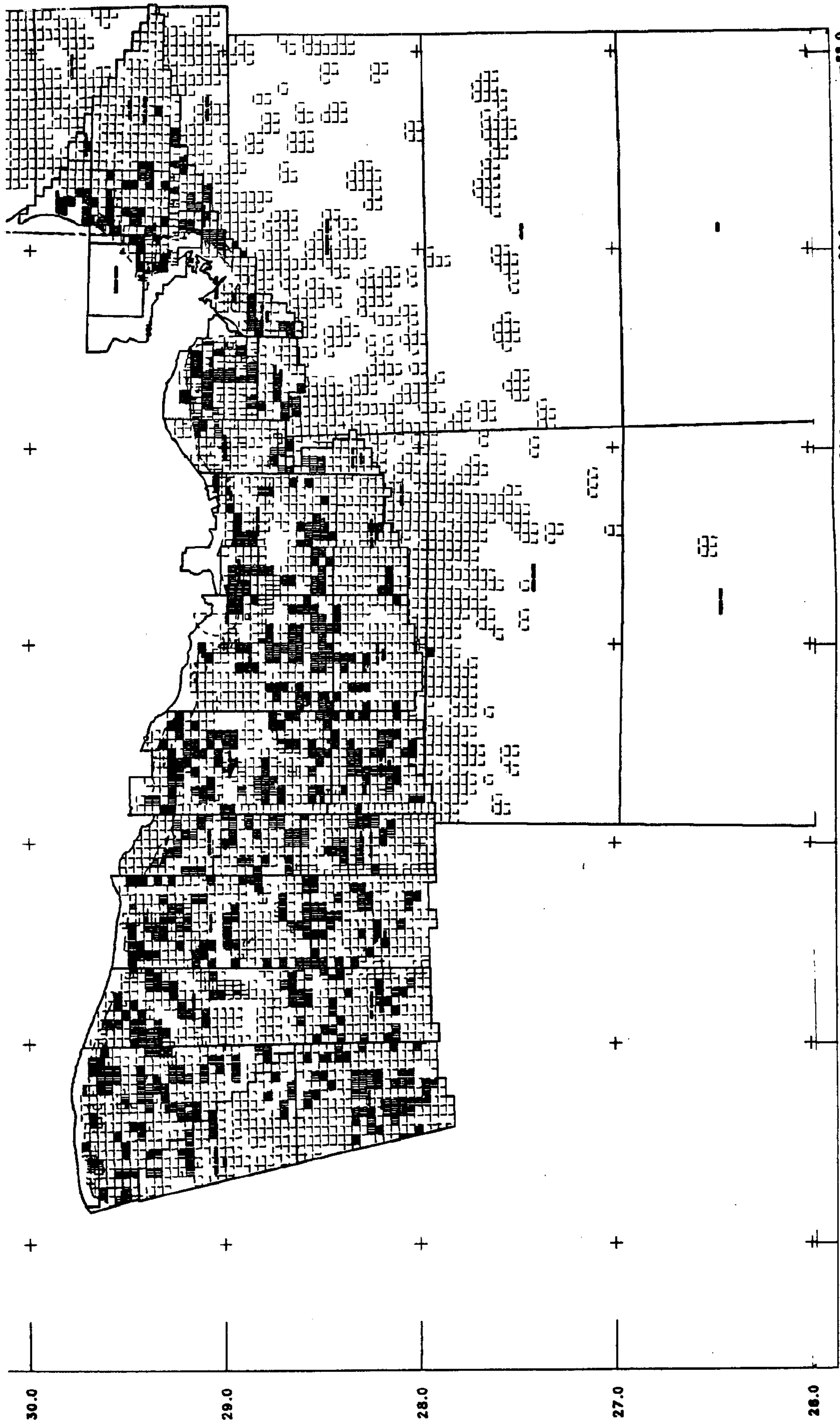

Figure I-11. Central Gulf of Mexico Planning Area - producing leases (shaded).

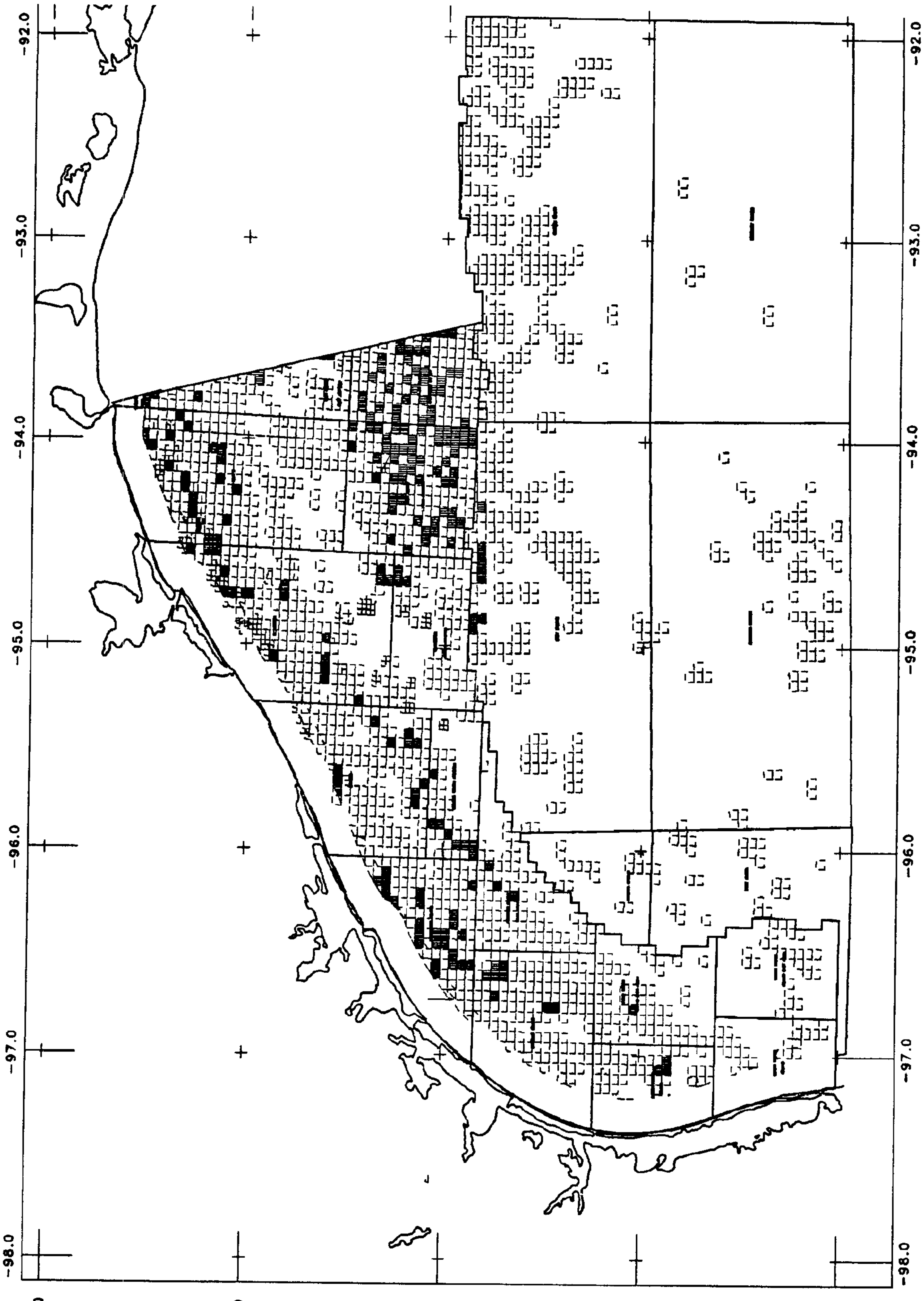

Figure I-12. Western Gulf of Mexico Planning Area - producing leases (shaded).

C. Pacific Region

Figures I-2 and I-3 summarize the levels of G&G exploration activities in the Pacific Region. Figures I-13 and I-14 show the numbers of exploration and development and production wells drilled by year. More detailed information relating to the OCS Program can be found in Pacific Summary Report/Index, (November 1984 - February 1986, MMS 86-0060 (S. P. Risotto and R. W. Rudolph, 1986).

1. Southern California Planning Area

Activities through 1986

Oil and gas exploration and development offshore California began in 1896 in State waters from wells drilled from a pier in Santa Barbara County. Since 1966, nine lease sales have been held in Federal waters in what is now the Southern California Planning Area, which encompasses all currently leased and producing areas within the Pacific Region. A total of 317 exploratory wells (including 2 COST wells) and 601 development wells have been drilled as of December 31, 1986, in the Pacific Region. As of December 1987, 20 platforms have been installed (figure I-15). Detailed historical aspects of OCS oil and gas development are reviewed and summarized in the Pacific Summary Report/Index (November 1984 - February 1986), MMS 86-0060 (Risotto and Rudolph, 1986).

Through 1986, OCS production from the Southern California Planning Area has amounted to 369 million bbl of oil and 243 billion cubic feet (ft^3) of natural gas.

2. Central California Planning Area

Activities through 1986

Activities in the Central California Planning Area began in 1963 when the first Federal OCS oil and gas lease sale offshore California resulted in the acceptance of bids for 24 tracts near the San Francisco area. Twelve exploratory wells were drilled (figure I-16), but no development occurred. All leases were relinquished by 1968.

3. Northern California Planning Area

Activities through 1986

One lease sale has been held in the Northern California Planning Area. Seventeen blocks were leased in the Eureka area and 10 in the Point Arena area during that 1963 lease sale. A total of seven exploratory wells were drilled (figure I-17), with three wells in the Point Arena area encountering sediments containing shows of oil. However, all leases expired during 1968 without any production taking place, as no commercial quantities of oil and gas were found (oil prices were about $2 to $3 per barrel in 1968).

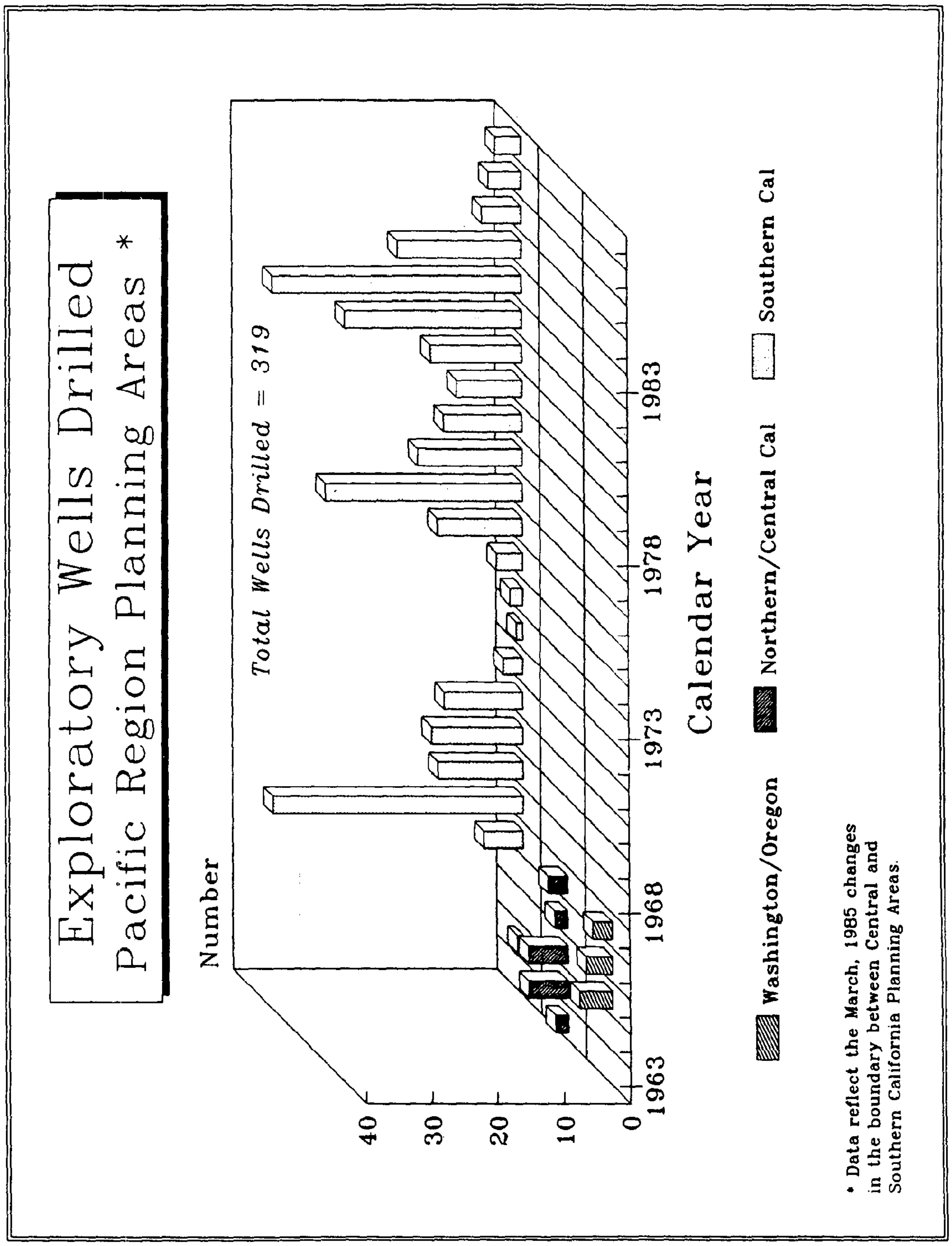

Figure I-13. Pacific Region Planning Areas - exploration wells.

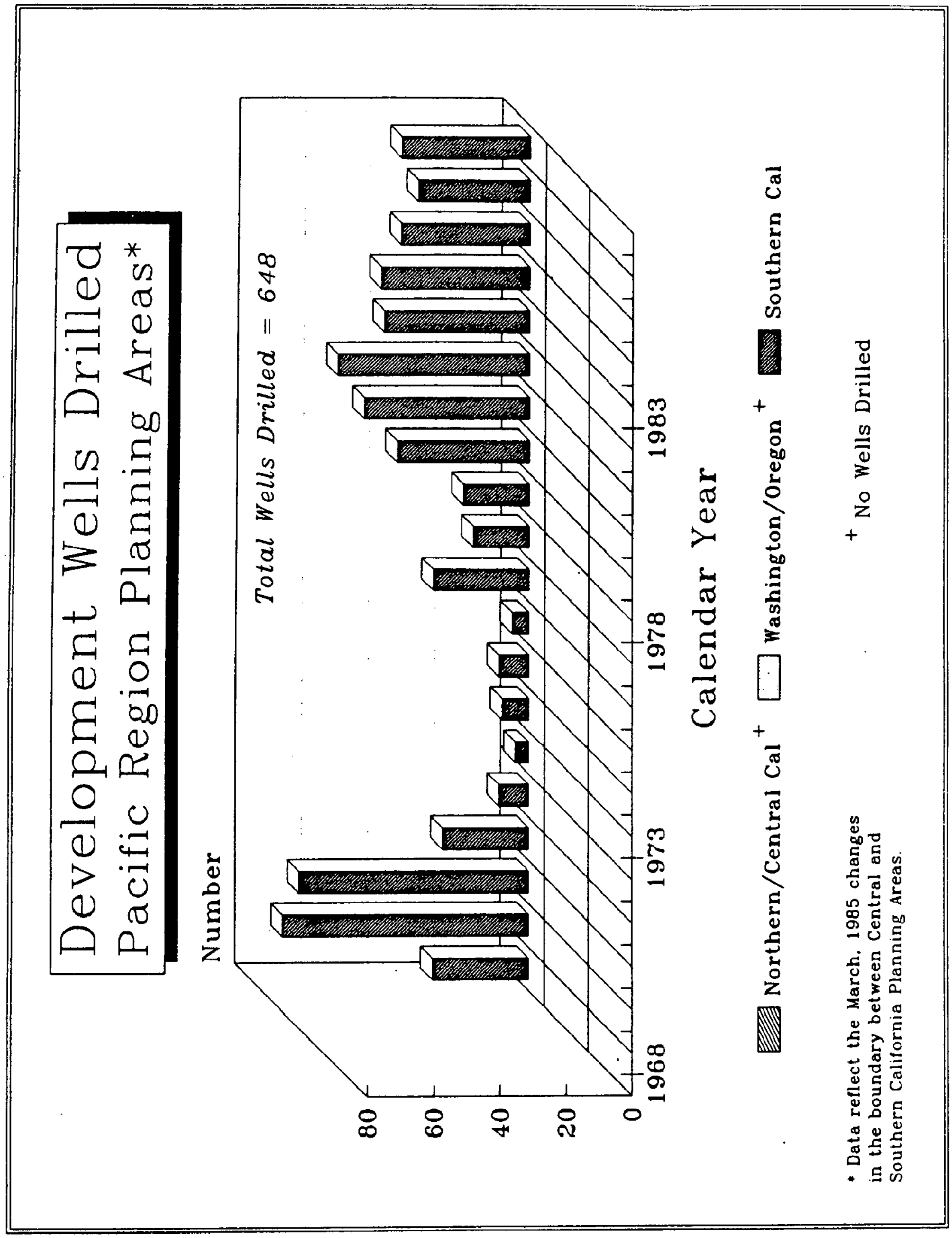

Figure I-14. Pacific Region Planning Areas - development and production wells.

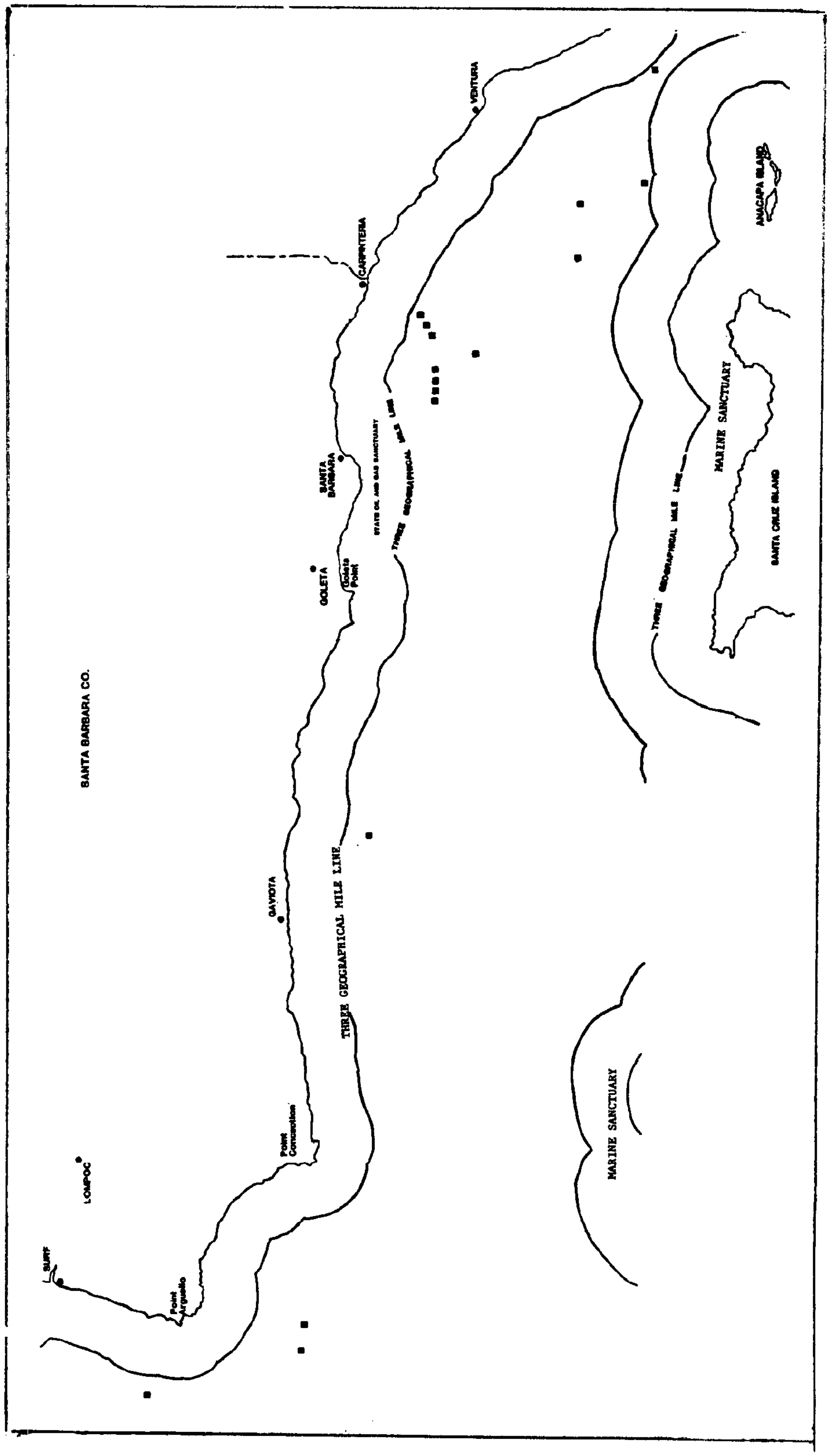

Figure I-15. Southern California Planning Area - location of production platforms.

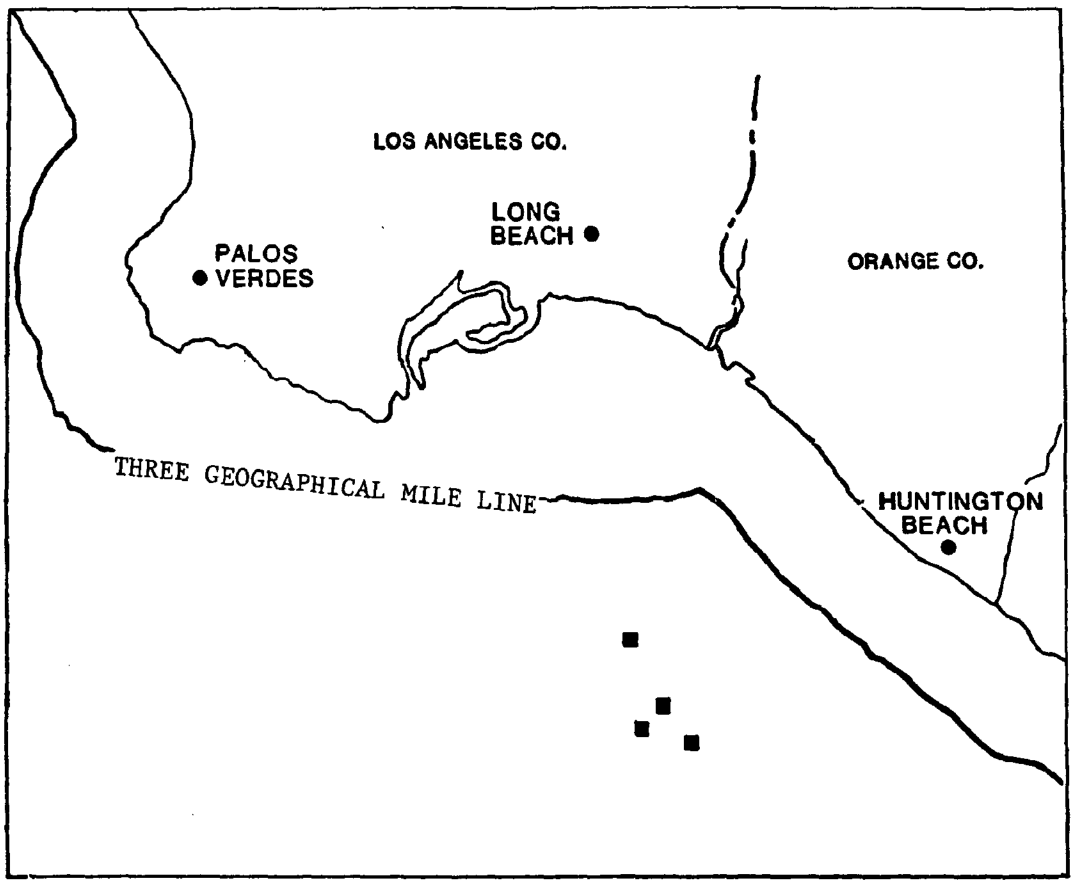

Figure I-15 (continued). Southern California Planning Area - location of production platforms.

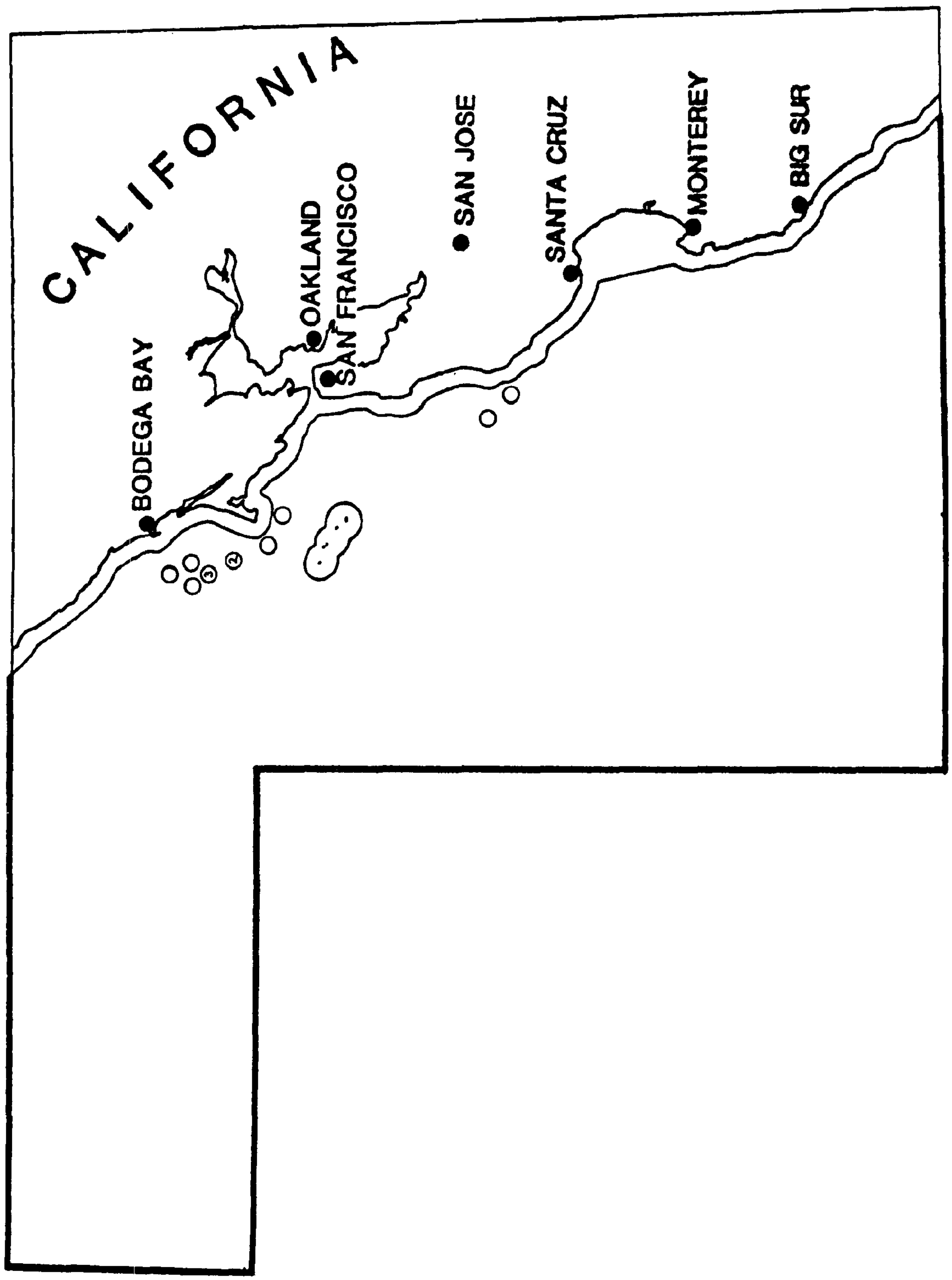

Figure I-16. Central California Planning Area - location of exploration wells.

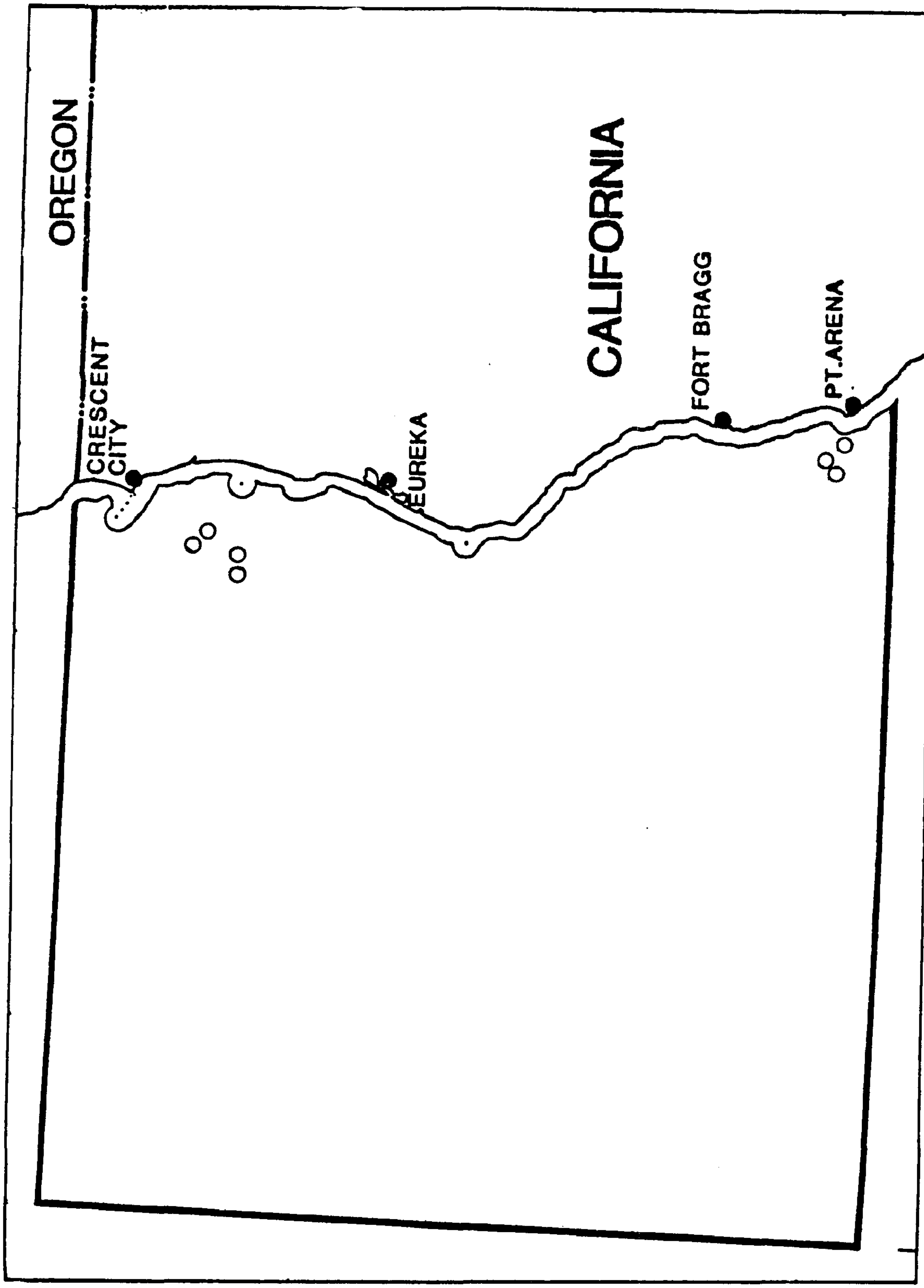

Figure I-17. Northern California Planning Area - location of exploration wells.

4. Washington-Oregon Area

Activities through 1986

The second Pacific OCS lease sale, which was held in 1964, covered what is now known as the Washington-Oregon Planning Area. One hundred and one leases were issued as a result of that sale, and 12 exploratory wells (4 off Washington, 8 off Oregon) were drilled (figure I-18). Three wells off Oregon and 2 wells off Washington had shows of oil and/or gas. No development occurred, and all leases were relinquished by 1969.

D. Alaska Region

There are 15 planning areas in the Alaska Region. For ease of presentation, these have been combined into three geographic subregions: Gulf of Alaska, Bering Sea, and Arctic. Figures I-2 and I-3 summarize the levels of G&G exploration activities in the Alaska Region. Figure I-19 shows the numbers of exploration wells drilled by year and planning area. More detailed information relating to the OCS Program can be found in Alaska Summary Report/Index (January 1986 - December 1986), MMS 87-0011 (D. L. Slitor and J. D. Wiese, 1987).

1. Gulf of Alaska Subregion (Gulf of Alaska, Cook Inlet, Kodiak, Shumagin) Planning Areas

Activities through 1986

Six lease sales have been held in the Gulf of Alaska Subregion beginning in 1976. There have been 320 permits for G&G surveys issued. Twenty-five exploratory wells and 8 COST wells have been drilled in the subregion. The locations of exploration wells are shown in figures I-20 and I-21. There have been no commercial discoveries. All of the leases have either expired or been relinquished, so there is no current drilling activity.

2. Bering Sea Subregion (Norton Basin, St. George Basin, Navarin Basin, North Aleutian Basin) Planning Areas

Activities through 1986

To date, three lease sales have been held in the Bering Sea Subregion. Drilling has occurred in three Bering Sea Planning Areas, with 24 exploratory wells and 6 COST wells drilled. The locations of exploration wells are shown in Figures I-22, I-23, and I-24. To date, no commercial discoveries have been announced. There have been 296 permits issued for G&G surveys in this subregion.

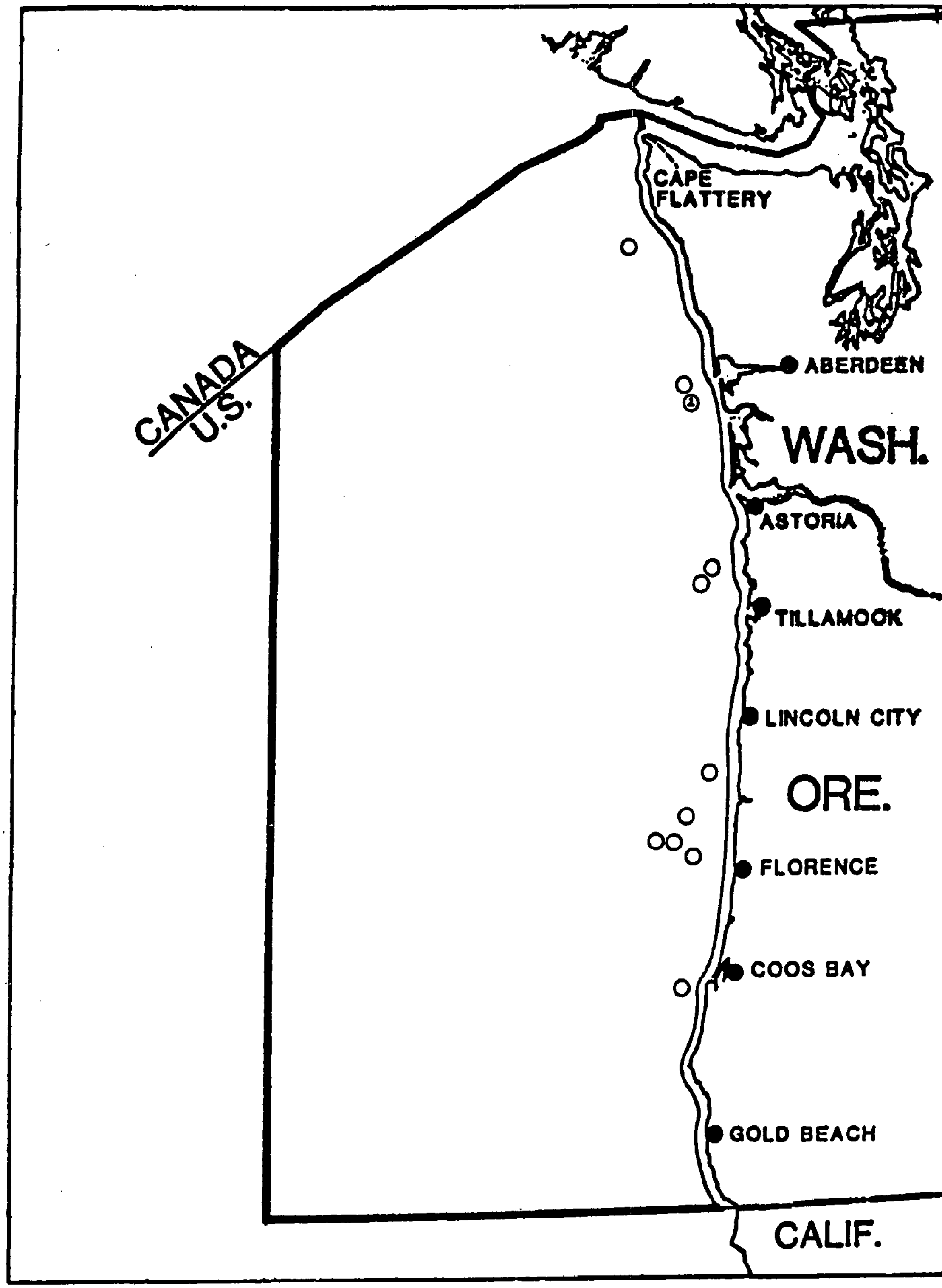

Figure I-18. Washington-Oregon Planning Area - location of exploration wells.

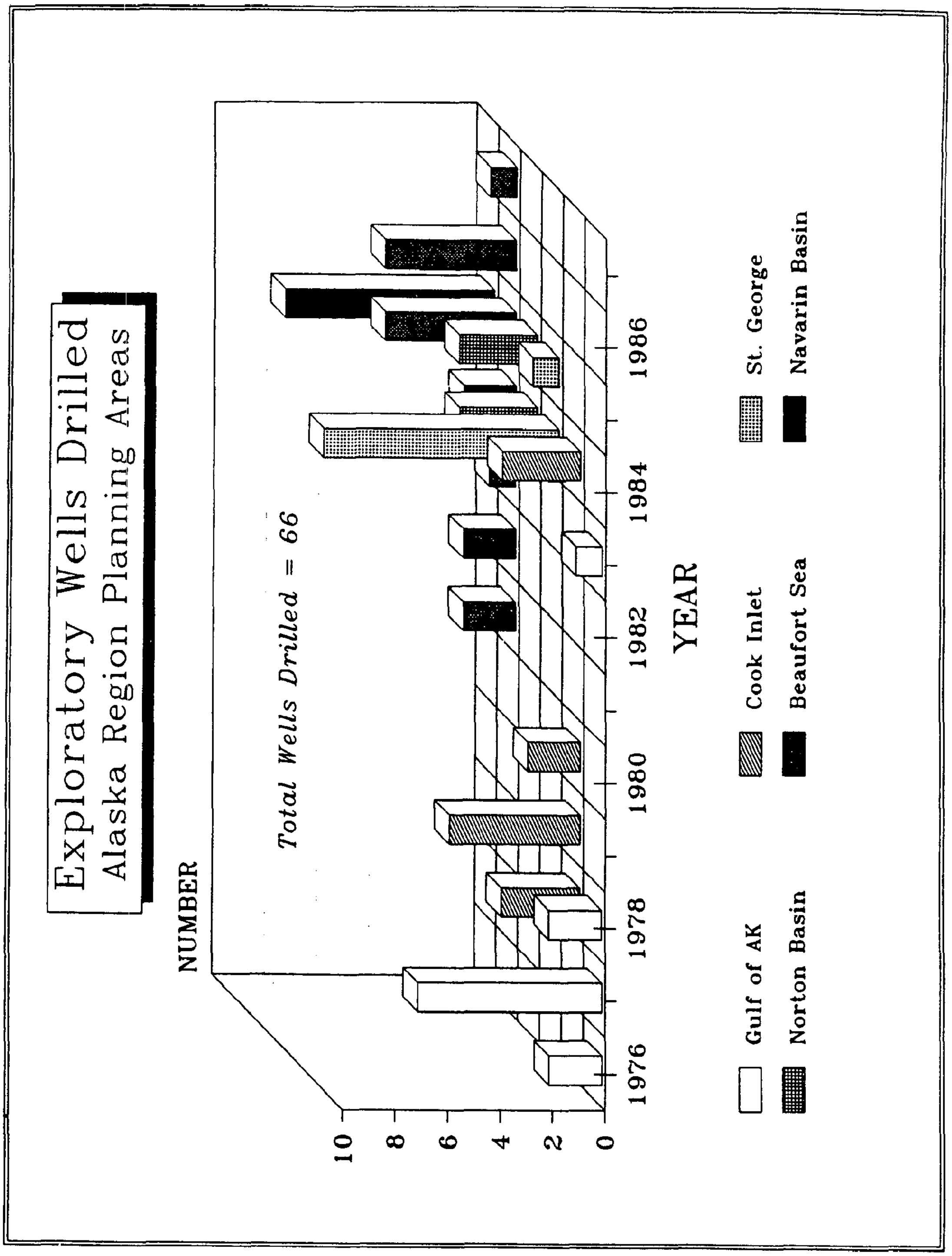

Figure I-19. Alaska Region Planning Areas - exploration wells.

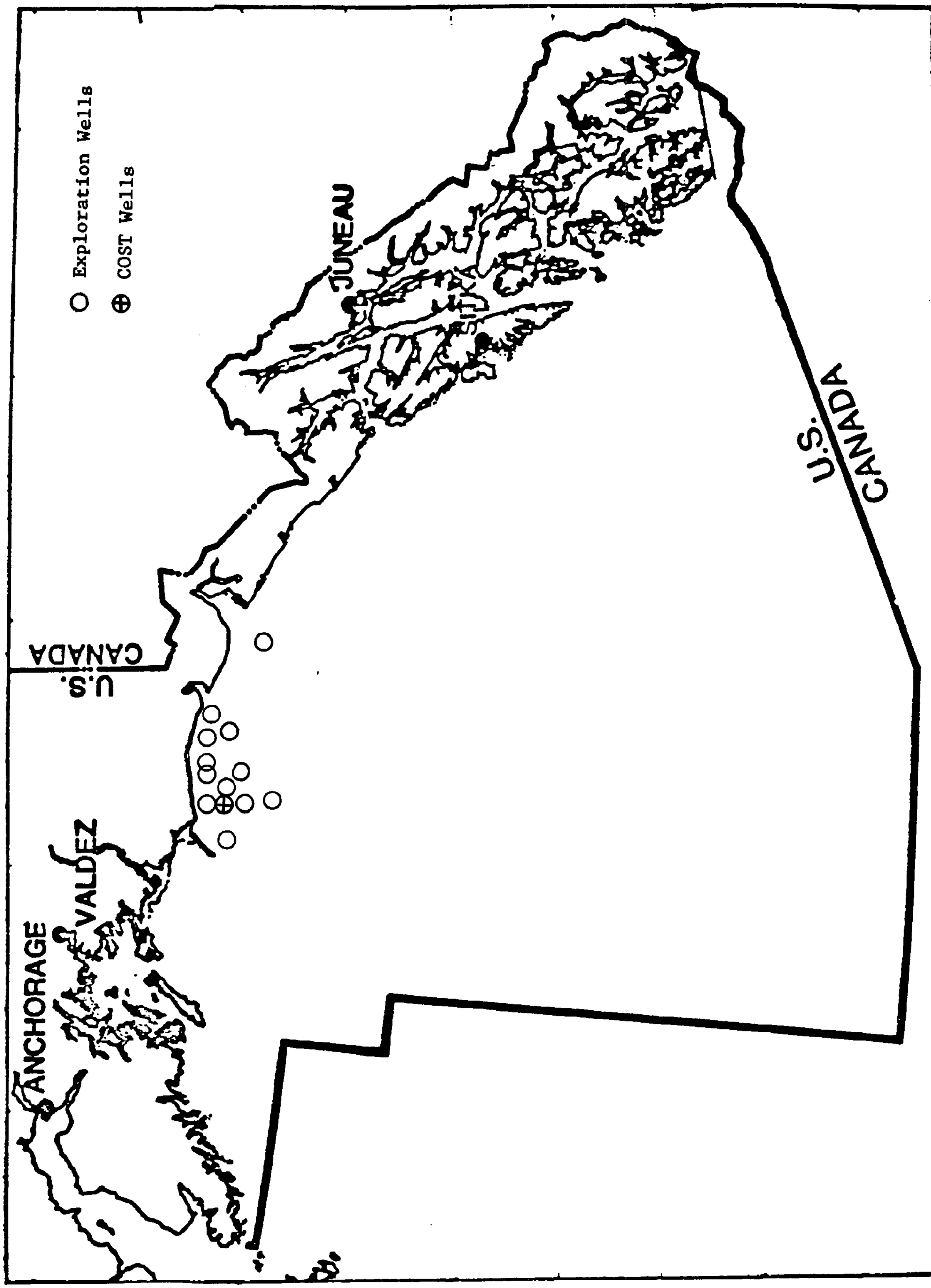

Figure I-20. Gulf of Alaska Planning Area - location of exploration wells.

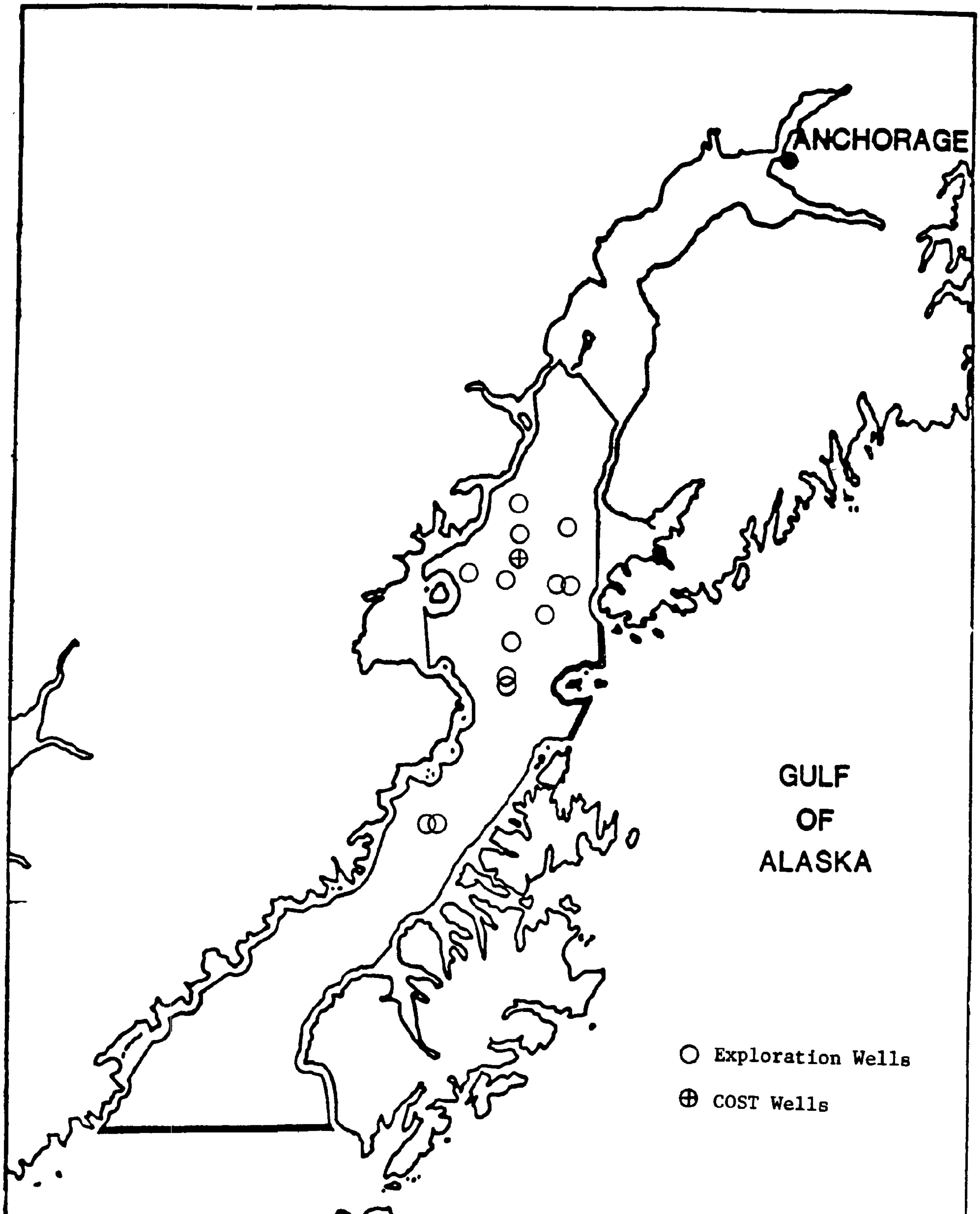

Figure I-21. Cook Inlet Planning Area - location of exploration wells.

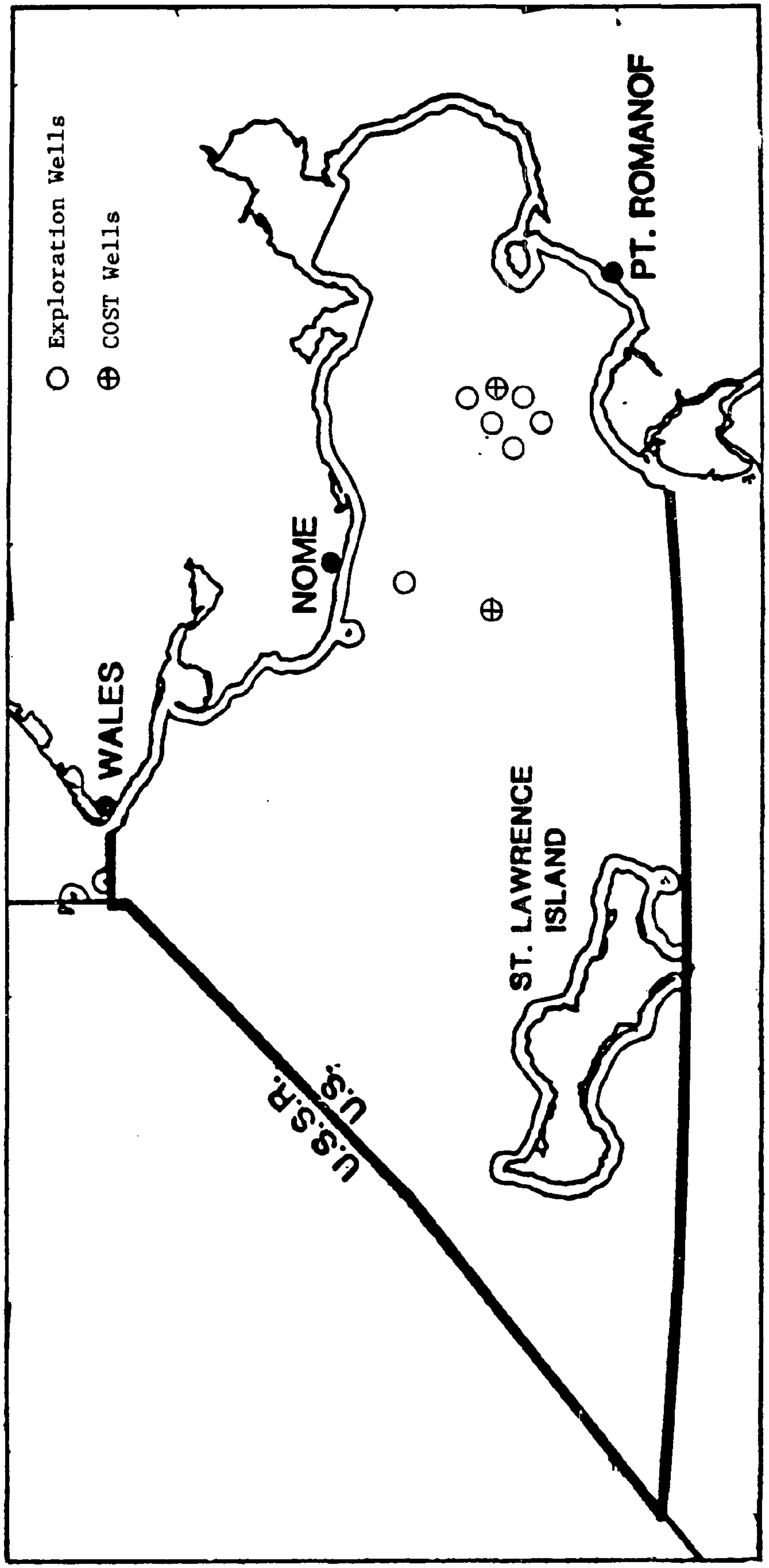

Figure I-22. Norton Basin Planning Area - location of exploration wells.

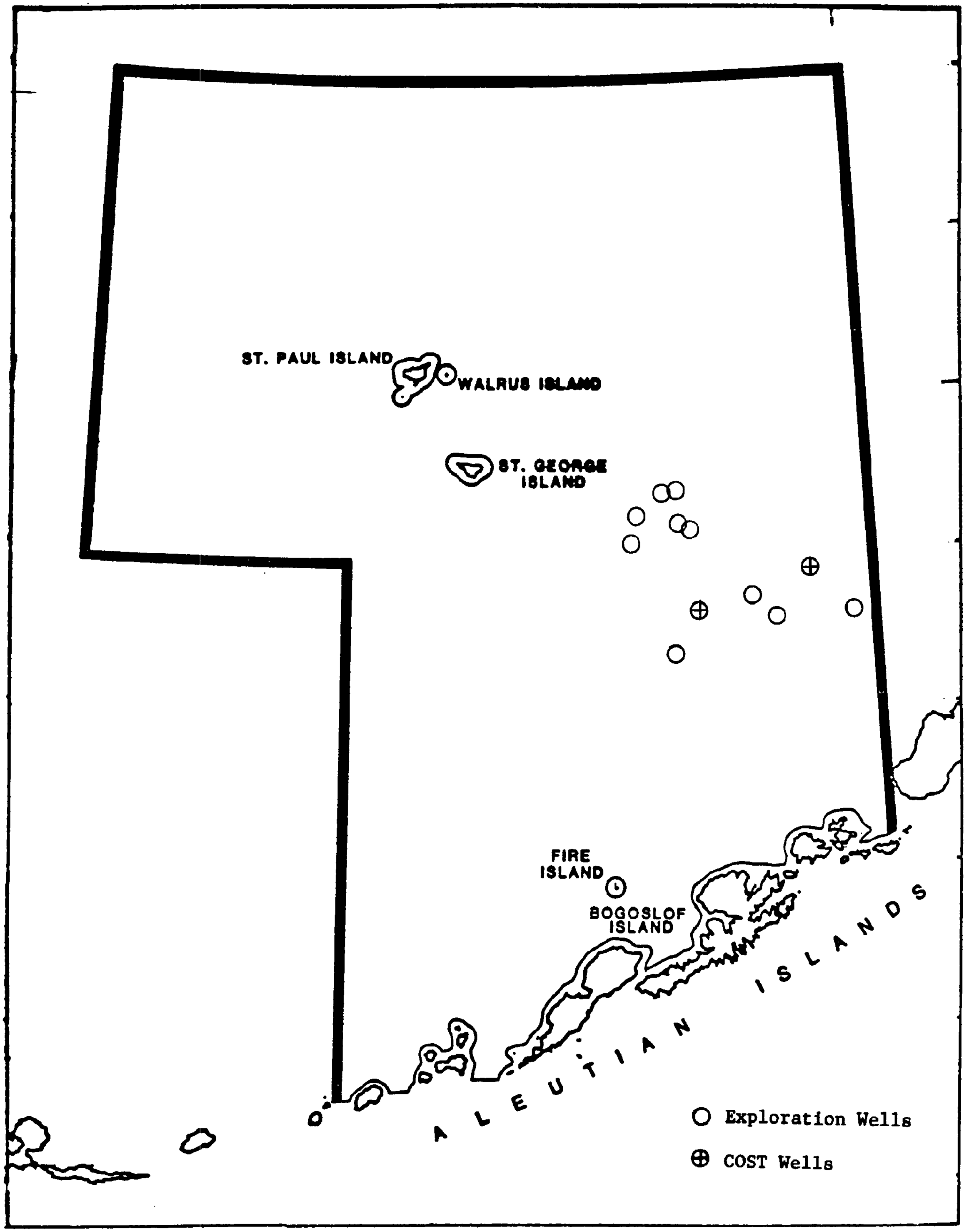

Figure I-23. St. George Basin Planning Area - location of exploration wells.

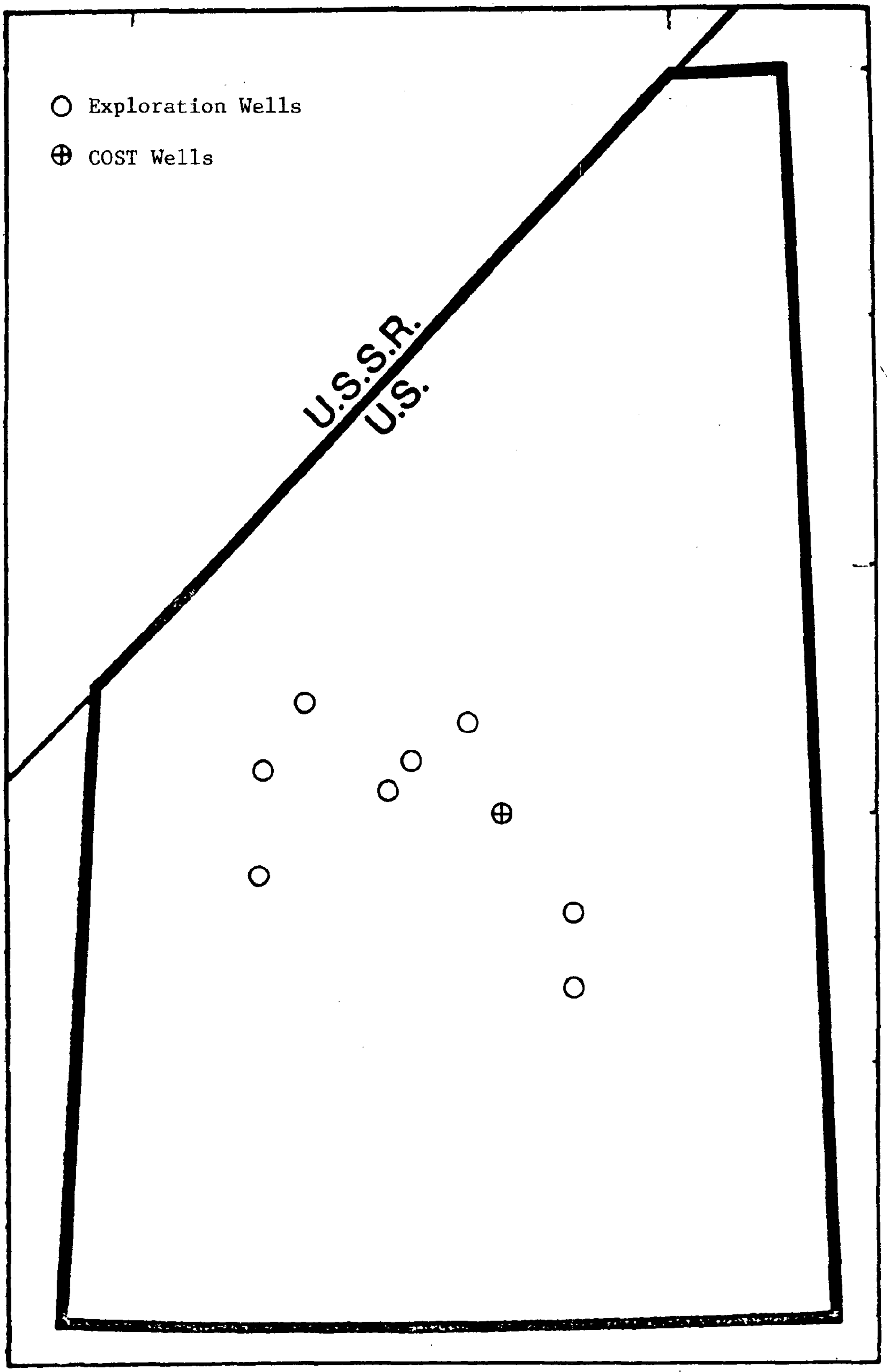

Figure I-24. Navarin Basin Planning Area - location of exploration wells.

3. Arctic Subregion (Beaufort Sea, Chukchi Sea, and Hope Basin) Planning Areas

Activities through 1986

There have been three sales in the Arctic Subregion since 1979, all in the Beaufort Sea. There have been 17 exploratory wells drilled in the Arctic Subregion through 1986, all in the Beaufort Sea (figure I-25). Five of these have discovered marginally economic quantities of oil. However, no development and production plans have been received to date. There have been 322 permits issued for G&G surveys in the subregion. All of the G&G permits issued in 1986 for Federal waters off Alaska were in this subregion. The number of such permits issued declined by over 350 percent from 1985 to 1986.

E. Effects on the Nation's Economy

1. OCS Sales and Production

From the program's inception in 1954 to the end of Fiscal Year (FY) 1986, 91 OCS lease sales have been held. Of these, 85 were oil and gas lease sales, including 2 reoffering sales. In addition, there were two salt sales, three sulfur sales, and one phosphate sale. The total bonus of nearly $53 billion and royalties of nearly $31 billion were paid by industry for all leased tracts from 1954 through FY 1986 (table I-1 and figure I-26). About 7 1/2 billion bbl of crude oil and condensate and 74 trillion ft^3 of natural gas (tables I-2 and I-3) were produced from the OCS between 1954 and the end of FY 1986.

2. Balance of Payments

In general, production of oil on the OCS substitutes for the highest cost direct alternative source of oil, foreign imports. These impacts, which have amounted to as much as 38 percent of the Nation's oil needs, constitute a drain of U.S. dollars into foreign treasuries. In 1986 alone, the U.S. imported about $24 billion worth of crude oil. Lacking OCS production, the Nation would be forced to pay out an amount equivalent to the value of the oil produced on the OCS, or rely on other forms of energy production. This would be difficult since alternatives sources have proven difficult to develop. Nuclear energy development has come to a standstill because of high costs and public opposition. Coal mining has also been beset by air pollution concerns, while solar and wind energy generation are still minor local sources. The OCS and onshore oil and gas production, however, continue to satisfy a meaningful portion (for 1987, approximately 12 percent of domestic oil production and 26 percent of domestic gas production) of the Nation's energy needs and help reduce the balance of payments. Finally, exportation of drill rigs, platforms, service vessels, technical and drilling equipment, and expert labor (developed because of our extensive experience on the OCS) all result in a flow of foreign currencies into the United States, further helping reduce the balance of payments deficit.

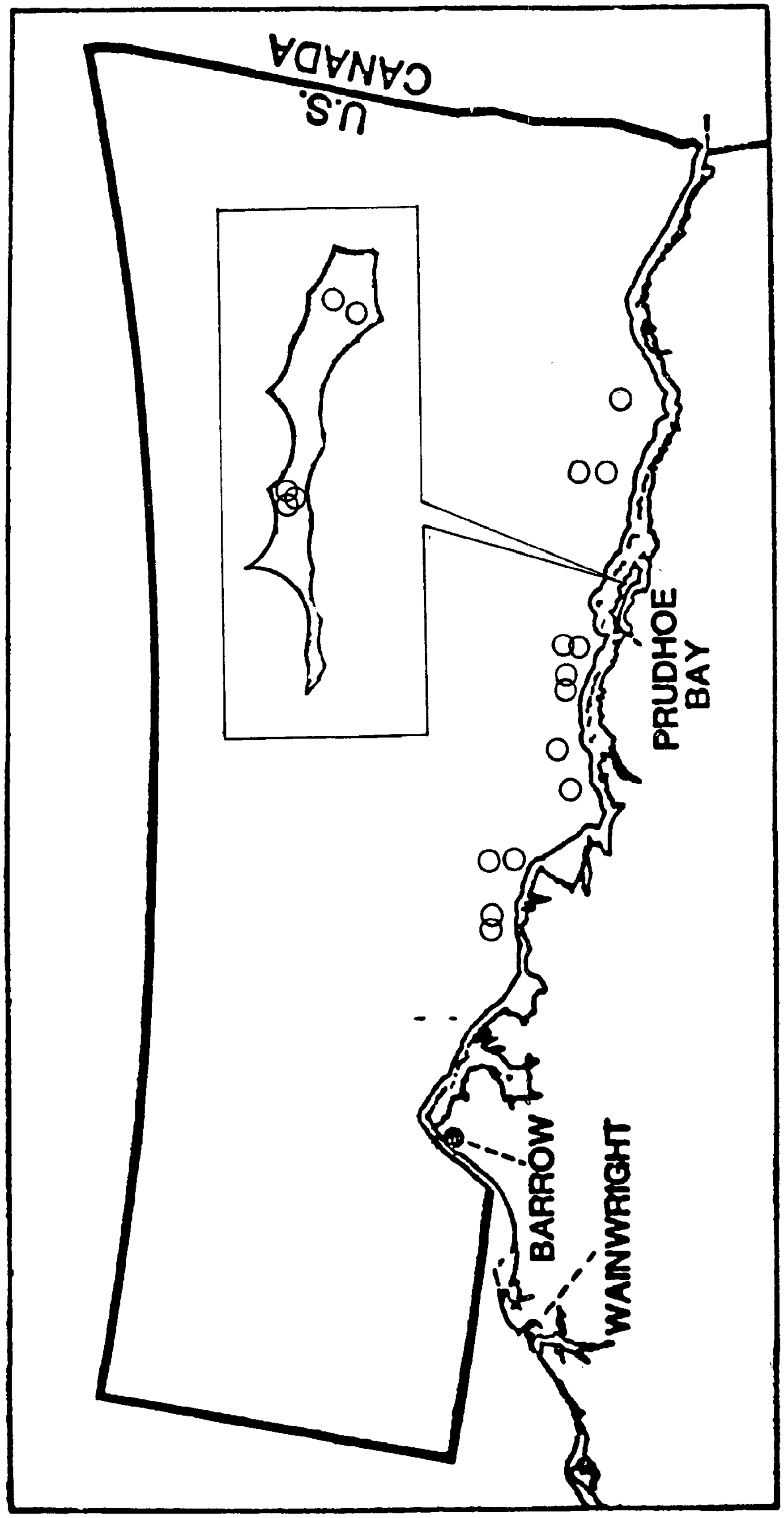

Figure I-25. Beaufort Sea Planning Area - location of exploration wells.

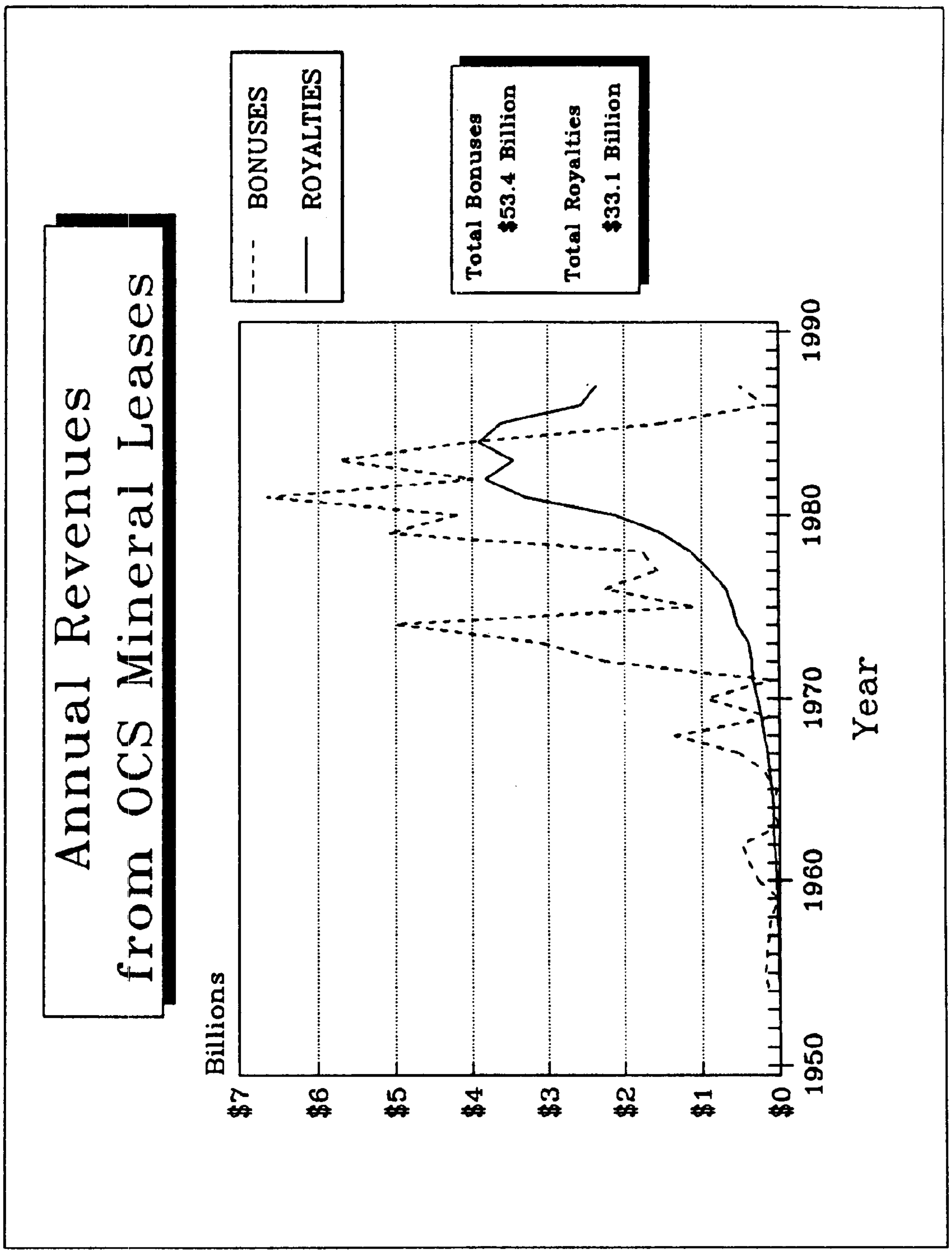

Figure I-26. Revenues from OCS minerals leases.

Table I-1
Annual Revenues from OCS Mineral Leases
(rounded off to the nearest thousand)

Year	Rents ($)	Royalities ($)	Bonuses ($)
1954	1,360,000	2,749,000	140,969,000
1955	3,406,000	5,140,000	180,529,000
1956	4,006,000	7,629,000	---
1957	3,270,000	11,391,000	---
1958	2,421,000	17,424,000	---
1959	2,286,000	26,540,000	89,747,000
1960	3,603,000	36,808,000	282,717,000
1961	3,074,000	46,734,000	---
1962	8,412,000	65,255,000	489,481,000
1963	8,435,000	75,374,000	12,807,000
1964	9,799,000	86,535,000	95,874,000
1965	8,731,000	99,656,000	33,740,000
1966	6,869,000	132,850,000	209,200,000
1967	6,209,000	153,432,000	510,110,000
1968	8,231,000	196,491,000	1,346,487,000
1969	8,313,000	235,682,000	111,661,000
1970	8,609,000	276,522,000	945,065,000
1971	7,742,000	340,635,000	96,305,000
1972	7,985,000	353,582,000	2,251,348,000
1973	8,949,000	389,736,000	3,082,463,000
1974	13,533,000	536,019,000	5,022,861,000
1975	17,522,000	594,725,000	1,088,133,000
1976	23,371,000	680,393,000	2,242,898,000

Table I-1 - (Continued)
Annual Revenues from OCS Mineral Leases
(rounded off to the nearest thousand)

Year	Rents ($)	Royalities ($)	Bonuses ($)
1977	19,830,000	890,470,000	1,568,565,000
1978	21,513,000	1,139,198,000	1,767,042,000
1979	20,287,000	1,512,018,000	5,078,862,000
1980	19,062,000	2,132,529,000	4,204,640,000
1981	21,731,000	3,287,279,000	6,651,253,000
1982	20,055,000	3,814,872,000	3,987,490,000
1983	32,463,000	3,454,318,000	5,748,716,000
1984	35,608,000	3,914,725,000	4,037,050,000
1985	61,383,000	3,612,783,000	1,488,027,000
1986	58,135,000	2,559,661,000	187,095,000
1987*	68,529,000	2,372,563,000	497,247,000
Totals	558,585,000	33,062,685,000	53,376,638,000

Sources: Mineral Revenues--The 1986 Report on Receipts from Federal and Indian Leases, USDOI, MMS.

Federal Offshore Statistisc--MMS 87-0008, 1985.
*Preliminary Figures

Table I-2
Federal offshore crude oil and condensate production
(thousands of barrels)

Year	Total OCS	Percent of U.S. Total Population	Gulf of Mexico	Pacific
1954	3,342	0.14	3,342	
1955	6,705	0.27	6,705	
1956	11,015	0.42	11,015	
1957	16,070	0.61	16,070	
1958	24,769	1.01	24,769	
1959	35,698	1.39	35,698	
1960	49,666	1.93	49,666	
1961	64,330	2.45	64,330	
1962	89,737	3.35	89,737	
1963	104,579	3.80	104,579	
1964	122,500	4.40	122,500	
1965	144,969	5.09	144,969	
1966	188,714	6.23	188,714	
1967	221,862	6.90	221,862	
1968	268,996	8.08	266,936	2,060
1969	312,860	9.28	302,919	9,941
1970	360,646	10.25	335,658	24,988
1971	418,549	12.12	387,445	31,104
1972	411,886	11.92	389,324	22,562
1973	394,730	11.74	375,815	18,915
1974	360,590	11.26	343,817	16,777
1975	330,237	10.80	314,932	15,305
1976	316,920	10.65	302,941	13,979
1977	303,948	10.10	291,680	12,268
1978	292,265	9.20	280,179	12,086
1979	285,566	9.15	274,605	10,961
1980	277,389	8.84	267,190	10,199
1981	289,765	9.26	270,160	19,605
1982	321,211	10.18	292,777	28,434
1983	348,331	10.98	317,804	30,527
1984	370,239	11.42	339,985	30,254
1985	389,324	12.01	359,543	29,781
1986	389,276	12.30	359,988	29,228
1987*	366,138	12.07	322,581	33,577

Source: Federal Offshore Statistics: 1985; OCS Report MMS 87-0008
*Preliminary Figures

Table I-3
Federal offshore natural gas production
(millions of cubic feet)

Year	OCS	Total Production	Gulf of Mexico	Pacific
1954	56,325	0.64	56,325	
1955	81,279	0.86	81,279	
1956	82,893	0.82	82,893	
1957	82,574	0.77	82,574	
1958	127,693	1.16	127,693	
1959	207,156	1.78	207,156	
1960	273,034	2.14	273,034	
1961	318,280	2.40	318,280	
1962	451,953	3.26	451,953	
1963	564,353	3.85	564,353	
1964	621,731	4.02	621,731	
1965	645,589	4.03	645,589	
1966	1,007,447	5.86	1,007,447	
1967	1,187,216	6.53	1,187,216	
1968	1,524,178	7.89	1,524,378	800
1969	1,954,487	9.44	1,949,641	4,846
1970	2,418,677	11.03	2,406,448	12,229
1971	2,777,043	12.55	2,761,372	15,671
1972	3,038,555	13.09	3,028,521	10,034
1973	3,211,588	14.18	3,204,301	7,287
1974	3,514,724	16.27	3,509,150	5,574
1975	3,458,693	17.20	3,454,741	3,952
1976	3,595,924	18.02	3,592,449	3,475
1977	3,737,747	18.67	3,734,457	3,290
1978	4,385,061	21.95	4,381,589	3,472
1979	4,672,979	22.83	4,670,112	2,867
1980	4,641,457	23.10	4,638,350	3,107
1981	4,849,537	24.03	4,836,771	12,766
1982	4,679,511	25.27	4,661,760	17,751
1983	4,040,734	24.02	4,024,710	16,024
1984	4,537,841	25.09	4,510,034	27,807
1985	4,000,975	23.26	3,951,811	49,164
1986	3,948,892	23.59	3,906,203	42,689
1987*	4,425,755	25.81	4,384,769	40,986

Source: Federal Offshore Statistics: 1985; OCS Report MMS 87-0008
*Preliminary Figures

3. Employment

The production of OCS oil and gas has been a major source of employment and revenues in the GOM Region since 1954, particularly in Louisiana. Approximately 130,000 jobs depend directly or indirectly on the OCS Program--110,000 associated with activity from offshore Louisiana and 20,000 from offshore Texas. Virtually every urban area in coastal Texas and Louisiana owes part of its economic base to the offshore petroleum industry. In Louisiana, taxes paid by energy companies account for 40 percent of the State's revenues (DOI, MMS, 1985).

In the Pacific Region, offshore oil and gas production has come exclusively from the Southern California Planning Area. In southern California, the infrastructure is concentrated in the Santa Barbara and Long Beach areas. Approximately 40,000 to 60,000 jobs depend directly or indirectly on the OCS Program.

4. National Security

Production on the OCS tends to substitute for imports. The resulting reduction in imports has several significant consequences for national security.

As imports decline, especially from hostile and unstable regions of the Middle East, the potential damages caused by a supply disruption are reduced. At the same time, the likelihood of such a disruption being used as a political weapon against the United States is reduced as well.

These conclusions emerge because of the importance of OCS production in domestic energy markets. From 1978 to 1984, production of oil on the OCS averaged about 3 million bbl of oil equivalent (includes gas converted to BTU equivalent of oil) per day, whereas imports of petroleum products averaged 6 million bbl per day. Thus, without the contributions of OCS production to domestic consumption, imports could have been about 50 percent higher.

With imports from the Organization of Petroleum Exporting Countries members averaging about 2 million bbl a day over the past 7 years, it can be shown that every 4 bbl of oil produced annually on the OCS could reduce the size of the Strategic Petroleum Reserve (SPR) inventory by 1 bbl. Accordingly, without Federal offshore production, the comparable target level of the SPR would have been 750 million bbl, representing the inventory level necessary to achieve the same level of supply protection as actually resulted with OCS production. The President authorized a 750-million-barrel-size reserve in 1986. The potential savings generated in acquisition, maintenance, and interest charges were substantial, especially with the plunge in oil prices in late 1985 and most of 1986.

To the extent that OCS oil and gas contribute to a stable energy supply for the Nation, this oil and gas also contribute to the protection of the country from serious environmental consequences of large oil spills from foreign tankers. The OCS production reduces the likelihood of the United States becoming involved in armed conflicts over oil and gas resources. Additionally, it prevents emergency shortages during which environmental laws and considerations might, by necessity, be abandoned.

II. ADMINISTRATION OF THE OCS OIL AND GAS PROGRAM

A. The MMS Regulatory Program

The MMS administers the provisions of the OCSLA, as amended, through regulations found at Title 30 of the Code of Federal Regulations (CFR) Parts 250-260. The regulations govern oil and gas leasing operations on the OCS. In addition to regulating the conduct of operations on the OCS, they provide for public participation in the leasing process, including the review by and coordination with State governments, consideration of State coastal zone management (CZM) programs, solicitation of information from the public concerning proposed lease sales through a Call for Information and Nominations, and comments on environmental impact statements (EIS's). In addition, the regulations provide for royalty payments and consultation with appropriate Federal and State agencies to develop measures to mitigate adverse effects on the environment.

Regulations under 30 CFR Part 251 contain the requirements for G&G exploration for mineral resources on the OCS by persons not holding leases. Part 251 applies not only to G&G exploration but to scientific research as well. The purpose of these regulations is to prescribe (1) when a permit or the filing of a notice is required to conduct G&G exploration on the OCS and (2) operating procedures for conducting exploration, as well as requirements for disclosing data and information, conditions for reimbursing permittees for certain costs, and other conditions under which exploration shall be conducted.

The regulations also require industry to submit to MMS an exploration plan, which includes measures to protect the environment. The MMS reviews the plan, analyzes the environmental effects, and determines appropriate mitigation before approving the plan.

Additionally, regulations require industry to submit a development and production plan before development can occur. The MMS approves the plan, if appropriate, taking into account environmental, technical, and economic considerations. Many other elements of leasing operations are covered in the MMS regulations, which reflect the mandates of the OCSLA, as amended.

Other Agencies, in addition to DOI, regulate specific aspects of OCS operations. For example, the U.S. Environmental Protection Agency (EPA) regulates waste discharges; the U.S. Department of Transportation regulates occupational safety and health, the reporting and containment of oil spills, and the design of certain pipelines and mobile offshore drilling units; and the Department of the Army Corps of Engineers (COE) regulates the placement of structures in navigable waters. Affected States with approved CZM programs review exploration and development and production plans for consistency with their coastal management plans.

B. Stipulations, Notices, and Conditions of Approval

1. Stipulations

Special stipulations are often included in OCS oil and gas leases in response to concerns of MMS, coastal States, fishing groups, Federal Agencies, and others. For example, the stipulations may require biological surveys of sensitive seafloor habitats, special environmental training for operational personnel, special waste-discharge procedures, archaeological resource reports to determine potentially historic or prehistoric sites, and special operating procedures near military bases or their zones of activity. Lease stipulations are legally binding contractual provisions.

2. Notices to Lessees and Operators

Notices to Lessees and Operators (NTL's) are used to notify operators within a particular OCS Region quickly about changes in MMS administrative practices or procedures for complying with rules, regulations, and lease stipulations. The NTL's clarify requirements on lessees that are already established.

3. Conditions of Approval

Conditions of approval are often attached to approved permits such as applications for permit to drill (APD's). These conditions range from administrative matters, such as the required frequency of reports, to technical or environmental conditions, such as requirements for the disposal of drilling mud. In all cases, they are specific conditions that amplify or explain a requirement in the regulations, OCS Orders, or lease stipulations.

C. Offshore Inspection and Compliance Program

The OCSLA authorizes the MMS to inspect oil and gas operations. The OCSLA requires that the MMS schedule onsite inspections at least once each year of each facility on the OCS that is subject to any environmental or safety regulation. This annual inspection includes all safety equipment designed to prevent blowouts, fires, spillages, or other major accidents. The OCSLA also requires that MMS conduct periodic inspections without advance notice to the operators of such facilities to assure compliance with environmental and safety regulations. The MMS performs these inspections using a checklist called the National Potential Incident of Noncompliance (PINC) list. The PINC list is a compilation of yes/no questions derived from all the safety and environmental requirements of the regulations and OCS Orders. The PINC list is divided into sections for drilling, production, environmental, production measurement, general, hydrogen sulfide, subfreezing, pipeline, and site security requirements.

Upon detection of a violation, the MMS issues an Incident of Noncompliance (INC) to the operator and uses one of two enforcement actions depending on the severity of the violation. If the violation is not severe or threatening, a warning INC is issued. The warning INC must be corrected within a certain amount of time. For violations that threaten the safety of the facility or protection of the environment, a shut-in INC is issued. The shut-in may be for a single component, a portion of the facility, or the entire facility. The violation must be corrected before the operator is allowed to continue the operation in question.

D. Environmental Studies Program

The OCS Environmental Studies Program (ESP) of MMS was initiated in 1973 to support DOI's oil and gas program. The objective of the program is to obtain information needed for the prediction, assessment, and management of impacts on the OCS and the nearshore area that may be affected. Since the program's inception in FY 1973 through FY 1987, more than $448 million has been spent through the ESP on studies (figure II-1). The studies are designed to:

(1) Provide information on the status of the environment upon which the prediction of the impacts of OCS oil and gas development may be based.

(2) Provide information on the ways and extent that OCS development can potentially impact the human, marine, biological, and coastal areas.

(3) Ensure that information already available or being collected under the program is in a form that can be used in making decisions associated with a specific leasing action or with the longer term OCS mineral management responsibilities.

(4) Provide a basis for future monitoring of the OCS operations.

The purpose of the ESP is to ensure that the environmental information on which decisions are based is the most definitive that can be assembled at the time.

Figure II-2 summarizes expenditures by topic area since the inception of the program in FY 1973 through FY 1986. Table II-1 summarizes expenditures by OCS Region through time.

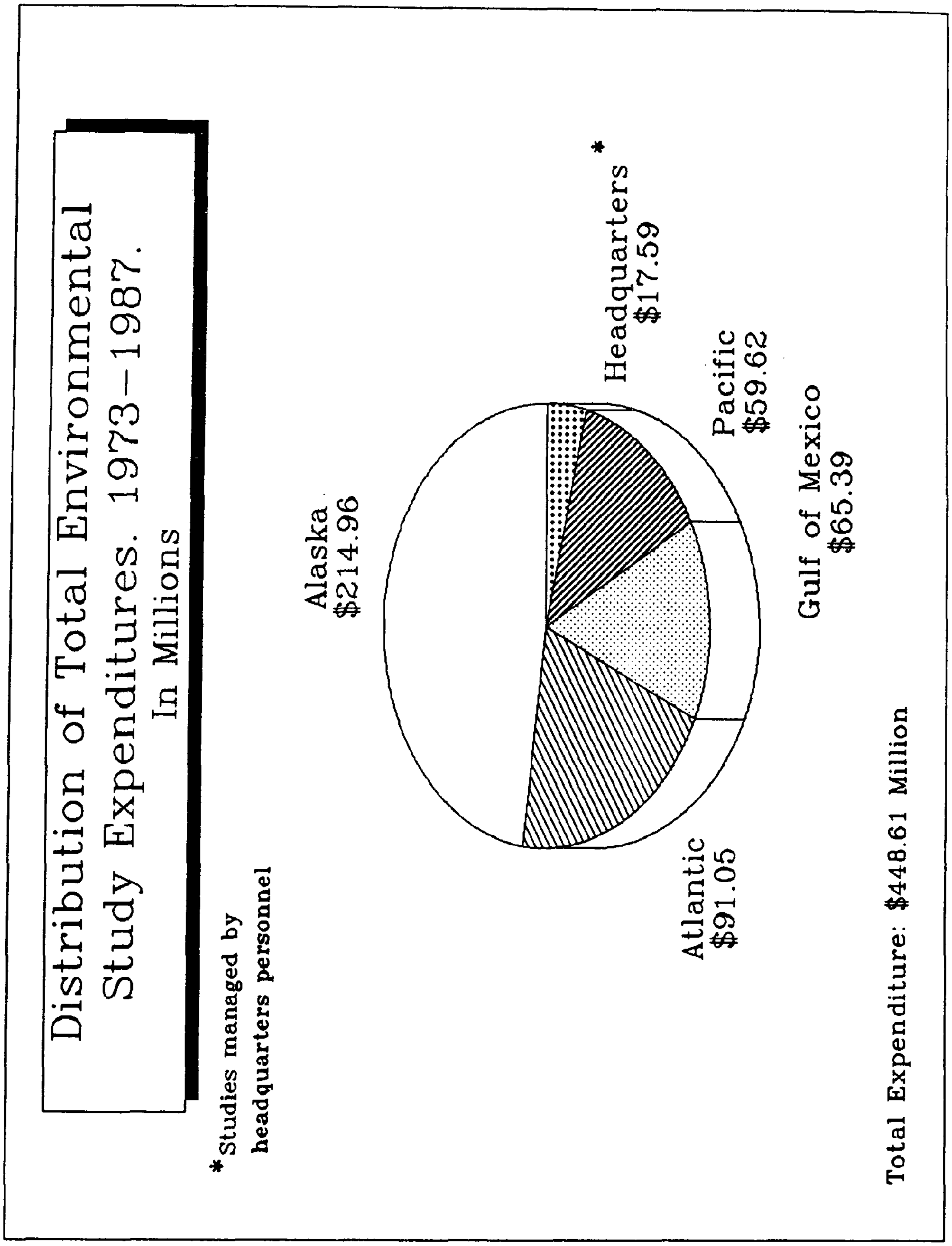

Figure II-1. Total environmental studies expenditures by OCS Region.

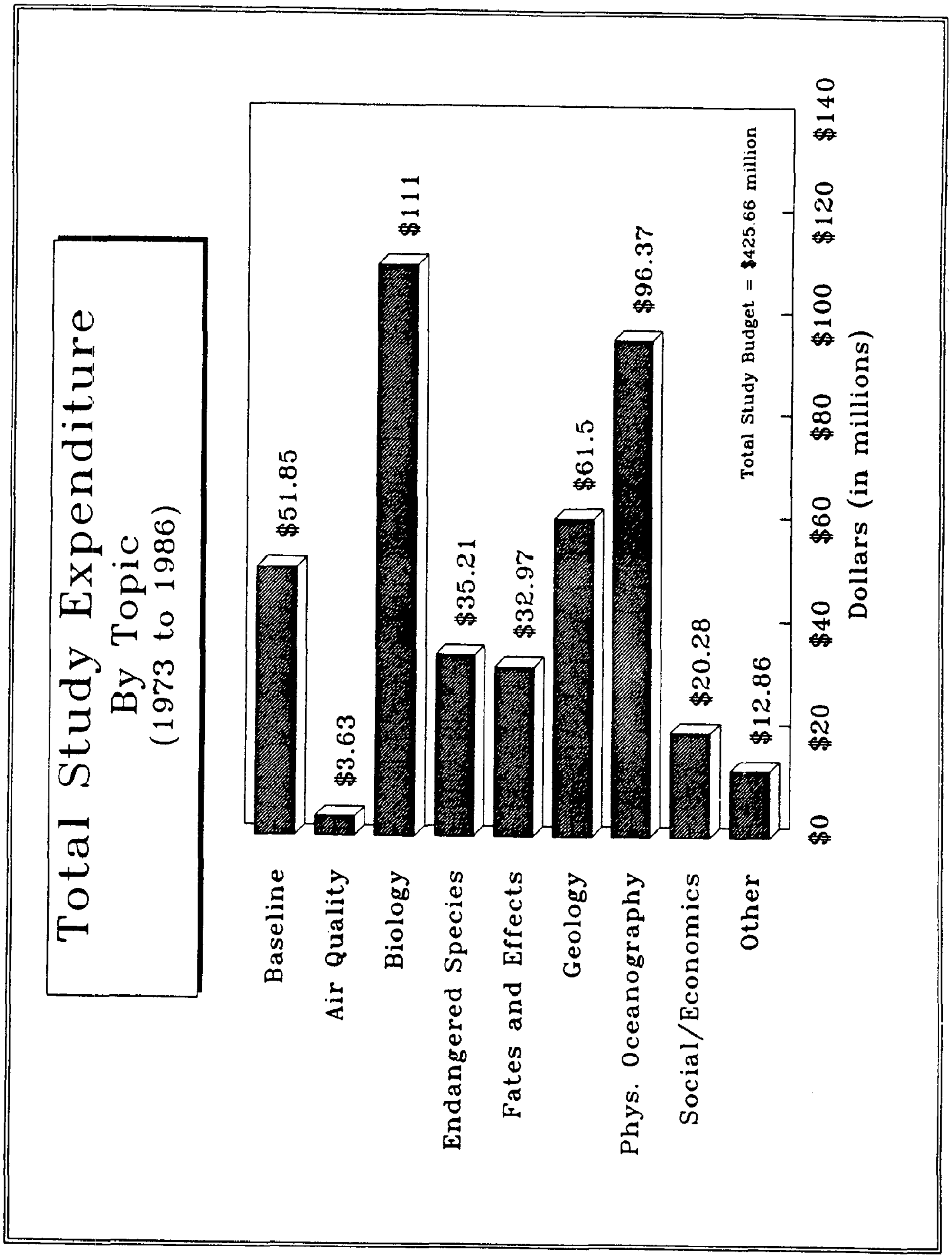

Figure II-2. Total study expenditure by topic.

Table II-1

Annual Environmental Study Expenditures by Region (millions)

Fiscal Year	Atlantic	Gulf of Mexico	Pacific	Alaska	HQ*
1973	0	0	0	0	0.37
1974	0	1.21	0.12	0	0.06
1975	2.88	5.72	4.58	9.97	0.92
1976	13.78	4.40	6.44	28.97	2.01
1977	9.35	7.57	4.86	21.56	1.48
1978	11.71	5.60	1.18	20.69	1.73
1979	5.14	2.86	4.64	18.11	0.55
1980	8.33	7.17	3.49	25.28	0.45
1981	9.24	4.84	3.15	19.63	0.65
1982	7.84	3.88	3.81	14.19	1.24
1983	7.84	5.48	5.20	13.18	1.86
1984	5.17	4.00	5.09	13.12	1.40
1985	5.37	4.17	3.85	11.38	1.52
1986	2.51	2.96	7.90	10.34	1.69

*Headquarters - Washington Office

E. Coordination with Federal Agencies, State Agencies, and local Governments

Coordination with other governmental agencies at all levels occurs both formally and informally. Formal mechanisms exist through compliance with the many laws that govern the OCS. Leasing and operation activities on the OCS are also subject to the requirements of some 30 Federal laws administered by numerous Federal Departments and Agencies. Among them are the following:

National Environmental Policy Act of 1969, which established requirements for preparing environmental assessments and EIS's for major Federal actions that could significantly affect the quality of the human environment.

Endangered Species Act of 1973, which requires that Federal Agencies ensure that their actions are not likely to jeopardize the continued existence of any threatened or endangered species.

Marine Mammal Protection Act of 1972, which provides for protection of marine mammals.

Coastal Zone Management Act (CZMA), which provides for State review of exploration plans and development and production plans that affect the land and water uses of the coastal zone. The Act requires consistency of Federal activities with federally approved CZM plans.

Federal Water Pollution Control Act, (commonly known as the Clean Water Act), which requires that pollutants generated by OCS operations and discharged into waters comply with the limitations and restrictions that are included in an applicable National Pollutant Discharge Elimination System (NPDES) permit.

Ports and Waterways Safety Act, which protects navigational safety.

Deepwater Port Act of 1974, which delegates to the Secretary of Transportation the regulation of ports and terminals handling oil for transportation.

National Historic Preservation Act, which requires the preservation of historic properties. To comply with the Act, the MMS has developed a program to protect archaeological resources on the OCS such as historic shipwrecks.

In addition, many sections of the OCSLA require coordination with affected States. The MMS has issued regulations (30 CFR 250.57) to ensure that emissions from OCS facilities do not significantly affect the onshore air quality of any State. Section 8(g) requires coordination between DOI and coastal States whenever a leasing proposal includes lands within 3 mi of State waters. Section 18 requires significant participation of affected States, Federal

Agencies, and the public during the development of a 5-year leasing program. Section 19 provides the framework for coordination and consultation with affected States and local governments for each proposed lease sale. Section 26 requires the Secretary of the Interior to provide the affected States with indexes and summaries of data to aid them in planning for the onshore impacts of OCS oil and gas activities. Other coordination mechanisms have been developed through the adoption of Memoranda of Understanding or Agreement with Federal Agencies and States.

The OCS Advisory Board was established in 1975 to provide a formal mechanism for the DOI to receive advice and recommendations from, and to provide a forum for, coastal States, various Federal Agencies, and public and private-sector representatives affected by or interested in minerals development of the OCS. The following three groups comprise the OCS Advisory Board: (1) the OCS Policy Committee, (2) the Regional Technical Working Groups (RTWG's), and (3) the Scientific Committee. This three-part structure provides for specialized consideration of the policy, technical, and scientific aspects of the OCS Program.

The Policy Committee of the board advises the Secretary of the Interior and other officers of the DOI, through the Director of the MMS, in the performance of its responsibilities under the OCSLA, including all aspects of leasing, exploration, development, production, and protection of the OCS resources. The Policy Committee represents a public forum wherein parties, both public and private, that are affected by OCS oil and gas activities may discuss policy issues with the responsible DOI officials.

The RTWG's advise the Director of the MMS, through the Regional Directors, on technical matters of regional concern regarding prelease and postlease activities. The roles of the RTWG's range from providing public participation opportunities for discussing technical issues and multiple-use concerns regarding offshore mineral activities to providing for technical review of the various MMS OCS Program documents and recommending future environmental studies.

Finally, the Scientific Committee advises the Director of the MMS on the feasibility, appropriateness, and scientific value of MMS's Environmental Studies Program. The committee reviews the information produced by the program and may recommend changes in the program's scope, direction, or emphasis. The membership of the Scientific Committee reflects a balance of scientific and technical disciplines considered important to the management of the ESP.

III. ACTIVITIES ASSOCIATED WITH EXPLORATION, DEVELOPMENT, AND PRODUCTION

A. Geological and Geophysical Investigations

The MMS, under the authority of 30 CFR Part 251, issues permits for reconnaissance for mineral resources and scientific research on the OCS. These activities include geophysical investigations (magnetic, gravity, electrical, sidescan sonar, and seismic surveys) and geological investigations (bottom sampling, coring, and test drilling operations). During FY 1986, the MMS acquired 48,681 line miles of geophysical data, down 32 percent from FY 1985. There were a total of 205 G&G permits issued in FY 1986, with 19 for Alaska, 4 for Atlantic, 166 for the GOM, and 16 for the Pacific.

1. Geological Surveying

Surveys to measure the earth's gravity field are conducted aboard ships to obtain a conception of gross geological features of the solid earth beneath the sea bottom of the OCS (e.g., the presence of large sedimentary basins and a measurement of the average density of a rock formation). Similarly, aerial surveys to measure the earth's magnetic field are conducted to detect anomalies that may reveal geological features of economic or other interest. These two survey methods provide information on how physical properties of the earth's upper crust vary vertically and laterally beneath large areas of the OCS.

The seismic reflection method involves creating seismic waves and measuring the travel time of the waves reflected from differing rock types. It is by far the most common geophysical survey method employed for mapping geological structures on the OCS. Although seismic surveys generally do not provide information on earth properties to as great a depth as gravity and magnetic field surveys, they do provide more detailed information on the distribution of geological boundaries at depth and a better resolved image of the subsurface.

In a typical seismic survey on the OCS, an array of seismic sources (sound wave generators) are towed behind a ship at a controlled depth. A streamer consisting of a cable and arrays of pressure-sensitive hydrophones grouped along the length of the cable is towed further behind the ship. The hydrophone streamer is typically 2 to 3 mi in length. Seismic waves generated by the energy sources reflect off the seafloor and at varying depths below the seafloor to the sea surface where they are detected by the hydrophones. Electrical signals generated by hydrophones are then transmitted to the survey ship where total travel times and other properties, such as amplitude and phase, of the seismic signals are recorded on magnetic tape.

After initial field data processing aboard ship and more extensive processing on shore, these recordings are displayed in the form of vertical cross sections. These seismic sections are then interpreted to identify structural features that may act as potential hydrocarbon traps, such as sediments that are arched, folded, faulted, or intruded by igneous rocks or by plastic-like sediments such as salt. Seismic sections are also used to identify stratigraphic traps as potential reservoirs. For example, an area can be identified where oil and gas are kept in place due to a change in the grain sizes of sediments or where a porous rock containing hydrocarbons thins out horizontally between layers of impermeable rock to block the route of fluids.

Travel times of the seismic waves are converted to depths to reflecting horizons by multiplying the travel time by the velocity of the seismic waves in the rocks. Thus, seismic sections can also provide information on the thickness of the various strata of sediments and the depth to drill to prospective locations in the subbottom.

In the early years of offshore exploration, seismic waves were generated by explosive charges detonated in the water column. Because of the hazards of explosives to the seismic ship, crew, and marine life, new equipment and methods evolved over the years to eliminate the need for dynamite or similar explosives in virtually all cases. Tests of the more modern seismic sources have shown little or no effect on marine life, the water column, or the sea bottom.

Other geophysical methods used on the OCS include electric surveys, which measure natural and artificially induced electric fields, and sidescan sonar, which maps the seafloor locating physiographic features (such as sand waves, rock outcrops, and mud slides) and manmade features (such as pipelines, shipwrecks, ordnance, and cables).

2. Geological Sampling and COST Wells

To gather physical samples, which can be analyzed to assess the likelihood of oil and gas, or other bottom data useful for engineering and geological purposes, several methods may be employed. These methods are divided into three types: seafloor sampling, core and shallow drilling operations, and deep stratigraphic drilling operations.

a. Seafloor Sampling

Seafloor sampling uses devices such as a grab, drag, or dart to acquire a small sample of bottom sediments. Bottom samples provide information necessary to determine engineering properties and basic scientific information on the bottom sediments.

b. Core and Shallow Drilling Operations

Core and shallow drilling operations are conducted to obtain information such as the lithology and geological age of the sediments, engineering properties, and stratigraphic correlations. Core and shallow test drilling can penetrate no more than 50 ft of consolidated rock or a total of 300 ft into the sea bottom, pursuant to 30 CFR Part 251.

c. Deep Stratigraphic Drilling Operations

Deep stratigraphic drilling operations, using either rotary or core drills, are those that penetrate more than 50 ft of consolidated rock or more than 300 ft into unconsolidated sediments. These holes are drilled on unleased lands to obtain regional geologic information as opposed to other wells that are drilled on leased lands to find oil and gas. (Deep stratigraphic tests are also known as COST wells.) A geological permit for mineral exploration or scientific research must be obtained from the appropriate MMS Region before conducting geological surveys on the OCS. A drilling permit is required for COST wells, in addition to a geologic permit for mineral exploration or scientific research.

B. Exploration

1. The Exploration Process

The lessee begins the exploratory phase of lease operations based on judgments about the hydrocarbon potential of the lease, the availability of rigs, and various commercial factors. As an initial step, the lessee conducts preliminary activities such as geological, geophysical, cultural, and biological surveys, which provide data necessary to develop a comprehensive exploration plan and an environmental report. The lessee then submits the exploration plan and environmental report to the MMS for approval. The exploration plan describes the proposed exploratory activities in detail including oil-spill contingency plans. The environmental report contains additional information pertaining to support facilities and activities and environmental aspects of the proposed operations. These documents form the basis of an environmental analysis, which the MMS performs as part of its review procedure.

Concurrent with MMS's technical and environmental review, the exploration plan and environmental report are forwarded for review to other Federal Agencies, Governors of all affected States, and other State agencies. The State review includes coastal zone consistency review pursuant to the CZMA. In addition, the exploration plan and environmental report are made available for public review and comment.

Although the MMS approves an exploration plan, actual drilling cannot begin until the lessee has submitted and received approval of an APD which is required for each well drilled. The APD includes extensive detail about the drilling program, with an emphasis on operational safety and pollution prevention. It is not approved until State concurrence with the coastal zone consistency certification is received (or conclusively presumed).

The objective of the exploration phase is to discover oil or gas in commercial quantities. To accomplish this, the lessee will drill one or more wells from drilling units that can be categorized as (1) mobile (floating) units such as drillships, semisubmersibles, and drilling barges, and (2) bottom-founded units that are floated to the drill site but rest on the seafloor during drilling operations. Drilling units in the latter category are jack-ups and submersibles. In arctic regions, wells are often drilled from gravel or ice islands or specially designed units, such as the concrete island and the mobile arctic caisson. A well generally will take from 1 to 6 months to drill. Once the lessee knows the results, the well will be plugged and the drilling equipment moved to a new site.

2. Rig Emplacement and Artificial Islands

Exploratory operations usually involve the use of drilling rigs, support vessels, and helicopters. These operations are typically of short duration--generally 4 months or less per site. Three types of drilling rigs are generally used for exploration in ice-free waters: jack-up rigs, semisubmersible rigs, and drillships. In areas subject to heavy sea ice, such as in the Beaufort Sea off Alaska, artificial islands are sometimes constructed to furnish a stable platform for drilling.

a. Jack-Up Rigs

The typical jack-up rig is towed by boat to the drilling site with the legs of the rig retracted--that is, extending upward out of the water. When the rig is positioned over the drill site, the legs are jacked down to the seafloor, and the deck is elevated above the water level to escape wave action.

b. Semisubmersible Rigs

The semisubmersible rig is towed (some are self-powered) to the site and then partially submerged to create a stable platform. The rig is moored with lines and anchors, which may extend out a mile or slightly more in some cases. A small number of these rigs have dynamic positioning capabilities and do not require anchors.

c. Drillships

A drillship is a self-propelled vessel with a hole through the hull for drilling operations. It is usually moored in place by anchors, although, especially in deep water, drillships hold their position over the drilling site by using a system of motor-driven propellers called thrusters (i.e., a dynamically positioned drillship). Operation in ice usually requires the assistance of ice-breaking support vessels.

d. Artificial Islands

Several artificial islands have been constructed as bases for exploratory drilling operations offshore Alaska. Usually these islands have been constructed of sand and gravel, which are transported over ice in the winter. The material is then dumped at the desired location to form an artificial island. During ice-free periods, islands can be constructed by dredging material from the sea bottom and delivering it to the site by barge or, if the dredge is working nearby, by pipeline. A recent improvement in the island building technique involves the use of a caisson into which the sand and gravel are pumped. This improvement leads to considerable savings in material and less disturbance in the area where the gravel is collected. Islands composed of ice and sunken barges have also been used in shallow water.

e. Movable Units for Use in the Arctic

Another type of drilling platform is referred to as a Mobile Arctic Drilling Unit. These are ice-strengthened mobile units that can be moved from location to location. An example is the Concrete Island Drilling System.

3. Drilling

Regardless of the type of drilling rig that is used, the drilling methods are similar. A drilling derrick is located on the vessel, rig, or island. A drill bit is attached to hollow drill pipe and rotated by an engine (or, in some cases, an electric motor). The rotation of the drill bit fractures the subsurface rock into chips (cuttings). As the drilling progresses, drilling fluids are circulated through the drill pipe and bit to remove cuttings from the bottom of the hole, to lubricate the drill string, to provide hydrostatic pressure to prevent the flow of formation fluids into the well bore, and to support and seal the sides of the well. Although in some cases drilling muds and cuttings are barged ashore, in most cases they are discharged directly from the drilling rig into the water under NPDES permits. As the well progresses, the sides of the hole are supported by installing steel casing. Blowout preventers are attached to the casing to close off the well in an emergency situation, such as an unexpected change in well pressure.

C. Development and Production

1. The Development and Production Process

When an oil or gas reservoir has been discovered and its extent determined through delineation drilling, the lessee may begin the development and production phase of operations. A development and production plan, including an oil-spill contingency plan and an environmental report, is prepared by the lessee and forwarded by the MMS to all affected States, State coastal agencies, and interested

Federal Agencies for review. The review process is similar to that for the exploration plan. An environmental assessment is then prepared. If the MMS determines that the approval of the development plan would constitute a major Federal action that would significantly affect the quality of the human environment, an EIS is prepared. Under the OCSLA, at least one production plan in each frontier area must be declared a major Federal action and an EIS prepared. Actual drilling cannot begin until the development and production plan has been approved. There also must be an approved APD for each proposed well. State concurrence for the coastal zone consistency certification--which is submitted by lessees for their development and production plans--must either be obtained or conclusively presumed.

Development and production entail installation of a platform or other production system. In addition, onshore support facilities must be constructed if they do not already exist. The oil and gas produced offshore are separated and moved to shore for final processing. Gas is transported by pipelines, whereas crude oil is moved by pipeline, barge, or tanker to shore facilities. All platform and artificial island installations, pipelines, and platform facilities, require MMS approval.

A production platform may accommodate from 1 to almost 100 production and injection wells and will remain in place for the life of the reservoir or field, which could be over 30 years.

During the productive life of a field, the lessee conducts well workover or repair operations to maintain a high production level. Such operations usually require MMS approval. Throughout the drilling and production phases, the MMS inspects the operations to assure compliance with regulations. This inspection further assures operational safety and pollution prevention. Also, MMS requires drilling personnel involved with well control to attend training given at MMS-certified schools.

The MMS also grants suspensions of production; sets maximum rates of production; estimates reserves; approves unit, pooling, and drilling agreements, when applicable; and approves applications for permission to install pipelines both on and off a lease.

When a field can no longer be economically produced and the lease expires, the lessee, with MMS approval, must plug and abandon all wells and remove all equipment from the lease, including the platform and any subsea devices.

2. Platform Emplacement

Offshore development and production activities are usually carried out from fixed-leg platforms that form an above-water, stable working area. Platforms consist of a deck (or decks) where drilling, production, and other activities occur, supported by legs and cross members that are driven into the sea bottom. Platform legs are normally constructed onshore, barged to the final location, and sunk into position. Pilings are driven through the legs to secure the base, then the upper working structure is welded on. Some platforms in deeper waters may require stabilizing because of their heights; for example, in one case, anchors were driven into the seabed and connected to the platform by cables.

3. Drilling

Once a platform is installed, several wells are drilled from a single platform to develop the surrounding area. On the OCS, as many as 67 wells have been drilled from a single platform; however, the average number is slightly more than 4. This average is highly influenced by the smaller number of wells per platform in the GOM. The average number of wells drilled per platform is 40 in the Pacific Region. The drilling procedures are similar to those discussed above in the section on exploration.

4. Discharge of Production Formation Water

Petroleum reservoirs often have water associated with the produced oil and gas that are brought to the surface. The amount of this produced water depends on the method of production, field characteristics, and location. As oil and gas production from a reservoir declines, most wells produce increasing amounts of water. The age of the production field, therefore, can impact the quantity of water generated.

5. Pipeline Construction

There are several types of vessels used for offshore pipelaying operations. The most common is the pipelaying barge on which the pipe sections are welded together and laid in a continuous string from the center or side of the barge. Newer variations to the pipelaying barge include semisubmersible vessels, ship-shaped vessels, and reel barges (which use reels of pipe rather than welded, straight sections).

Barges are anchored to hold them on site. The barge winches itself forward allowing the pipestring to slide off the barge and sink to the seafloor. Periodically, the anchors must be reset as the pipeline advances.

The pipelines are usually placed in trenches to protect them from the forces of currents and wave action in shallow water and to minimize impacts on fish trawling activities in trawling areas. In the surf and beach zone, pipelines are usually pulled into a prepared trench and covered to restore the area to its original configuration. Pipelines coming ashore and crossing wetlands use specialized technologies that include the single ditch, double ditch, and flotation canal methods.

6. Platform Removal

At the end of their useful life, platforms are removed, and the surrounding seafloor is cleared of obstructions. Current technology available for platform removal includes bulk explosives, shaped explosive charges, mechanical cutters, and underwater arc cutters. The use of bulk explosive charges has been the most common procedure (about 90 percent). With this method, the pilings of the platform are blown off below the seafloor, and the platform is loaded on barges for transportation away from the site.

IV. POTENTIAL IMPACTS OF OCS OIL AND GAS ACTIVITIES

The possible impacts discussed in this chapter are considered potential impacts and are based on research; experience in offshore oil and gas technology; and, in some cases, knowledge derived from actual events. It is important to note that many of these impacts have not occurred as a result of the OCS oil and gas program, but the descriptions of the effects are described to assist the reader in understanding perceptions about offshore activities.

A. Fate of Oil in the Marine Environment

The nature of impacts from oil spills in the marine environment depends largely on the nature and proportion of the oil's chemical components (e.g., hydrocarbons present) and on the changes in this composition as the oil weathers. Weathering ("aging") processes, in turn, largely depend on oceanographic and meteorologic conditions at the time of the spill (and after the spill).

Petroleum hydrocarbons include three major components: the alkanes, or aliphatic hydrocarbons, consisting of the fully saturated normal alkanes (paraffins) and branched alkanes; the cycloalkanes, or saturated ring structures, also called cycloparaffins or napthenes; and the aromatic compounds containing one or more benzene rings connected as fused rings (e.g., napthalene) or lined rings (e.g., biphenyl) (National Academy of Science (NAS), 1985). Crude oils from different sources can differ appreciably in percentage composition of the various hydrocarbon fractions. Consequently, the possibilities for combined chemical types are enormous, resulting in extremely complex mixtures of varying toxicity.

Nonhydrocarbon components of oil, which include compounds containing sulfur, nitrogen, oxygen, and trace metals, generally range from 0 to 15 percent. Trace metals are present in very small concentrations in the parts per million (ppm) range, with nickel and vanadium usually found in the largest proportion, and cobalt, mercury, iron, and manganese present in smaller amounts (Connell and Miller, 1980).

Weathering involves a number of physical and biochemical processes, which change the chemistry and reduce the concentration of oil in the environment. These processes include evaporation, dissolution, dispersion, emulsification, sedimentation, photo-oxidation, and biodegradation. Any or all of these processes can be expected to affect any spilled oil. Eventually, a tarlike residue will be left, which will break up into tar lumps or tar balls. Types of weathering processes and transport pathways of spilled oil at sea are depicted in figure IV-1; their relative importance is shown in figure IV-2.

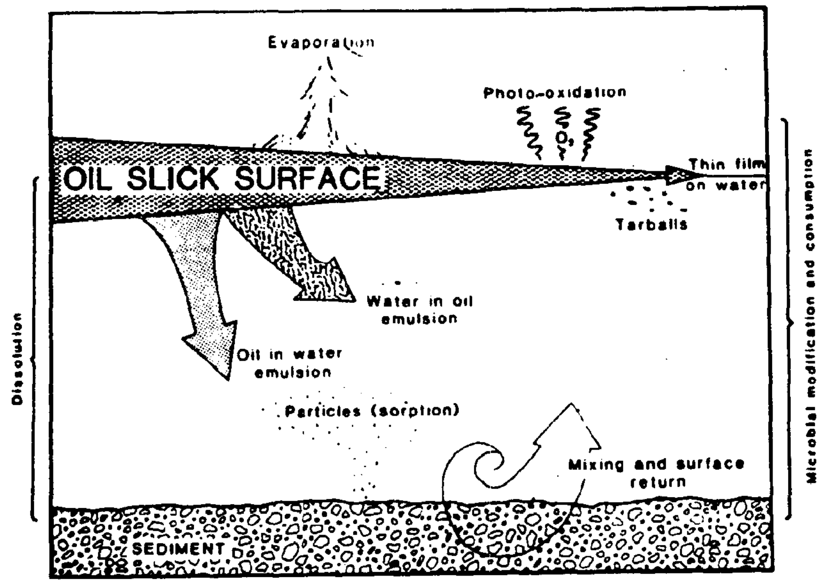

Figure IV-1. Schematic representation of weathering processes and transport paths of spilled oil at sea, adapted from Clark and MacLeod, 1977 (Boehm, 1982).

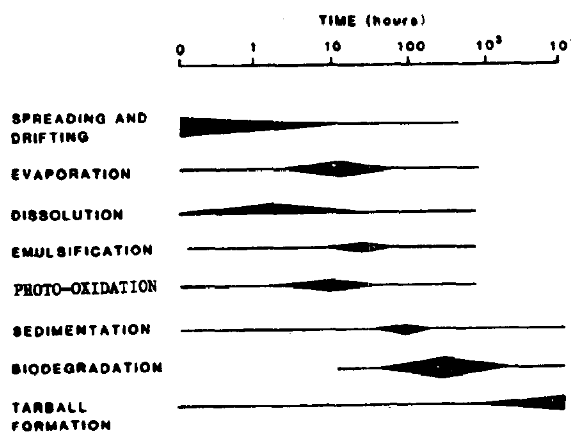

Figure IV-2. Relative importance of various processes affecting oil. Line length is the probable time span of a process; line width is the relative magnitude of the process. Composite figure, from figures in Koons and Wheeler (1977) and Wheeler (1978) presented in Lee (1980) and Mackay et al. (1983).

After the discharge of oil into water, a surface slick forms because of the low solubility of most oil components. Currents, waves, and winds then actto spread the oil slick into thin films (Lee, 1980). The extent of spreading also depends greatly on the physical and chemical nature of the particular oil (NAS, 1985).

Evaporation of the more toxic and volatile, lower-molecular-weight hydrocarbons (e.g., benzene, toluene) from the surface film would begin immediately after oil is spilled. The amount of oil that would evaporate depends on the extent of spreading, temperature, wind speed, solar radiation, and composition of the oil. Within a few days, evaporation could remove up to about 50 percent of the oil, depending on environmental conditions (e.g., rough seas would tend to increase evaporation rates) (NAS, 1985). For the IXTOC I blowout offshore Mexico, oil evaporated immediately after escaping from the well, resulting in a nearly equivalent loss of saturated and aromatic hydrocarbons (Boehm et al., 1981; Golob and McShea, 1981). After the North Sea Ekofisk Bravo blowout, 35 to 40 percent of the lighter hydrocarbon components of the oil evaporated immediately. After 12 hours, 50 percent had evaporated, and after 15 days, 68 percent had evaporated (Haegh and Rossemyr, 1980). Similarly, after the Amoco Cadiz spill off the coast of Brittany, France, evaporation was an important weathering process for all the low-boiling components of the oil, including aliphatic and aromatic compounds (Jordan and Payne, 1980). Also, Martec (1984) estimated that 75 percent of the condensate emitted during the Uniacke G-72 incident (offshore Sable Island, Canada), which consisted of gas and gas concentrate from an above-surface blowout, evaporated during the first 24 hours of the incident.

Dissolution of the low-molecular-weight, more toxic, and soluble hydrocarbons would occur simultaneously following a spill. However, since only about 1 to 5 percent of spilled oil generally goes into solution, evaporative processes would still predominate in the removal of hydrocarbon components from seawater. The rate of dissolution for the various hydro-carbon components would depend on complex interactions between properties inherent in the oil and environmental factors (e.g., turbulence, salinity, temperature). Generally, dissolution would be a significant process only within the first several hours after a spill.

The ultimate loss from the spilled oil by evaporation and dissolution for the IXTOC I, Uniacke G-72, and Bravo blowouts was close to 70 percent; components up to n-C14 were not detected. Although components up to n-C22 were relatively reduced, some of this loss may have been a result of photochemical and microbial degradation (Haegh and Rossemyr, 1980).

In addition to dissolution, the mechanisms that may also act to incorporate spilled oil into the water column include dispersion, sinking, and sedimentation.

The agitation of oil slicks by wave action and the action of the surf supply the energy to form small droplets of stable emulsions from 5 micrometers to several millimeters in size. Such droplets are then pushed into the water column and dispersed. Dispersion of a surface slick is an important process in determining the lifetime of the slick. The formation of droplets increases the surface area of the oil, thereby increasing the rates of physical, chemical, and biological processes affecting the weathering of the oil.

The insoluble heavier hydrocarbon components of spilled crude oil can disperse to form oil-in-water or water-in-oil emulsions. Oil-in-water emulsions can be rapidly dispersed by currents to undergo enhanced microbial degradation provided by the oil's increased surface area. After the IXTOC I spill, oil dispersed into such droplets in the water column to a depth of 12 meters (m) (Golob and McShea, 1981).

Water-in-oil emulsions, also known as "mousse," are more coherent and weather slowly because of the relatively small proportion of water and the limited supply of oxygen necessary for microbial degradation (Connell and Miller, 1980; NAS, 1985). This stable emulsion, which forms from within a few hours to a few days after an oil spill, floats on the water surface and eventually can be carried ashore by wind and waves. If there is strong, turbulent mixing, it could be driven into the water column.

Water-in-oil emulsions are likely to cause biological harm in the form of physical (mechanical) effects, while oil-in-water emulsions may cause chemical (toxic) effects. Oil in dispersed droplets exhibits slightly less toxicity than the water-soluble fraction. Consequently, although high-molecular-weight aromatics are least degraded in oil and show high toxicity in laboratory tests, the relative toxicity of the lower boiling aromatics may be more important because of their solubility in water.

Shortly after contacting the sea surface, oil from both the IXTOC I and Bravo blowouts formed viscous emulsions of approximately 70 percent water and 30 percent oil, similar to the emulsion formed following the Amoco Cadiz spill (Golob and McShea, 1981; Haegh and Rossemyr, 1980). Weathering of the latter oil mass was accelerated by the formation of a sheen in the surface microlayer of the mass, which then underwent a greater degree of evaporation and/or photo-oxidation than the underlying mass. However, oil injected into the water column remained there for significant periods of time (Boehm et al., 1981). Whether the oil remains entrained in the water column depends on droplet size, buoyancy of the oil, and water column hydrography. Oil spilled at or near the water surface would generally tend to remain in the surface layers of the water column. However, whole oil in the form of mousse or tar could become heavier than the surrounding water and sink until encountering a density or thermal boundary strong enough to inhibit penetration (Walter and Proni, 1980).

Under the circumstances of a subsurface release of oil, as may occur from a pipeline rupture or an undersea well blowout, a subsurface oil plume may form. Fiest and Boehm (1980) and Walter and Proni (1980) examined the characteristics of the IXTOC I blowout occurring at an approximate depth of 48 m (157 ft). They determined that a significant quantity of the oil released by the subsurface plume formed oil droplets suspended in a mixed layer at a depth of 5-20 m. The subsurface petroleum hydrocarbons, representing approximately 3 percent of the introduced oil, were trans- ported by ocean currents (Boehm and Fiest, 1982). An oceanic frontal system may have acted as a barrier to the lateral transport of the oil plume and may also have acted as a conduit for the subsurface movement of oil along the frontal axis. Within 5 kilometers (km) of the wellhead, the subsurface plume was made up of oil droplets greater than 0.45 microns and had petroleum hydrocarbon concentrations greater than 600 parts per billion (ppb). Such whole oil was found at concentrations greater than 20 ppb at 20-meter depths within 25 km of the well (Fiest and Boehm, 1980). Although there appeared to be other, unidentified processes controlling the movement of the surface slick, the subsurface plume was, for the most part, aligned with the surface slick.

Water samples taken from the IXTOC I subsurface plume were considerably enriched in light aromatic hydrocarbons relative to other aromatic components, presumably due to the presence of considerable quantities of soluble, solubilized, or colloidal material in the water. The fact that the subsurface oil could be characterized by a different chemistry and weathering regime implies that the subsurface oil was a "fresh" oil plume which had remained subsurface since its discharge and in which evaporative loss of aromatics was greatly decreased (Fiest and Boehm, 1980). Of particular importance is the fact that increased concentrations of some of the more toxic components appeared in the water column. The concentrations of individual hydrocarbons in the dissolved fraction (0.01-3 ppb), measured in the study by Fiest and Boehm (1980) on oil in the water column following the IXTOC I blowout, appeared to lie below the toxic range, even in the acute impact zone. However, the total concentration of waterborne, low-molecular-weight aromatics (alkyl benzenes and naphthalene compounds) in water fell in the 0.5-500 ppb range, and concentrations of total waterborne oil dispersions were in the 100-10,000 ppb range.

Absorption processes are characterized by oil associating with particulate material in the water column. For example, in the case of the IXTOC I blowout, in several instances, particulate-bound oil was found where surface slicks were not readily apparent (Payne et al., 1980). To explain this occurrence, it was hypothesized that once oil had been absorbed onto particulates, it was then subject to subsurface horizontal and vertical transport and could be transported a considerable distance before settling to the bottom. Payne et al. (1980) reviewed the literature and found that particulate/oil interactions are dominant processes in the ultimate disposition of petroleum.

Sedimentation processes within shallow areas could remove dispersed oil from the water column to the bottom by absorption into clays, fine-suspended sediments, or organic materials. Sedimentation would not be an important process in most open-ocean areas since these areas have relatively low concentrations of suspended particulates and dynamic oceanographic forces prevail. However, in coastal or other shallow areas where concentrations of suspended material are high, sedimentation would quickly remove dispersed oil. In addition, zooplankton fecal pellets have been found to transport ingested oil droplets to the bottom sediments (Geyer, 1980). Lee (1980) mentions that "The bottom sediments are the ultimate sinks for undegraded oil." However, just as sedimentation may remove oil from the water column, sediment resuspension (e.g., during a storm in shallow water) may, in turn, reintroduce the oil into the water column to some degree.

The processes discussed thus far distribute oil spilled within the marine environment into different phases (i.e., air or water) but do not actually degrade the oil. Degradation is accomplished primarily by photo-oxidation and microbial degradation.

Photo-oxidation involves energy from sunlight in the presence of oxygen transforming hydrocarbons into oxygenated compounds (e.g., carboxylic acids, benzoic acid, alcohols, ketones, phenols). Photo-oxidation would produce highly soluble end products in the water column below the slick. Some end products, however, have been found in the laboratory to be more toxic than the original products, and some (polycyclic aromatic hydrocarbons) have been found to be carcinogenic agents. Larson (1977), however, found that although fuel oil was photo-oxidized and produced toxic materials in the water phase, comparable tests on crude oil showed no photo-oxidation, presumably because of natural inhibitors in the oil (Lloyd, Shell Offshore Inc., personal communication, December 10, 1982). The production of toxic products as a result of photo-oxidation in the natural marine environment has not, as yet, been reported.

Because of the time needed for the initiation of microbial degradation of oil slicks, which generally have short lifetimes, it is assumed that microbial degradation is less important than other processes in removing an oil slick. However, once the oil is dispersed into fine droplets or particles in the water or deposited on sediment, microbial degradation becomes important (Lee, 1980). Microbial processes would transform hydrocarbons to more soluble oxidized products. Eventually, those compounds would be completely oxidized to carbon dioxide and water. However, following the IXTOC I spill, biodegradation was nearly inoperative in the open ocean. The primary reason appeared to be related to the low concentrations of nutrients in the underlying water (Atwood and Ferguson, 1982). In comparison, microbial degradation played an important role in the weathering of oil spilled during the Amoco Cadiz incident (Gundlach et al., 1983).

Finally, after evaporation and dissolution and after emulsification, photo-oxidation and microbial degradation act on an oil slick, the viscous residue remaining in the water would form tar lumps or balls in the water column. Tar balls generally contain higher molecular weight hydrocarbons and oxygenated sulfur-containing compounds (e.g., asphaltenes). As much as 0 percent of a crude oil spill could remain as such a residue. Since tar balls resist microbial degradation, their lifetime could be several months to years (Geyer, 1980).

Oil from the IXTOC I spill persists as tar reefs along the Texas coast. It has been estimated that 5 to 10 percent of the petroleum hydrocarbons existing as pelagic tar in the eastern GOM originated from IXTOC I. At least 50 percent of this pelagic tar is thought to have originated from the operational discharge of crude oil tanker washings (Oil Spill Intelligence Report, vol. VI, no. 24, June 24, 1983).

B. Oil Spills

Table IV-1 lists the number and volume of oil spills as a result of oil and gas operations on the OCS. The primary source of data is the OCS Events File of the MMS. Operators conducting oil and gas operations are required to report information regarding oil spills to the MMS through their respective OCS Region.

Table IV-1
Number and volume of spills reported to the Minerals Management Service each year for the OCS, by Region, 1966-1986, in barrels.

Year	Spills >1- 50 bbl Number	Spills >1- 50 bbl Volume	Spills 51-1000 bbl Number	Spills 51-1000 bbl Volume	Spills of >1000 bbl Number	Spills of >1000 bbl Volume
			Gulf of Mexico			
1967	--	--	1	65	1	160,638
1968	--	--	1	85	1	6,000
1969	2	100	5	855	2	10,032
1970	8	171	3	723	2	83,000
1971	267	1,331	7	1,110	0	0
1972	204	899	1	100	0	0
1973	178	856	2	334	3	21,935
1974	80	530	5	590	2	23,333
1975	109	495	2	266	0	0
1976	66	307	3	796	1	4,000
1977	71	462	3	620	0	0
1978	79	389	3	1,139	0	0
1979	114	654	3	546	1	1,500
1980	50	296	8	1,170	1	1,456
1981	65	365	4	328	1	5,100
1982	70	332	3	842	0	0
1983	91	613	9	1,939	0	0
1984	59	280	1	100	0	0
1985	66	419	5	1,194	0	0
1986	51	331	1	52	0	0
			Alaska			
1985	1	--	--	--	--	--
			Atlantic			
1978	1	2	--	--	--	--
1983	2	24	--	--	--	--
			Pacific			
1969	--	--	1	900	1	10,000**
1972	--	--	--	--	0	10,325
1973	--	--	--	--	0	1,825
1974	--	--	--	--	0	1,460
1975	--	--	--	--	0	1,460
1976	1	2	--	--	0	1,458
1977	1	4	--	--	0	1,458
1978	--	--	--	--	0	1,456
1979	1	2	--	--	0	1,456
1980	2	7	--	--	0	1,456
1981	10	75	--	--	0	1,456
1982	1	3	--	--	0	1,456
1983	4	25	--	--	0	912
1984	3	36	--	--	0	730
1985	3	9	--	--	0	365
1986	3	12	--	--	0	365

Data taken from the MMS OCS Events File as of 10/8/87.
Note: Spilled oil consists of processed, nonprocessed, unidentified oil and condensate. Those years where no spills were reported are not shown.

** Column shows initial spill for the Santa Barbara blowout of Platform A of 10,000 bbl for the first 10 days (January 1969) and the continual subsurface seepage. The 1972 figure includes seepage between 2/7/69 and 12/31/72.

Data on oil spills of 1 bbl (42 gallons) or less have not been included in this discussion for two main reasons: (1) It is not likely that such small spills will significantly impact the environment, and (2) It is difficult to determine the real volume of such small spills. Generally, spills of 1 bbl or less have run about 1,000 per year in the most active Region, the GOM. The long-term chronic effect of such spills may not be insignificant, but, to the present, data related to this concern are not conclusive (NRC, 1985). Chronic spills of this type are practically nonexistent in other Regions due mainly to limited OCS activity.

The Santa Barbara blowout of Platform A in January 1969 attracted much media attention. This was a subsurface blowout with seepage estimates of 10,000 to 71,500 bbl for the first 10 days. Seepage has continued, as indicated in table IV-1, with seepage declining to a current estimate of approximately 365 bbl per year. It has been, therefore, a continuous subsurface spill that is currently decreasing.

The Allan Hancock Foundation at the University of Southern California performed a series of yearlong studies to examine the effects of the Santa Barbara Platform A blowout on various trophic levels and habitats of the Santa Barbara Channel. All of the major areas of concern were studied. These included primary productivity, zooplankton, benthic fauna, sandy beaches, intertidal areas, fisheries, cetaceans, pinnipeds, seabirds, and the general ecology (Straughan, Dale, ed., 1971).

Significant mortality was suffered by bird populations (estimated at slightly over 3,600 by the California Department of Fish and Game), the intertidal barnacle Chthamalus fissus, the marine grass Phyllospadix torreyi, and the alga Hesperophycus harveyanus. Documented mortality suffered by other species or inhabitants could be attributed to other sources or to a combination of oil and other impacts. As of November 1970, less than 2 years after the initial spill, most intertidal areas appeared to have returned to a normal population status. The only sublethal effect was the reduction in breeding by the barnacle Pollicipes polymerus in localized areas.

1. Impacts of Oil Spills on the Coastal Environment

An oil spill that reaches shore will impact the coastline. Rocky shores may be coated with oil that will smother or otherwise damage much of the intertidal community. Recovery from this damage should begin within a year, especially in areas of moderate to high tidal activity. Sandy beaches may become coated with oil, and oil may penetrate and become lodged beneath the surface. Depending on the amount of oil, this coating would result in a loss of recreational use until the spill had been cleaned up. In cases of heavy contamination, beaches can usually be cleaned with heavy equipment such as earthmovers. Recovery time depends greatly on the intensity of wave action and grain size of the beach and, in some cases, the amount of sand removed (by bulldozer or other means) from a beach during the cleanup process. In estuaries, some floating oil will encounter suspended particulate matter and sink to the bottom. Exposed intertidal areas may become coated with oil. Vegetation in wetlands may become coated with oil and killed if oiling is severe. Persistence of oil in estuaries and wetlands varies from a single season to many years, the latter especially in a cold climate.

2. Impacts of Oil Spills on Water Quality

Water quality is altered and degraded by oil spills through the increase of, primarily, petroleum hydrocarbons (alkanes, cycloalkanes, and aromatic compounds) and their various transformation/degradation products. The extent of impact from a spill depends on the behavior and fate of oil in the water column (e.g., movement of oil and rate and nature of weathering) which, in turn, depend on oceanographic and meteorological conditions at the time. The impacts of the spilled oil also depend on the types of organisms and habitats affected.

The fate and effects of spilled oil from OCS operations have been reviewed recently by NAS (1985) and Boesch and Rabalais (1985). Instances where spilled oil was extensively distributed throughout the water column (e.g., the IXTOC I wellhead blowout, a non-United States operation) and where it persisted in the water in high concentrations for months (e.g., Amoco Cadiz tanker grounding) have been noted (Boehm and Fiest, 1982; Teal and Howarth, 1984). However, no extensive and long-lasting impacts on water quality specifically resulting from United States OCS oil and gas operations have been identified.

3. Impacts of Oil Spills on Marine Biota

Short-term effects resulting in biological loss occur from an oil spill by direct kill through coating and asphyxiation; by contact poisoning or incorporation of water-soluble carcinogenic or mutagenic components of the oil; or by destruction of the generally more sensitive juvenile forms of organisms or of the food source of higher trophic species; and by modification of habitats, delaying or preventing recolonization (Blumer, 1971).

4. Impacts of Oil Spills on Lower Trophic Organisms

Lower trophic organisms considered in this assessment include phytoplankton, zooplankton, and benthic invertebrates. Potential impacts of spilled oil on phytoplankton, as summarized by NAS (1985), include direct mortality, depression of photosynthesis, and inhibition of growth. At low concentrations of oil, however, phytoplankton growth may be enhanced (Gordon and Prouse, 1973). This enhancement most likely is the phytoplankton's response to low levels of a pollutant that triggers an increase in the rate of reproduction. To date, there have been no reports of mass toxicity to phytoplankton in the marine environment caused by spilled oil or chronic oil input (NAS, 1985). Effects of oil on zooplankton include direct mortality due to lethal toxicity or physical coating, abnormal development of fish embryos, lowered feeding and reproductive rates, and abnormal metabolic rates (NAS, 1985). Such effects, however, are not significant on a population or community level in the open waters of the OCS where the zooplankton quickly recover because of their wide distribution and rapid regeneration rates (NAS, 1985). Potential impacts of oil on benthic invertebrates include mortality due to smothering, lethal toxic effects, and sublethal toxic effects such as altered metabolism, feeding, and reproductive rates (NAS, 1985). Intertidal and shallow subtidal invertebrates, especially those in low-energy environments such as lagoons, marshes, and estuaries, are more vulnerable to potential oil-spill impacts due to elevated oil concentrations likely to be encountered in these environments following an oil spill (NAS, 1985). There is evidence that benthic invertebrate populations may be perturbed by spilled oil for several years (Elmgren et al., 1983; and Gilfillan and Vandermeulen, 1978).

Although some researchers have speculated that arctic or polar species may be more sensitive to petroleum hydrocarbons than temperate species, there is no evidence that such differences exist (NAS, 1985). Polar organisms demonstrate the same variability in sensitivity to petroleum hydrocarbons, over the same concentration range, as organisms from other latitudes (Percy, 1981).

5. Impacts of Oil Spills on Birds

Birds that spend much time on the sea surface (e.g., shearwaters, cormorants, seaducks, and alcids) are especially vulnerable to oil spills (King and Sanger, 1979). Mortality results primarily from hypothermia (excessive heat loss), as oil mats the plumage destroying the thermal barrier. Direct contact by birds with oil of appreciable amounts is usually fatal. Information on mortalities of birds resulting from 12 separate oil-spill incidents (none are OCS related) is summarized in Oil in the Sea (NAS, 1985, p. 433).

Abnormalities in bird reproductivity, physiology, and behavior resulting from ingestion of oil (Hartung and Hunt, 1966; Stickel and Dieter, 1979; Ainley et al., 1981; Holmes, 1984; Peakall et al., 1981; and Gorsline and Holmes, 1982) potentially could have substantial adverse effects on egg production in seabird and waterfowl populations. In addition, transfer of oil from adults to eggs results in reduced hatchability, increased incidence of deformities, and reduced growth rates in young (Grau et al., 1977; Albers, 1978; and Szaro et al., 1978). Holmes et al. (1978) have shown that stress from ingested oil can be additive to ordinary environmental stress (e.g., low temperature). Presumably, the effects of oiling would be also more severe when birds are in environmental stress (e.g., insufficient food supply) or physiological stress (e.g., molting).

6. Impacts of Oil Spills on Fish

Adult pelagic fish are, for the most part, able to avoid spilled, floating oil in open-water areas by swimming away from the affected region. However, other stages of the fish life cycle are more susceptible to acute biological loss. Fish eggs and larvae are vulnerable to oil damage in the open-water environment as they float along. Teal and Howarth (1984) have reported fishkills, mortality of fish eggs and larvae, spawning inhabition, slower growth rates, and declines in fish catches in areas of major oil spills. Spills reaching nearshore bays, and spawning or breeding grounds, could have serious detrimental effects (NAS, 1985). In 1987, a tanker spill in Cook Inlet (not OCS related) caused a shut down of a large portion of the salmon fishing district. Additionally, large amounts of oil tainted salmon were destroyed by the Alaska Department of Environmental Conservation. However, there is no evidence that commercially important fish stocks have been significantly affected by spills or chronic oil pollution. The effects may be masked by natural fluctuations in popula tions and our present crude stock assessment methods (NAS, 1985).

According to Evans and Rice (1974), the impacts on fishery resources from oil pollution are (1) killing organisms through coating and asphyxiation; (2) killing organisms through contact poisoning; (3) killing organisms through exposure to water soluble toxic components of oil at some distance in space and time from the accident; (4) destroying the generally more sensitive juvenile organisms; (5) destroying sources of food and shelter; (6) incorporating sublethal amounts of oil and oil products into organisms (resulting in reduced resistance to infection and other stresses); (7) incorporating carcinogenic and potentially mutagenic chemicals into marine organisms; and (8) introducing low-level effects that may interrupt any of numerous behavioral stimuli (such as prey location, predator avoidance, mate location, other sexual stimuli, and homing behavior) necessary for the propagation of the species and for those species higher in the marine food web.

The NAS (1985) has published a complete review and synthesis of information on the input, fates, and effects of oil in the marine environment. Summary information is also available in the review paper by Anderson et al. (1986) and the report edited by Boesch and Rabalais (1985). The MMS has conducted a number of relevant studies on this topic including laboratory and field experiments, literature reviews and syntheses, and numerical modeling studies.

The damage from an oil spill will depend on a number of factors, including (1) amount of oil spilled; (2) how much weathering the oil experiences before contacting fish, larvae, or eggs; (3) the depth at which the various life stages are found, since the concentrations and composition of oil decrease rapidly with depth; (4) how large an area is affected; and (5) the toxicity of the oil (refined products are generally more toxic).

7. Impacts of Oil Spills on Turtles

Offshore oil spills could seriously affect sea turtles, especially juveniles. Sea turtles must come to the surface to breathe and could contact floating oil. Some evidence indicates that sea turtles, especially juveniles, are transported by passive drift and are associated with density shear lines and sargassum weed. This association could prolong their exposure to a large oil slick transported in a similar manner. Sea turtles, especially juveniles, will snap at or attempt to swallow any object of appropriate size, such as tar balls. Ingestion of tar balls has been recorded and could result in mortality. The volatile, soluble, and tar fractions of an oil spill could affect the lungs of sea turtles, reducing ventilation and reducing time for feeding. Ingestion of oil could affect the gastrointestinal tract by reducing absorption. Oil coating of head and eyes could affect the orbital salt glands, which may upset many physiological processes. Oil spills contacting a turtle nesting beach during egg incubation or hatching periods could cause significant turtle mortality (Fritts and McGhee, 1981).

8. Impacts of Oil Spills on Marine Mammals

Direct contact with spilled oil may cause mortality in some marine mammals and have no apparent long-term effect on others, depending on such factors as species, age, and physiological status of the animal. Sea otters, fur seals, and newly born seal pups are likely to suffer direct mortality from oiling through loss of fur water-repellency and subsequent loss of insulative capacity resulting in hypothermia. Of the above species, sea otters are probably the most sensitive to oiling because they rely almost entirely on their fur for insulation, whereas fur seals and other pinniped pups possess some subdermal fat layers, depending on age and physiological status (Ling, 1974, and Kooyman et al., 1976). However, Kooyman et al. (1976) also report that oiling of northern fur seals reduces their ability to thermoregulate by as much as 50 percent, and such physiological stress can often lead to death. Adult harbor, ribbon, and spotted seals and walrus are likely to suffer some temporary adverse effects such as eye and skin irritation, with possible infection. Such effects may increase physiological stress and perhaps contribute to the death of some individuals (Geraci and Smith, 1976; Geraci and St. Aubin, 1979). Deaths attributable to oiling are likely to occur during periods of natural stress; for example, during molting, times of fasting, food scarcity, and disease infestations.

Contact with oil spills could interfere with the olfactory sense in marine mammals. Hydrocarbons in the water column or in the sediments could affect possible chemoreception in marine mammals. Oiling of pinniped fur may mask olfactory recognition of young pups by nursing females. The sense of smell has been reported to be important in harbor seal mother-pup bonds (Renouf et al., 1983) and is probably important in other seals. Benthic feeders, such as walrus, may rely on chemoreception for locating food. Contamination of bottom sediments may interfere with prey identification in contaminated habitats.

Oil ingestion by marine mammals through grooming, nursing, or consumption of contaminated prey could have pathological effects, depending on the species and physiological state of the animal. Although research indicates that ringed seals, and probably other pinnipeds, rapidly absorb oil in body fluids and tissues, ingestion of relatively large quantities of oil for a short period of time showed no apparent acute organ damage (Geraci and Smith, 1976). However, with longer periods of ingestion, accumulation could increase. Ingestion of large amounts of oil may have serious acute effects, as demonstrated with polar bears. Englehardt (1981) reported the deaths of two polar bears due to renal failure and dysfunction of red blood cell production after the bears were heavily coated with crude oil and, subsequently, ingested large amounts of oil while grooming.

9. Impacts of Oil Spills on Whales

Observed or projected effects of oil on endangered whales based on laboratory research and/or conjecture (Geraci and St. Aubin, 1985; Goodale et al., 1981; and Gruber, 1981) are (1) a mild deleterious but reversible effect on the skin; (2) possible eye irritation, which would be reversible unless exposure was prolonged; (3) possible short-term baleen fouling with possible feeding reduction for 1 or 2 days; (4) possible blowhole fouling and death due to respiratory stress for very young animals in heavy oil; and (5) temporary food reduction or contamination, and oil ingestion. Potential but unlikely effects include (1) possible mortality due to respiratory stress; (2) possible mortality to young or already stressed animals immediately after a spill, due to ingestion of oil or inhalation of vapors; and (3) possible mortality due to stress if individuals are already stressed. Mortality due to an oil spill has not been verified for any cetacean.

C. Manmade Structures

1. Onshore Manmade Structures

Onshore manmade structures refer to shore and landing facilities or structures that are needed to support OCS-related oil and gas activities. There could be a need for the following types of onshore structures or facilities.

(1) Oil and gas treating facilities,

(2) Crude oil storage tanks,

(3) Supply and crew boat bases,

(4) Onshore oil and gas pipelines,

(5) Temporary support bases for onshore and offshore pipeline installation activities, and

(6) Airports (existing) for helicopter support activities.

Most of these facilities already exist in OCS-related oil and gas producing areas.

Direct, impact-producing agents resulting from these onshore manmade structures include space-use conflicts, air emissions, and temporary beach disturbance.

2. Offshore Manmade Structures

Significant impact-producing agents related to manmade structures are described below.

a. Exploratory Activity--Short-term Presence

Exploratory operations usually involve the use of a drilling rig, support vessels (crew, supply, or tug boats), and helicopters. These operations are typically short term, lasting approximately 4 months per well, per site.

Generally, three types of drilling rigs are used for exploratory operations: jack-up rigs, semisubmersible rigs, and drillships.

A typical jack-up rig may be about 200 ft (61 meters) long, and it is towed onto the drilling site by tug boats. The legs are jacked down to the ocean bottom. The rig remains floating until the legs are properly placed on the bottom, and the rig deck is elevated about 30 ft above the water level. The primary power onboard the rig is furnished by several diesel generators.

A typical semisubmersible drilling unit is a self-propelled 290-foot (90-meter) drilling rig. The primary equipment on the rig includes eight 30,000-pound (13,500-kilogram) anchors, two 50-ton cranes, and a 160-foot (49-meter) derrick. Propulsion for the vessel is furnished by twin propellers, each typically driven by six 850-horsepower electric motors.

A typical drillship is a self-propelled, 459-foot (140-meter) vessel. The vessel is moored with an eight-point wire-line system using eight 30,000-pound (13,600-kilogram) anchors, or it can be dynamically positioned with thrusters. Each anchor is marked by a welded steel cylindrical anchor buoy, 10.5 ft long and 8 ft in diameter. A 142-foot derrick is situated in the center of the vessel with two nearby working cranes.

Direct, impact-producing agents of exploratory operations are as follows: (1) vessel anchorage, (2) drilling process, (3) discharges, (4) noise, and (5) vessel presence.

Vessel anchorage would affect the organisms inhabiting the ocean bottom, particularly in rocky and mud-clay bottom areas. As anchors are lowered onto the substrate, epifauna, epiflora, and infauna would be crushed either by the anchor itself or by the anchor chains. When the anchors are removed, they are sometimes dragged toward the drillship, crushing organisms along the way. However the standard method of retrieval is for work or tug boats to pick up the anchors and carry them back to the drill vessel. Anchors have also caused mud mounds, trenches, or scars. Anchors could also affect archaeological resources such as historic shipwrecks or aboriginal sites. The likelihood of such impacts are reduced, however, by MMS requirements for archaeological surveys.

The drilling process itself is a direct, impact-producing agent. A typical well is begun with the drilling or jetting with seawater of a surface hole (usually 30 to 36 inches (in) in diameter) to a depth of 100 to 350 ft. The materials (drill cuttings) that result from these first several hundred feet are discharged directly to the ocean bottom. Subsequent cuttings are returned to the drill vessel and discharged from there. Structural casing is then cemented to the bottom surface. Progressive sections of the hole are drilled with progressively smaller drill bits. Thus, the actual volume of cuttings that is discharged steadily decreases with increasing well depth. Other discharges to the bottom and water column include drill muds and formation water.

Discharges to the air result from the mechanical operation (diesel engines) of the drilling process. These discharges include sulfur dioxide nitrous oxides and particulates.

Activity on and around drilling equipment generates noise both above and below the water surface. Beneath the water, noise can carry for long distances, possibly masking natural communication sounds between animals and possibly preventing some species from using large areas around offshore operations.

Another direct, impact-producing agent of exploratory operations is the presence of the drilling rig itself. However, this activity is only temporary in nature (generally, duration is less than 4 months) during exploratory operations.

Commercial fishing (trawling) is temporarily displaced at any site occupied by a drilling rig. Generally, the spatial reduction of fishing depends upon the water depth of the wells and is about twice the area taken by the drilling rig or is within the boundary of the anchor scope radius. Thus, one typical rig could preclude fishing from an area of up to 500 acres.

Vessel presence could result in navigational hazards to other vessels under certain adverse conditions. These adverse conditions include periods of high sea state and periods of reduced visibility (e.g., during fog, rain). Exploratory operations must comply with applicable MMS operating orders and all U.S. Coast Guard (USCG) safety, navigation, and notification requirements.

b. Development Activity--Platform and Subsea Pipelines

(1) Installation Operation--Short-term Presence

(a) Platforms

Platform installation operations usually involve the use of barges, crew boats, supply boats, tug boats, helicopters, and the platform itself. Platforms are generally fabricated at onshore platform fabrication yards and transported to the offshore site by barge for installation. Platform jackets are launched from a launch barge and lowered to the ocean bottom by controlled flooding. Steel pilings are driven to the desired depth through the jacket legs. The platform is leveled, grouted, and welded in place to each of the piles. Platform installation generally requires a few weeks, and the total offshore construction time is about 6 months.

Direct, impact-producing agents that are associated with platform installation operations are vessel anchorage, vessel presence, and air emissions from barges, cranes, etc. These impact-producing agents are similar to those associated with exploratory operations.

(b) Subsea Pipeline

Installation activities usually involve the use of an installation barge and support vessel (crew, supply, or tug boats). These operations are short term and usually last less than 10 days. The time would vary, depending on the length of pipeline to be installed and weather conditions.

A number of different methods are presently available to install offshore pipelines. Pipelines are initially prepared for installation either at an offshore pipeline lay-site on a pipeline lay barge or at an offshore facility, then towed to the lay-site by a reel barge, surface tow, or bottom tow method.

Direct, impact-producing agents that are associated with subsea pipeline installation operations include impacts from vessel anchorage and vessel presence, similar to those associated with exploratory operations. A major difference is as follows: exploratory operations take place at a stationary location (e.g., the well site); the installation activities of subsea pipelines take place over a much greater distance (i.e., the pipeline route). Thus, the potential impacts from vessel anchorage (e.g., anchor scars) or vessel presence would be distributed over a much greater area but for shorter periods of time at any specific location. Pipeline burial operations, abandoned buoys, air emissions, and blasting in rocky areas are also short-term, direct impact-producing agents.

(2) Long-term Presence of Offshore Structures--Platforms Pipelines, Single Anchor Leg Moorings, Subsea Wellheads, Gravel Causeways

The previous section concentrated on short-term activities: exploratory, installation, and/or construction operations. This section describes the long-term OCS-related oil and gas activities (i.e., lasting for periods of 20 to 40 years). These long-term activities involve the actual presence of structures and their associated discharges and emissions. Impacts to the offshore structures could result in an oil spill. Once installed, offshore platforms become a quasi-permanent feature of the OCS area.

The visual impact of offshore oil and gas drilling rigs and platforms is determined by the actual size of the offshore facilities, the elevation of the observer, the distance from shore to the offshore facility, and atmospheric conditions. On perfectly clear days, the curvature of the Earth will obstruct the lower portion of offshore facilities from coastal observers. The farther offshore the facility is located, the more the curvature of the Earth will reduce the visible portion of the base of the offshore facility. The highest point on offshore facilities is the light atop the drilling mast. About 260 ft is usual maximum height on offshore facilities, and 300 ft is an estimate for the maximum height of any offshore facility. The curvature of the Earth obstructs the view of even the top of the drilling mast 300 ft above the water line when the facility is located 26 mi from the shore. However, if the coastal observer has an elevation of 400 ft above the shoreline (e.g., the top floor of a high-rise hotel or condominium), the maximum distance that the light atop a 300-foot drilling mast could theoretically be seen is 49 mi from the shore. Thus, on a perfectly clear night it may be possible to see the light atop the drilling mast when the offshore facility is located 26 mi offshore for an observer at sea level or 49 mi for an observer atop a high-rise complex.

The apparent size of offshore facilities is, perhaps, a more important factor in determining the visual impacts of offshore facilities. Apparent size is the comparison of how big the offshore facility appears next to objects held in the hand. Even a large offshore facility located, for example, 2.8 mi from shore has an apparent size of about one half inch--the size of a dime. Another example which could be used is Platform Harvest, located approximately 10 mi offshore and standing about 266 ft above the water line. The apparent size of this platform at arms length is less than one eighth of an inch.

Platform presence could also cause navigational hazards to other vessels under certain adverse weather conditions. These adverse conditions include periods of high sea state and periods of reduced visibility (e.g., during fog, rain). On the other hand, platform presence could provide a benefit for safe navigation by serving as a navigational aid.

Commercial trawling space will be displaced at any site occupied by a platform. Platforms may occupy up to 7 acres; however, the average platform occupies about 1 acre. This space would not be available for trawling, but would be available for other types of commercial fishing (e.g., snapper fishing) and for sport fishing.

The platform itself may serve as an artificial reef, attracting a community of attached organisms and those that would use it as shelter, as well as those that would feed on the attracted organisms. In the GOM, extensive use of oil and gas structures is made by scuba divers and recreational fishermen.

The long-term presence of an unburied subsea pipeline on the ocean bottom could conflict with commercial trawling operations. The MMS requires, however, that pipelines be compatible with fishing operations. Invertebrates and macrophytes (seaweeds) will settle onto this new substrate rapidly following the platform's installation. These organisms develop quickly and serve as an attractive food source for offshore fish populations.

All natural gas produced on the OCS is considered interstate and, thus, comes under the purview of the Federal Energy Regulatory Commission (FERC). To build a pipeline to transport OCS-produced natural gas, a Certificate of Public Convenience and Necessity from FERC must be obtained. In its application to FERC, the pipeline company must show how the construction and operation of its proposed facility will conform to State and local laws, permit requirements, and policies. According to FERC's guidelines, the construction and maintenance of facilities authorized by certificates granted under Section (7)(c) of the Natural Gas Act should be undertaken in a manner that will minimize adverse effects on scenic, historic, wildlife, and recreational values. These guidelines also recognize that the construction of pipeline facilities are compatible with existing State and regional land development plans. The FERC may hold public hearings on a proposed right-of-way before granting its approval.

Gas pipelines are generally buried to prevent damage from anchors and fishing gear (in the Pacific Region pipelines are only buried through the surf-zone because of a higher potential for earthquake activity). Trenching soft soil, such as the sands in the north Atlantic, to a depth of approximately 2 m disturbs the sediments up to about 9 m on either side of the pipeline. Based on calculations in Gowen et al. (1980), up to 21,700 m^3 of sand per kilometer of buried pipeline would be displaced, and 19,000 m^2 of sediment surface area per kilometer of pipeline would be directly disturbed.

The construction of gravel causeways, if necessary, could adversely affect regional populations of anadromous fish. Studies of the Prudhoe Bay causeway showed that deflection of the longshore current offshore was instrumental in altering temperature and salinity around the causeway. With the prevailing northeast winds, temperatures on the west side would be 2 to 4 degrees cooler, while salinities would increase by 10 parts per thousand (ppt) (Bendock, 1979). Although these differences are well within the range of fluctuations frequently observed in the area (Craig and Haldorson, 1981), the consistent tendency for these differences might affect fish.

Currently, the extent of cumulative causeway effects is not well known. Recent studies by Fechhelm and Gallaway (1983) have shown that at least one important anadromous species, Arctic cisco, exhibits a definite temperature preference which relates positively to its distribution along the coastline. By modeling movements and distribution of Arctic cisco relative to changes in temperature and salinity around the Prudhoe Bay causeway, Neill et al. (1982) estimated that fish density would be reduced slightly (about 7 percent) in the area of less preferable conditions (lower temperatures and higher salinities). Additionally, these causeway-induced changes could pose migration and movement "barriers" to those species that require less saline conditions (e.g., broad and humpback whitefish).

D. Vessel Traffic

1. Oil Tankers

With the exception of oil produced from Platform Hondo (offshore California) and minor barging in the GOM, almost all oil and condensate produced on the OCS is brought to shore by pipelines. Any tankers transporting OCS-produced crude oil must conform with all standards established for such vessels, pursuant to the Port and Tanker Safety Act of 1978 (P.L. 95-474). Only U.S. flag vessels, which are regulated by the USCG, can be used to transport OCS crude oil. In the Santa Barbara Channel, Exxon has transferred over 28 million bbl of oil from the offshore storage and treatment facility (Platform Hondo) to tankers with only a 1-gallon spill occurring during transfer operations. Tankers (U.S. flag vessels) carrying Alaskan North Slope crude to the west, east, and gulf coasts have also shown an excellent record. The spill rate for tankers is 1.3 large spills (greater than or equal to 1,000 bbl) per billion bbl transported. Problems associated with tankers usually involve carriers of imported crude oil or refined (generally more toxic) petroleum products.

To reduce problems of heavy traffic, Traffic Separation Schemes (TSS's) and Precautionary Areas have been established for many of the major ports. Although there are no formal restrictions concerning the placement of structures within TSS's, International Maritime Consultative Organization guidance recommends that lanes remain free of obstructions. The USCG does not usually approve siting structures within traffic lanes or within a 500-meter buffer zone on either side of both the inbound and outbound lanes. Alternatively, traffic lanes can be temporarily shifted or suspended to permit exploratory drilling in areas that would otherwise be prohibited.

2. Supply and Crew Boats

Supply and crew boats are used to service offshore vessels and structures. Supply boats typically transport drilling equipment, cement, drill muds, oil-contaminated muds, cuttings or formation water, food, and other supplies to and from the platform or drill site. Supply boats require harbor or port facilities such as docks, berthing space, and staging areas (for the storage and loading of equipment and supplies). Crew boats typically transport drilling personnel to and from the platform or drill site. Unlike supply boats, crew boats only require docking and berthing facilities at harbors or ports. Helicopters generally transport personnel to rigs or platforms distant from shore.

Direct, impact-producing agents that are associated with supply and crew boats follow. These are explained below.

(1) Additional marine traffic
(2) Support facility requirements
(3) Crew and supply boat engines (air emissions)

Impacts associated with additional marine traffic include the increased possibility of vessel-to-vessel and vessel-to-structure incidents. These incidents could lead to oil spills, loss of lives, and loss of equipment. In certain locations, wakes from boats contribute to bank erosion. Impacts that are associated with support facility requirements include space-use conflicts between the oil industry and other industries (e.g., commercial fishing). Impacts that are associated with crew and supply boat engines are air emissions (fumes and exhaust) that could potentially degrade the ambient air quality.

E. Noise and Other Disturbances

1. Noise from OCS-related Activities

a. Impacts on the Human Environment

Noise resulting from OCS oil and gas development is associated with the operation of offshore platforms, drilling rigs, seismic surveying, petroleum transfer facilities, onshore processing plants, pump stations, aircraft, and vessels. In addition, construction equipment used during the installation of the facilities emit various levels of noise. The degree of noise impact depends upon the emitted sound level and the proximity of the source to schools, hospitals, residences, and recreation areas.

Machinery noise sources found on drilling and production platforms are, generally, similar to those of onshore operations. Special noise-attenuated devices are sometimes used on offshore platforms to protect workers in their living quarters. Compressors and diesel engines are typically the loudest equipment on platforms emitting about 90 decibels (dB) at a distance of 15 m (50 ft). By comparison, a diesel truck under full load also emits about 90 dB at 15 m. Although other sounds such as banging of pipes may be more intense, they are of short duration. Platform noise can potentially degrade the underwater acoustic environment; it may also adversely affect naval activities in certain areas. Gales (1981) indicated that in light seas the subsea surface noise propagated by a platform could be detected up to 100 mi away.

In a quiet sea with light wind conditions, normal offshore platform operations would be inaudible beyond about 2 mi (assuming ambient background noise level of 40 dB and attenuation due to sound wave spreading only). In rough seas and weather conditions, the offshore facility would be inaudible beyond about one eighth of a mile (assuming 70-decibel background).

b. Impacts on the Biological Environment

The response of animals to acoustic stimuli has generally shown variance in behavioral and physiological effects, depending on species studied, characteristics of the stimuli (i.e., amplitude, frequency, pulsed or nonpulsed), season, ambient noise, previous exposure of the animal, physiological or reproductive state of the animal, and other factors.

Possible adverse effects from loud sounds include (1) auditory discomfort due to loudness and/or pressure changes, (2) possible hearing loss, (3) the potential masking of sounds that might be used in intraspecies communications, and (4) behavioral responses resulting in avoidance of an area.

Shock waves associated with seismic airguns would not immediately be harmful to marine animals (Geraci and St. Aubin, 1980), although noise may affect behavior.

The Acoustical Society of America (1980) has estimated maximum source levels at 230-250 dB relative to 1 micropascal at 1 m for various types of activities associated with seismic exploration. These are classified as the highest sound pressure levels associated with offshore oil and gas explorations--the pulses are of short duration (generally less than 1 second) and are generated intermittently for relatively short survey periods (of about a few months) in any given area (Gales, 1982). Seismic surveys also may be interrupted for a period of several hours or days.

Received-noise levels are less than produced levels, and the rate of decay depends on bottom absorption ability, the type of spreading (cylindrical or spherical), and other physical factors. Even with the maximum pressure levels estimated for seismic arrays at the sound source (230-250 dB), the sound pressure level is expected to be under 200 dB at distances beyond 100 yards (yd) (Gales, 1982).

It seems unlikely to expect adverse responses to very high-pressure-noise disturbances in animals that are adapted to life in the sea, where pressure changes, on the order of many atmospheres in magnitude, are routinely experienced in ocean margin earthquakes (Northrop, 1972) or in diving. Also, some cetaceans routinely breach or jump free of the surface and return with a diving splash that creates a sudden large increase in pressure.

(1) Coastal and Marine Birds

Human activities associated with OCS exploration and development, especially air and vessel traffic near nesting waterfowl and seabirds, could reduce productivity of some species and may cause abandonment of important nesting, feeding, and staging areas. Effects studies in the arctic indicate that the arctic tern, black brant, and common eider all show lower nesting success in disturbed areas (Gollup et al., 1974). Schweinsberg (1974) reported that snow geese were particularly sensitive to aircraft disturbance during premigratory staging. The responses of birds to human disturbances vary greatly. These responses depend on the species; the physiological or reproductive state of the birds; distance from the disturbance; type, intensity, duration of the disturbance; and many other factors. Waterfowl nesting on deltas and islands may also be disturbed by aircraft and vessel traffic, and some disturbance of molting and staging birds can occur. In recent years, repeated aircraft flights (not related to OCS activities) near several colonies in the Bering Sea region may have been one factor contributing to fewer nesting attempts and reduced reproductive success (Biderman and Drury, 1978; Hunt et al., 1978). However, effects studies by Ward and Sharp (1974) and Gollup et al. (1974) indicate that long-term displacement or abandonment of important molting and feeding areas due to occasional aircraft disturbance is unlikely.

In offshore areas, helicopter and vessel traffic to drill rigs or platforms would constitute the most important source of disturbance affecting marine birds. Onshore activities, air traffic, human presence, and activities associated with construction and operation of support facilities near seabird colonies and waterfowl and shorebird staging and nesting areas can significantly disrupt breeding activities and preparation for migration. Nesting birds may be subjected to increased predation pressure from gulls and foxes whose populations may increase if supplementary food (garbage) becomes available at onshore support facilities. Construction and operation of onshore facilities may encroach upon wildlife habitat causing nearby breeding areas to be abandoned during such activities. Low-flying aircraft, especially helicopters, can frighten large numbers of cliff-nesting birds (e.g., murres) from the nesting ledges, resulting in eggs and/or young falling to the rocks below. Those not displaced from the ledges by adults are left exposed to the elements and predators (Hunt, 1976; Hunt et al., 1978; Jones and Petersen, 1979). Disturbance of birds in important feeding, staging, and overwintering areas can cause excessive expenditure of energy and displacement to less favorable habitats during critical periods in the annual cycle.

In Alaska's Beaufort Sea, artificial gravel islands are used for exploration and production activities. Birds could be temporarily displaced (1 year near island and dredge sites as well as at terrestrial gravel storage sites) during construction activities. Displacement could occur because of noise disturbance and temporary disruption or removal of food sources near island and dredging sites. In some cases, gravel islands would provide additional shoreline habitat and may attract some bird species by providing shelter on the leeward side of the islands. However, human presence may limit bird use of the island, and bird attraction to gravel islands may increase the chances of their direct contact with oil spills. Disturbance of birds from dredging and island construction would normally be short term, and disruption of food sources would be local and temporary.

(2) Marine Mammals

Underwater noise may disturb or alarm the mammals and cause them to flee the sound sources. Intense noise could damage the hearing of marine mammals or cause them other physical or physiological harm (Geraci and St. Aubin, 1980; Hill, 1978). Frequent and/or intense noise that causes a flight or avoidance response in marine mammals could permanently displace animals from important habitat areas.

Sources of airborne and waterborne noise include drilling operations, pipeline laying, geophysical surveying, aircraft, support vessels, offshore construction, dredging, and other offshore operations. These noises may disturb marine mammals within a few kilometers of these sources; however, marine mammals may detect and respond to underwater noises from some sources at greater distances.

The presence of sea lion, elephant seal, sea otter, and cetacean populations near human and industrial activity and marine-vessel traffic along the California coast, as well as the presence of sea lions and seal and beluga whales near commercial fishing traffic in Bristol Bay and Cook Inlet in Alaska, strongly suggests that some marine mammals have adjusted to human development activities with no apparent adverse effects. However, some species of marine mammals, such as fur seals, are probably more sensitive to human presence and disturbance, particularly during the nursing and breeding seasons. The presence of sea otter populations near human and industrial activity and marine-vessel traffic along the California coast strongly suggests that this species has adjusted to most human development activities with no apparent adverse effects. Playback recordings of industrial noise and actual seismic sounds from airguns had no apparent effect on California sea otters (Riedman, 1984). Sensitive species may adjust to human presence and industrial noise to a certain degree, with a portion of the population remaining in industrial areas. Noise and disturbance could conceivably exceed the tolerance level of sensitive species and eventually displace them from development areas; however, such permanent displacement has not been demonstrated.

A task force report on Geophysical Operations (1982), submitted to the Executive Officer of the California State Lands Commission, determined that no evidence was found to suggest that airguns and other nonexplosive acoustic sources cause injury to marine mammals, including gray whales. As stated in the task force report, the National Marine Fisheries Service (NMFS) believes that "sufficient information is available in the literature to conclude that geophysical exploration does not result in physical harm or mortality of marine mammals in the vicinity of operations." The task force report has determined that geophysical exploration off the California coast does not constitute "harassment" of migrating gray whales, as defined under the Endangered Species Act. The NMFS determination also may apply in parts of Alaska, since gray whales, when in the North Aleutian Basin, are migrating. Current knowledge of cumulative effects on endangered whales is too limited, however, to permit definitive generalizations; there may be a presently unknown threshold, beyond which cumulative effects could be significant.

(a) <u>Pinnipeds</u>

Offshore activities that may disturb pinnipeds involve mainly airborne or underwater noise and human presence. Major sources of mobile-airborne noise disturbance are low-flying aircraft and high-speed motorboats, as well as other high-frequency, high-pitched sounds. Low-flying aircraft are known to panic hauled-out seals. If such disturbance occurs at pinniped rookeries during the pupping season, pup mortality would increase significantly, and pupping success would be reduced (Johnson, 1977). Disturbed adult seals are likely to crush pups when they stampede into the water, and nursing females are likely to abandon their pups during the first 3 weeks of nursing if disturbance separates the mothers and pups. Stampedes into the water also can injure the young. Repeated disturbances may lead to abandonment of traditional breeding or hauling areas in favor of less suitable sites (Geraci and St. Aubin, 1980). If seals and sea lions are frequently disturbed during the molting period at haul-out areas, the successful regrowth of skin and hair cells may be retarded. The physiological stress on seals and sea lions would, thus, increase during an already stressful period.

Information concerning responses of marine mammals other than cetaceans to seismic and vessel noise is primarily speculative. The principal evidence is provided by Burns and Kelly (1982), who found no significant difference in ringed seal density along seismic control transects. Other information (Alaska Dept. of Fish and Game, 1981;

Dome Petroleum, 1982) suggests that while seismic and vessel noise might temporarily affect hearing, mask vocalizations or sound used to locate prey or predators, or result in temporary displacement, effects on regional population are likely to be minor or negligible.

(b) Cetaceans

Noise, including seismic exploration, may be the most likely byproduct of normal OCS industrial activities to affect whales (Fraker et al., 1981). Although little information is currently available on the sounds perceived by large whales (absolute hearing thresholds in baleen whales have not been measured), it is generally assumed that most animals can hear sounds similar to those that they produce (Gales, 1982). Fraker et al. (1981) indicates that bowhead whales are known to produce sounds at 175 to 185 dB relative to 1 micropascal at 1 m and that right whales can produce sounds at 172 to 187 dB relative to 1 micropascal at 1 m. Therefore, it is assumed that whales are able to perceive normal sounds associated with OCS activities.

Concern has been expressed by some cetacean researchers that, if the sound source is close enough and the intensity is loud enough, disturbance and displacement of whales, and perhaps some physical impairment of cetacean hearing, could occur (Braham et al., 1982).

The degree of behavioral response by endangered whales to sounds associated with oil and gas exploration and development has been investigated for several species. Potential acoustic responses may result from several noise sources such as drilling platforms, drillships, semisubmersibles, and air and vessel traffic. The levels of effect on endangered species may range from very low to moderate, depending on the species and the population's well-being.

Acoustical studies and observations at offshore oil and gas platforms in Cook Inlet, Alaska, and Santa Barbara, California (Gales, 1982); indicated that platform noise was unlikely to interfere with cetacean echolocation and was expected to interfere with certain other acoustic communication signals only within close proximity of the platform. Observations indicated that whales either ignored or easily avoided platforms, without an appreciable change in behavior.

The level of seismic activity associated with a lease sale area would most likely depend upon the number of exploratory and or delineation wells and production platforms installed. Whales exposed to drilling platform, helicopter, and production platform stimuli also showed avoidance responses in which migration routes were deflected away from the source of the playback stimulus (Malme et al., 1983, 1984). Eighty percent of the time, avoidance to these prerecorded sounds was noted at a transmitted sound level of 130 dB. Fifty percent of the time, avoidance by migrating gray whales to playbacks of drillship noise was noted at 1,100 m. Other recorded sounds showed similar avoidance only at distances less than 100 m.

Short-term responses of whales to acoustical disturbances that have been demonstrated include flight and startle response; vacating of an area; deflecting of migration routes; and changes in swimming, diving, and respiration characteristics. Fraker et al. (1978) reported the startle response and flight of beluga whales 2,400 m from barges and boats that were traveling through an area of whale concentration. Underwater noise also may interfere with or mask reception of some marine mammal low-frequency communication signals or may interfere with reception of other environmental sounds used by marine mammals for navigation (Terhune, 1981).

Aircraft-noise disturbance of cetaceans from flyovers generally is transient, with events not lasting more than a few seconds (Stewart et al., 1983). Such brief disturbances are not likely to pose any serious consequences to nonendangered cetaceans.

Degrees of theoretical and observed response range from those so subtle that statistical analysis is necessary to determine whether or not a change has occurred to total abandonment of an area for several years, and return only when historic ambient noise levels are restored. There are many areas where industrial noise has been present for several years. Whales have continued to use these areas, to some degree, during their migration cycle. If accoustical disturbances persist in critical areas, long-term effects may result. Long-term effects may include permanent abandonment of some habitats, physical damage to the whale's auditory system, and changes in some portion or timing of their migratory cycle. Areas where long-term effects may be most likely to develop are in habitats where ambient noise levels do not presently include high levels of industrial noises (e.g., summer feeding areas, overwintering areas) or where many whales use a small area intensively (e.g., Unimak Pass, Bering Strait). Habituation may be possible if increases in industrial noise levels proceed at a very slow rate (20 to 40 years).

Bowheads whales, which summer in the Beaufort Sea and winter in the northern Bering Sea, seem more sensitive to aircraft than are other species of whales, but sensitivity to aircraft varies with season, whale activity, and water depth (Richardson et al., 1983). Bowheads engaged in socializing appear less sensitive to aircraft than are bowheads engaged in other activities. Reactions to the observation aircraft were conspicuous when the craft was below 457 m above sea level, occasional at 457 m, and seldom at 610 m.

Reactions to boats were stronger than to any other type of stimuli. Experiments with bowheads indicate that they react strongly to close approaching vessels of any size. Reactions began when boats were as far away as 4 km; by 2 km, travel away from the approaching vessel was more pronounced. An industry-sponsored study showed apparent avoidance by bowheads to drillship operations in the Beaufort Sea during their fall migration. Other behaviors consisted of changes in surfacing and respiration patterns and increased spacing within grouped whales. However, the flight response did not persist for long after the boat had moved away. The scattering of grouped bowheads continued longer than the flight reaction, which indicated that some degree of social disruption occurred.

Bowheads have been observed at 4 to 20 km from drillships in the Canadian Beaufort Sea. The whales' activities appeared to be characteristic of undisturbed whales, although a few exceptions occurred. Playback experiments showed that some bowheads reacted, although not strongly, to drillship noise at intensities similar to those that would be found several kilometers from a real drillship.

Humpback whales generally winter in warmer waters offshore Hawaii, California, and further south, and many summer in waters of southeastern Alaska, the Gulf of Alaska, and south of the Aleutian Islands. Some summer in the Bering Sea, and a comparatively few summer in the Chukchi Sea and even as far north as the western Beaufort Sea. Humpbacks are sometimes thought to be more sensitive to noise and other disturbance factors than other endangered whales. The NMFS biological opinion for Sale 55, Gulf of Alaska (Leitzell, 1979), concluded that "Uncontrolled increases of vessel traffic, particularly of erratically traveling charter or pleasure craft, probably have altered the behavior of humpback whales in Glacier Bay, Alaska, and thus may be implicated in their departure from the Bay the past two years." However, other factors also may have affected humpback use of the bay. Baker et al. (1982) and Miles and Malme (1983) indicated that humpback whales in Glacier Bay showed markedly different behaviors in response to approaching boats. Most frequently observed was an increase in breaching behavior as the boats got closer to the whales. Evidence of humpback sensitivity to disturbance has been reported in their wintering grounds (mostly in the Hawaiian Islands--see above) (Norris and Reeves, 1978). However, Payne (1978) listed numerous instances of apparent insensitivity of humpback whales to noise. Feeding humpback whales studied in the fall of 1984 in southeast Alaska (Malme et al. 1985) showed little or no short-term avoidance to industrial sounds at the sound levels received (up to 172 dB). This behavior may indicate a general insensitivity to oil industry noise by humpbacks, or it may indicate that feeding whales will tolerate more acoustic disturbance than migrating ones.

Gray whales summer mainly in the Bering Sea, although some summer also in the Chukchi Sea and even in the Beaufort Sea. In the eastern Pacific, they move south in winter to breed and calve mainly in Mexican lagoons. Their migration has been studied, and experiments have been conducted using both a single airgun and an airgun array (Malme et al., 1983, 1984). Whales began to show avoidance to seismic noise at average pulse-pressure levels of 160 to 164 dB relative to 1 micro Pascal at 1 m. They generally demonstrated a 0.5 probability of avoidance to seismic operations only at received sound levels above 170 dB relative to 1 micro Pascal at 1 m. The 170 dB corresponded to a distance of about 400 m from a single airgun and 2.5 km from the 40-gun array. The distances between the airgun-array vessel and whale groups which showed responses, obvious at the time of observation, were consistency on the order of 2 km.

Reactions of cow-calf pairs were tested separately. No responses by these maternal pairs (April-May experiments) were noted during line runs of seismic airgun arrays at distances of 5 to 83 km. When a moving array of larger airguns was turned on suddenly within 1 km of these pairs, responses were dramatic. The whale groups were seen changing direction, exhibiting confused swimming, moving inshore into the surf zone, and milling about for varying lengths of time--often followed by rapid swimming to avoid the source area. On four occasions, whales were observed moving into the surf zone and within the sound shadow of a nearshore rock or outcropping. Such a dramatic effect was believed to represent a "startle response," rather than a typical response to increasing sound levels. The distance at which these groups resumed normal migration ranged between 3.6 and 4.5 km.

Fraker et al. (1981) observed a group of seven bowheads within 13 km of a seismic exploration vessel, and they showed no obvious disturbance of behavior. Their surface time, intervals between blows, and blows per surfacing were normal. The sound level at the whale's location was stated to be at least 135 dB relative to 1 micropascal, and possibly as high as 146 dB. On eight occasions in 1980 to 1982, Richardson et al. (1983) observed bowhead behavior in the Canadian Beaufort Sea in the presence of noise from seismic operations. The source level was 150 dB, and the received noise levels at 6 to 8 km were approximately 141 to 150 dB, respectively. There was no clear evidence that these whales attempted to move away from the seismic ships. The bowheads generally continued to produce their usual types of calls in the presence of distant seismic sounds, and they did not swim away from seismic vessels operating 6 km or more away. Reeves and Ljungblad (1983) observed bowheads on 14 geophysical-monitoring-survey flights in the Alaskan Beaufort Sea. Whales seen as little as 9 km from active geophysical operations were not observed to vacate the area or to display avoidance behavior. Observations of bowheads, 6 to 99 km away from active seismic vessels, showed them engaged in normal activities (received levels 158 dB relative to 1 micropascal).

Specific behavior in the presence and absence of seismic noise varies; however, the above data suggest that bowhead whales (and possibly right whales) are generally tolerant of geophysical seismic noise, at least at ranges of 6 to 8 km, but show avoidance behaviors at ranges of less than 5 km.

Effects from seismic activity have not been directly tested for the blue, sei, or fin whales, although it is anticipated that reactions would be similar to those of gray and bowhead whales. Fin whales feed in the upper portions of the water column and, therefore, may be exposed more frequently to seismic noises than whales that feed deeper in the water column.

Although the effects of geophysical seismic activities and oil spills have not been observed for right whales, the knowledge gained from observing bowhead whales can be extrapolated to effects on the right whale, since right whales are the closest living relatives of bowhead whales. The right whale's appearance and behavioral repertoire are very similar to those of the bowhead whale (Wursig, personal communication). The similarities in behavior between the bowheads and right whales have been described by researchers familiar with both species (Wursig et al., 1982).

Sperm whales, which typically occur in deep oceanic waters and at Continental Shelf breaks in temperate but also colder climates, use their acoustical system, which generally operates at high frequencies (1-100 kilohertz), to echolocate and communicate. Because they operate at high frequencies of shorter wavelengths, the acoustical receiving and transmitting system of sperm whales tends to be directional and is capable of discriminating against unwanted sounds. It does not appear that any serious interference with their communication is likely, especially since the more powerful geophysical seismic noises are produced at low frequencies. Sperm whales have been observed in day-long proximity (200-3,000 yd) to an operational drillship, indicating a lack of aversion to drilling sounds (Tony Ladino, MMS, personal communication).

Additionally, the MMS has established, through permit conditions and NTL's, guidelines and standards to detect whales and prohibit or limit seismic operations when endangered whales may be adversely affected by seismic noise. The MMS may also order operations to cease when adverse effects occur. Through these measures and the observed spatial limits of the observed effects, it is not likely that seismic surveys will inhibit successful whale migrations or significantly disrupt feeding, mating, and other essential whale activities.

2. Dredging

Dredging may be used to prepare foundations for production platforms and may be used for trenching and burial of subsea pipelines. Pipeline installation would involve the greater overall volumes of dredged materials.

High turbidity plumes would extend about 1 km downcurrent of dredging sites. At this distance, turbidity levels have returned to the upper range of ambient concentrations. Effects from dredging would occur approximately in a 1-kilometer radius in the vicinity of the dredging and would occur only during periods of actual dredging for pipeline and platform emplacement.

Experience with dredging or dumping operations shows that the concentration of suspended sediments decreases to background levels with time (2-3 hours) and distance downstream (1-3 km) from the discharge. In the dredging operations associated with artificial island construction and harbor improvement in the Canadian Beaufort

Sea, the turbidity plumes tended to disappear shortly after operations ceased and generally were not spatially extensive (Passah, 1982); sand was the predominate material moved.

The sites, duration, and amount of turbidity depend on the grain-size composition of the discharge, turbulence in the water column, and current regime. However, the turbidity would not be expected to extend further than a 3-kilometer radius about the construction site of the gravel island, or about 28 km^2.

The short-term, site-specific increases in turbidity expected from dredging and island construction may not adversely affect endangered whales or habitats. The amount of sediments introduced into the water column by dredging operations associated with artificial island and causeway construction would be less than the amount that enters naturally during spring breakup (in Alaska) or when storms resuspend bottom sediments (Lowry and Frost, 1984).

Dredging activities and gravel deposition during island construction could affect marine mammals through noise and disturbance, habitat alterations, and changes in availability of food sources. Based on theoretical work (Fraker et al., 1978), noise and disturbance from dredging, island and causeway construction, and support traffic could displace marine mammals within 2 to 3 km of the activity site during operations. Dredging and gravel deposition could temporarily disrupt or remove prey species within several kilometers downstream of the dredging site and near the island construction site. Observations of bowheads from 1980 to 1983 near island construction and active dredges indicate they occasionally tolerate noise levels associated with these activities (Richardson et al., 1983).

A long-term change in species composition or abundance of benthic prey for whales could occur in localized areas as a result of dredging and artificial island construction if substrate characteristics or depth regime were substantially altered. Should these changes occur, however, they would likely be confined to a very small area in comparison to available feeding habitat. It is unlikely that long-term changes in sea-ice deformation (in Alaska), currents, water regime, sediment transport, and productivity, or whale migration would result from petroleum industry habitat alteration.

F. Effluents and Discharges

1. Water Quality

a. Offshore Oil and Gas Industry Activities

Under normal offshore operations, varying degrees of water quality degradation could occur as a result of oil and gas exploration and development activities.

Potential water quality degradation factors include the resuspension of bottom sediments through exploration and development activities and pipeline construction; the discharge of drill cuttings and muds; the discharge of formation waters or produced waters; sanitary and domestic wastes; excess cement; cooling water; desalinization brine; the discharge of deck drainage; and operational discharges from support vessels. Discharges of hydrocarbons may also occur due to accidental spills or blowouts.

Wastes from these activities are varied and may be transformed physically, chemically, or biologically when introduced to the marine environment. These contaminants may be dissolved and form new substances or be mixed vertically and horizontally in the water column by small-scale motions or large-scale currents. They also may be incorporated into the bottom sediments or be recycled by these same processes. These transformations will govern a contaminant's transport through the water column. The method of delivery to the environment as well as the intrinsic chemical properties of each source will influence a contaminant's distribution through the water column and its toxicity to marine organisms. The biological effects may involve individual organisms or whole ecosystems, with long-term effects occurring, such as changes in reproductive habits or genetic makeup of species.

Because of the complexity of these contaminant movements and behaviors, several parameters are needed to determine the extent of their impact. Specification of point sources, the type of the contaminant, rate of release, frequency of disposal, and geographical location of disposal are parameters essential in determining the extent of impact on water quality in any given area. Also important are the areas affected, the duration of impact, and the period of time required for recovery.

(1) Resuspension of Sediments

Impacts resulting from the resuspension of bottom sediments may include increased water turbidities and mobilization of pollutants in the water column. These effects may be a result of increased dredging activities in areas containing sediments with high concentrations of pollutants. The magnitude and extent of any turbidity increases will depend on the hydrographic parameters of the area, duration of the activity, and composition of bottom materials. Dredging may be used to prepare foundations for production platforms and may be used for trenching and burial of subsea pipelines. Pipeline installation would involve the greater overall volumes of dredged materials. Dredging activities in nearshore waters may result in resuspension of settled pollutants, toxic heavy metals, and pesticides, if present. The toxic effects of some of these pollutants could be long lasting in confined areas, depending on the quantities disturbed, local hydrographic effects, and the biota of the immediate area.

Pipeline burial could also resuspend toxic metals, pesticides, or other organic or inorganic compounds if a sludge or chemical waste dumpsite were traversed. However, pipeline routing emphasizes avoidance of such areas.

(2) Drill Cuttings and Muds

Drill cuttings are composed of rock fragments obtained as a result of the drill bit cutting through solid rock. To remove the drill cuttings, drilling mud (fluid) from the mud system (mud tanks) is circulated down the hole (well) through the drill pipe. Drilling mud passes out through the drilling bit nozzle, picks up drill cuttings, and returns to the surface between the drill pipe and walls of the borehole and/or casing. At the surface, drill cuttings are physically separated from the mud by screening and washing techniques. After the drill cuttings and drilling mud are separated, the drill cuttings may be discharged to the ocean or barged ashore, and the mud is returned to the mud tank for recirculation down the hole. Drilling mud that adheres to drill cuttings is discharged to the ocean or barged ashore. Additionally, mud is discharged to the ocean or barged ashore when excess mud is generated by (1) adding solids or water to adjust the mud properties, (2) changing mud types, and (3) dumping at the conclusion of drilling unless it can be used in a subsequent well (Sheen Technical Subcommittee, 1976).

Removal of drill cuttings from the hole is only one function of drilling mud. To obtain satisfactory results in the completion of any well, drilling muds have a variety of functions. These include controlling subsurface pressures, cooling and lubricating the bit and drill pipe, preventing the walls from caving, and preventing clogging of the formation penetrated. The amounts of discharges of cuttings vary but may range from 3,000 to 6,000 bbl over the life of the well (National Research Council, 1983).

There is a great diversity of drill hole characteristics and a variety of purposes for which drilling mud is employed. As a result, mud characteristics vary greatly. The ranges in concentration of major components present in drilling mud are given in table IV-2 for muds tested under the EPA guidelines. The concentrations of trace metals in whole muds (not used or diluted) are given in table IV-3 for the EPA-tested muds. Discharges of drilling mud must comply with requirements found under 30 CFR Part 250 and the NPDES permitting procedures. These requirements restrict the discharge of any drilling mud containing oil. The EPA permits require that if any oil-base mud is used, the mud cannot be released to the ocean, and cuttings must be cleaned or barged to shore for disposal. Some permits also restrict the discharges of water-based muds based on toxicity test results.

Table IV-2 Composition of typical generic muds

Component	Maximum Allowable Concentration (pounds per barrel)
1. Seawater/Freshwater/Potassium/ Polymar Mud	
KCI	50
Starch	12
Cellulose Polymar	5
Xanthan Gum Polymar	2
Drilled Solids	100
Caustic	3
Barite	575
Seawater or Freshwater	As needed
2. Lignosulfonate Mud	
Bentonite	50
Lignosulfonate, Chrome or Ferrochrome	15
Lignite, Untreated or Chrome-treated	10
Caustic	5
Lime	2
Barite	575
Drilled Solids	100
Soda Ash/Sodium Bicarbonate	2
Cellulose Polymar	5
Seawater or Freshwater	As needed
3. Lime Mud	
Lime	20
Bentonite	50
Lignosulfonate, Chrome or Ferrochrome	15
Lignite, Untreated or Chrome-treated	10
Caustic	5
Barite	575
Drilled Solids	100
Soda Ash/Sodium Bicarbonate	2
Seawater or Freshwater	As needed

Table IV-2 Composition of typical generic muds - Continued

Component	Maximum Allowable Concentration (pounds per barrel)
4. Nondispersed Mud	
Bentonite	50
Acrylic Polymar	2
Lime	2
Barite	180
Drilled Solids	70
Seawater or Freshwater	As needed
5. Spud Mud	
Lime	2
Bentonite	50
Caustic	2
Barite	50
Soda Ash/Sodium Bicarbonate	2
Seawater	As needed
6. Seawater/Freshwater Gel Mud	
Lime	2
Bentonite	50
Caustic	3
Barite	50
Drilled Solids	100
Soda Ash/Sodium Bicarbonate	2
Cellulose Polymar	2
Seawater or Freshwater	As needed

SOURCE: Environmental Protection Agency
Discharge Permit No. AKG285000

Table IV-3 Metals composition of drilling muds tested by EPA program

Metal	Concentration (ppm-whole mud)
Arsenic	1 to 3
Barium	2,800 to 141,000
Cadmium	<1
Chromium	2 to 265 (see 1)
Copper	2 to 26
Lead	1 to 24
Mercury	<1 (see 2)
Nickel	1 to 8
Vanadium	6 to 35
Zinc	12 to 181

(1) A Mobile Bay mud had 5,960 ppm Cr
(2) An arctic mud had 2.8 ppm Hg

SOURCE: Adapted from ERCO, Inc., 1980.

Based on the dispersion and/or dilution model developed by Brandsma et al. (1980) (as cited by Neff, 1985), the discharge of drilling muds and cuttings from a submerged pipe can be viewed as going through three distinct phases. These phases are convective descent of the jet of material, dynamic collapse, and passive diffusion. In the first phase, low density particles are entrained and bend toward the direction of current flow. Larger or denser solids descend until they hit the bottom, whereas light particles and solubles undergo dynamic collapse when the plume encounters a level of neutral density. Dilution by passive diffusion and convective mixing of the lighter plume (containing less than 10 percent of the solids) continues as the remaining 90 percent of the solids settles to the bottom. Dilution of drilling fluids to low concentrations is very rapid, usually within 1,000-2,000 m downcurrent of the discharge pipe and within 2-3 hours of discharge (ECOMAR, 1978, 1983; Ayers et al., 1980a, 1980b; Ray and Meek, 1980; Houghton, 1980; Northern Technical Services, 1983). Typically, suspended solid concentrations are reduced to 1,000 ppm within 2 minutes of discharge and below 10 ppm within 1 hour (Neff, 1985). Dilutions of 1,000-fold or more are generally encountered within 1 to 3 m of discharge. Localized turbidity associated with the muds and cuttings plume will reduce light penetration and, therefore, photosynthesis by phytoplankton.

Solids may accumulate on the bottom beneath the discharge plume and bury sessile benthic organisms. They may also cause changes in sediment characteristics and, subsequently, result in changes in the benthic community. Acute toxicity from the drilling muds and cuttings is not expected because of rapid mixing and because drilling fluids generally have low toxicity (Neff, 1985). Chronic or sublethal effects may include bioaccumulation of metals by some organisms. Investigations by Neff (1988) however, reach the conclusion that metals associated with drilling mud are virtually nonavailable for biaccumulation by marine organism.

Because of dilution, dispersion, and settling, the drilling discharges (muds and cuttings) and their associated elevated levels of suspended solids and trace metals generally have limited impact on ambient water quality beyond the immediate vicinity of the discharge. The fate of these discharges in a particular area is greatly influenced by water currents and depth. The lighter particulate and soluble discharge components associated with the upper or visible plume are generally dispersed or diluted to ambient levels within approximately 200 to 2,000 m of the discharge. The heavier drilling discharge materials tend to settle out in the general vicinity of the drilling rig. However, in water deeper than approximately 80 m, the settling of some of these heavier materials within the main or lower plume may be temporarily delayed when encountering neutral buoyancy conditions within the water column (National Research Council, 1983).

An EPA study suggests that despite decreased water circulation under ice cover, dilution of drilling-mud discharges at 300 m from the source would be roughly 100-fold greater than in open water (Jones and

Stokes Associates, Inc., 1983). The greater dilution is at least partially attributable to the greater sedimentation of drilling mud very close to the discharge point with the lesser turbulence and lower water velocities that occur under ice cover.

Dissolved oxygen, pH, salinity, and temperature would be affected only in the immediate vicinity (within less than 40 m) of the discharge. These discharges are during the drilling period and normally last for less than 1 hour.

Temperature and pH may rise slightly, while oxygen concentrations and salinity may decrease. Beyond the immediate area of discharge, the parameters that would be affected by drilling discharges are the levels of suspended solids and light transmittance (EG&G, 1982; Ayers et al., 1980a; Ray and Meek, 1980).

Trace metal dilution rates, as measured by suspended solids concentrations, have been shown to be similar to that of whole muds. Comparing the estimated concentrations of trace metals in drilling muds after 10,000-fold dilution (100 m downcurrent from the discharge point) with EPA criteria for saltwater aquatic life shows all estimated metal concentrations being below the EPA criteria levels, thus within "safe" levels (table IV-4). Light transmittance values reach background levels at a slightly greater distance from the discharge than do suspended solids because of colloidal particles (Ayers et al., 1980b).

The distance that the solids from drilling muds become dispersed and their concentration in bottom sediments depend on the quantities discharged, hydrographic conditions during and after the discharge, and the height of the discharge pipe above the bottom. In some cases, piles of drilling cuttings may be several meters high and 100-200 m in diameter around the base of the platform. In nondepositional environments with relatively strong currents, the solids may be dispersed or resuspended from their depositional sites and eventually may settle in low energy areas (National Research Council, 1983).

(3) Discharges of Formation Water

Formation water (i.e., produced water) is recovered along with oil during petroleum production. Formation water is derived from water trapped within pore spaces of the sediments at the time the sediments were deposited. In some cases, produced water may contain seawater or other surface water which has been injected into the formation to maintain reservoir pressure, as well as formation water. During compaction of the sediments, a portion of the water may be displaced. The displaced water is associated with migrating oil and gas.

After oil is separated from formation water, the formation water may be disposed of by injection into disposal wells (wells drilled for the purpose of storing formation water), discharged into the marine environment, or disposed of by using a combination of these two methods. Rejection of produced water, however, is an expensive option and not always technically feasible.

During initial oil production, formation water volumes will represent a small fraction (less than 1 percent) of the total fluid extracted from the well, with oil composing almost the entire amount of fluid. As the reservoir is depleted, the ratio of formation water to oil increases to as much as 10 to 1. The most common chemical constituents found in formation waters are iron, calcium, magnesium, sodium, bicarbonate, sulphates, and chloride. In addition, formation waters contain entrained oil or petroleum hydrocarbons and measurable trace metal concentrations. Relative to ambient water, formation water has (1) increased organic salts, (2) increased temperature, (3) decreased dissolved oxygen, and (4) increased trace metals.

However, formation waters discharged during production tend to undergo dispersion similar to that described for fine particulate and liquid drilling discharges. They are rapidly diluted and dispersed in the large volume of receiving water.

Because of the relatively high density and low-oxygen content of formation waters, if large volumes are discharged near the ocean bottom in deeper areas where turbulence is not strong, high density flows of low-oxygen water could result. If discharged near the surface, however, they would rapidly disperse in the water column within a few hundred meters and, thereby, have no substantial effect on ambient water quality.

The trace metal concentrations in discharged formation waters are generally reduced to background levels within a few hundred meters of discharge, depending on hydrographic conditions. For example, a comparison of the estimated concentrations of trace metals in typical California formation waters after 1,000-fold dilution (500 m from the discharge point) with EPA 24-hour water quality criteria showed all trace metals falling below EPA criteria "safe" levels. (See table IV-4.)

Table IV-4 Comparison of estimated trace metals concentrations in drilling muds, following 10,000-fold dilution, with EPA water quality criteria for seawater aquatic life (Federal Register, November 28, 1980).

Trace Metal	Mud Concentration ppm	EPA Criteria Value (ppm)	Estimated Concentration (ppm) at 100 m Downcurrent and and 10,000-Fold Dilution
Arsenic	3	0.5	0.0003
Barium	141,000	N/A	14.1
Cadmium	<1	0.05	0.0001
Chromium	227	10.3	0.02
Copper	11.3	0.02	0.001
Lead	9	0.66	0.0009
Mercury	1	0.003	0.0001
Nickel	8	0.140	0.0008
Vanadium	35	N/A	0.0035
Zinc	181	0.170	0.0181

Source: EPA, 1981 NPDES Permit Determinations (Georges Bank/Atlantic Ocean), Region I.

Studies done on water produced from GOM oil fields, in some cases, have shown radionuclide levels of up to four levels of magnitude higher than found in open-ocean surface waters. These higher concentrations probably reflect upward migration of solutions containing radionuclides from areas deeper in the Earth's crust. Despite these higher levels in formation water as compared to open seawater, there seemed to be no apparent human health or environmental health contamination problem because of the rapid dilution of these formation waters when discharged offshore.

After discharge to the sea, formation water is rapidly mixed and diluted. Although formation waters have low dissolved oxygen and pH and high salinity relative to the receiving waters, these parameters do not pose a hazard to organisms in the water column because of rapid mixing. Low-molecular-weight aromatic hydrocarbons and some metals in produced waters are potentially toxic when present in sufficient concentrations. However, more than 88 percent of the 54 bioassays performed to date (Neff, 1985) suggest that the effects of formation waters are minimal. Laboratory studies on potential sublethal or chronic effects of formation waters on marine organisms have not been reported. Field studies have shown the potential for bioaccumulation of petroleum hydrocarbons from formation waters. However, while they are bioavailable they are not persistent in animal tissue and are not biomagnified in the food web (Neff, 1988).

(4) <u>Sewage</u>

Domestic waters (from sinks, showers, laundries, and galleys) and sanitary (sewage) wastes (from toilets and urinals) are discharged from drilling rigs and platforms. The discharge of treated sanitary and domestic wastes would increase levels of suspended solids, nutrients, chlorine, and biological oxygen demand (BOD) in a small area near the point of discharge. The discharge is regulated by Environmental Protection Agency NDPES regulations, for example, regarding floating solids and residual chlorine content. Some residual chlorine may be present in discharged waters following treatment. However, due to evaporation and conversion to other chemical forms when combined with seawater, it would be quickly diluted.

(5) <u>Hydrocarbon Discharges</u>

<u>Oil Spills</u>: Hydrocarbons may be discharged into the marine environment as a result of accidental spills. The volume of oil that enters the marine environment will depend on the type of accident and is difficult to predict. Once the oil enters the ocean, a variety of physical, chemical, and biological processes act to disperse the oil slick, such as spreading, evaporation of the more volatile constituents, dissolution into the water column, emulsification of small droplets, agglomeration sinking, microbial modification, photochemical modification, and biological ingestion and excretion. The rates at which the oil is removed from the ocean will depend on

water temperature, current movements which may spread dissolution, wind speed which may aid evaporation, and physical mixing by wind waves.

A large oil spill at the water surface may result from a platform accident (e.g., platform blowout) or leakage from a tanker accident. Subsurface spills could occur from pipeline failure or a wellhead blowout. Most of the oil from a subsurface spill would likely rise to the surface and would weather and behave similarly to a surface spill. However, some of the subsurface oil may also get dispersed within the water column, as in the case of the IXTOC I seafloor blowout (Fiest and Boehm, 1980). Depending on the density stratification of the water column and on temperature and salinity gradients, a subsurface plume may form.

Formation waters: Hydrocarbons are present in formation waters as small droplets or in dissolved form. The EPA requires that before discharge, formation waters be treated such that the concentration of oil does not exceed 72 milligrams per liter (mg/l) (ppm) for any 1 day nor exceed an average monthly concentration of 48 mg/l (40 CFR Part 435).

Gas Line Break or Leakage: A gas pipeline leak or break is not regarded as posing a substantial threat to water quality. The natural gas released would result in an increased level of light-molecular-weight hydrocarbons (C-2 to C-5), which would likely rise quickly to the surface and be released to the atmosphere. However, some localized disturbance of sediment may temporarily increase water column turbidity. Additionally, higher molecular weight hydrocarbons, commonly associated with deposits of natural gas, may also be released into the water column.

Deck Drainage: Deck drainage includes all effluents resulting from platform washings; deck washings; and runoff from curbs, gutters, and drains including drip pans and work areas. Constituents of concern in effluents are oil and grease. The NPDES permit regulations specify there should be "no discharge of free oil" in deck drainage that would cause a film, sheen, or discoloration on the surface of the water or cause a sludge or emulsion to be deposited beneath the surface of the water (40 CFR Part 435). In compliance with this requirement, contaminated deck drainage is collected by a separate drainage system and treated for solids removal and oil and water separation. The oil is then held for onshore disposal.

(6) Ocean Dumping and Incineration-at-sea

Ocean dumping of waste materials includes, or has included in the past, municipal sewage sludge, low-level radioactive wastes, and industrial wastes. However, on the basis of volume, dredging related to shipping is the largest single source of material that is dumped in the ocean. During 1979, more than 72 million yd^3 of dredged material were deposited in the marine environment (COE, 1980). The total constituted nearly eight times the combined tonnage of industrial wastes, sewage sludge, construction debris, and other waste material disposed of during 1979 (COE, 1980). Dredging of new channels and maintenance dredging of existing channels are required to provide safe and efficient navigation conditions for commercial and recreational marine transportation. Channel dredging generates significant amounts of dredged material consisting of the sediment and water mixture excavated from areas dredged. These materials are dumped at designated dredge spoil dumpsites, used as replacement materials for beaches, or used inland for reclamation projects. Compared with other materials that are disposed of in the ocean, most of the dredged material excavated in the United States is innocuous. In many instances, they contain no harmful pollutants and, in most of the remaining cases, contain only trace levels of contaminants. The primary concern associated with disposal of the relatively innocuous materials centers around the direct physical effects of disposal. These physical effects include burial of organisms, increased levels of suspended sediments, reduction in photo-synthesis, and accretion of disposed material (COE, 1978). However, dredged material taken from highly polluted areas is usually contaminated with harmful chemical constituents such as heavy metals, synthetic organics, oil, and grease. Open-ocean disposal of these materials poses the threat of acute or chronic toxic effects on marine organisms and potential contamination of human food resources. Much research has been conducted to describe the effects of dredged material disposal in the marine environment and to evaluate disposal options that may be preferable to ocean dumping.

b. <u>Nearshore/Onshore Oil and Gas Industry Activities</u>

Oil and gas industry activities and other onshore and coastal activities contribute to point source and nonpoint source pollution and, thereby, affect nearshore water quality.

Substantial amounts of oil and hazardous material enter the marine environment through spillage during loading and unloading operations in ports and harbors, pipeline leakage, equipment failures, and spills from land vehicles and storage facilities onshore. It should be pointed out however, that less than 2 percent of the oil entering the marine environment results from offshore production (NAS, 1985). Oil contained in urban and river runoff (spent oil and grease that wash from the streets and sewers of cities) is a major contributor to the oil content of the oceans. About 39 percent of the total annual oil pollution added to the seas is a result of accidental discharges from oil transportation (by tankers, pipelines, and barges) (NAS, 1985). The remainder enters from coastal facilities, industrial and municipal waste discharges, land runoff, natural seeps, and OCS-related activities.

Ocean outfalls of industrial wastes and those associated with oil and gas industry activities are regulated by the EPA through NPDES permits. Pollutants that may be associated with various industrial effluents include synthetic organic compounds, heavy metals, oxygen-consuming materials, suspended solids, and nutrients.

The construction and operation of onshore facilities supporting OCS-related activities may affect local onshore water quality by increasing the number of point and nonpoint pollution sources. Increases of nonpoint waste sources to site runoff may contribute particulate matter, heavy metals, petroleum products, and chemicals to local streams, estuaries, and bays, causing temporary elevations in turbidity and pollutant levels. During site preparation, the vegetation is cleared from the area, and the topsoil is compacted by the constant movement of heavy machinery. These, in turn, alter the retention properties of the soil and increase erosion and runoff from the site. By controlling the erosion generated within the construction site boundaries, several of the adverse impacts can be localized, and thus offsite impacts on water bodies can be prevented. Land clearing and associated development change the natural process of storm-water runoff. The volume and rate of runoff increase as the natural vegetation is modified.

Increases of point source discharges may also contribute to effluent discharges of domestic wastewater, cooling and boiler water, process water, and, in marine terminal areas, the discharge of ballast and bilge water. The following discussion on wastewater discharged to surface waters by OCS-related support facilities is largely based on the New England River Basin Commission (NERBC) (1976).

Wastewater effluents from OCS-related support facilities are commonly discharged to surface waters after treatment. Although the degree of environmental damage, if any, will be related directly to the toxic nature of the discharge and the biota present in the receiving waters, certain characteristics of the discharge zone are important. These characteristics include the size of the effective mixing zone (dilution factor) or the ratio of discharge volume to receiving volume; the flushing rate or residence time (estuaries characteristically have a slow flushing rate); and the physical-chemical characteristics of the receiving waters (e.g., marine waters have a higher buffering capacity than fresh or estuarine waters).

Domestic wastewater from support facilities will be collected and delivered to a municipal treatment plant or will receive secondary treatment in an onsite package treatment plant that includes chlorination before discharge to the receiving waters. These receiving waters may also contain high-organic carbon concentrations and organic chlorine compounds (e.g., chloroform and chloramines). These can be highly toxic to certain aquatic organisms. The discharge of properly treated sewage wastewater into urban harbors is not expected to measurably degrade the receiving waters.

Point source discharges are subject to treatment by municipal and industrial facilities in compliance with Federal and State discharge permit requirements. The NPDES permits are issued on a regional and a facility-by-facility basis, limiting the quantities of contaminants in and the temperature of each facility's effluent. The NPDES limits reflect a site-by-site analysis of flushing rates and mixing zones of the receiving water and the ability of indigenous populations to tolerate higher temperature and pollutant concentrations.

2. Effects on Marine Life (Effluents)

The effects on marine life by materials other than petroleum hydrocarbons, discussed in Chapter IV, Section A, that are discharged into the ocean are discussed in this subsection. Resuspended bottom sediments, drilling muds and cuttings, formation water, and discharged wastewater may all have impacts on marine biota. The effects on marine life from resuspended sediments resulting from pipeline laying or platform placement would primarily be through turbidity or smothering effects. These mechanisms of impact are believed to be the principal ones for drilling muds and cuttings; therefore, research conclusions regarding the effects of fluids and cuttings are applicable to sediment perturbations.

a. Resuspended Bottom Sediments

Bottom sediments are put in suspension during the emplacement of platforms and associated reentry collars, blowout preventers, and pipelines. Impacts associated with the resuspension of bottom sediments are due to increased turbidity and the release of pollutants from the sediments into the water column.

Suspended solids may significantly decrease light penetration in water, thereby decreasing photosynthesis in aquatic plants. These solids may also cause abrasive injuries, clog gills in fish, and smother eggs and larvae on the bottom. They may provide additional substrates for bacterial decay, leading to oxygen depletion in the lower water column. Alternately, they may contain nutrients that increase growth rates of endemic plant and animal populations.

The magnitude and extent to which sediment is put into suspension depend on the sediment type and grain size, water currents, and the duration of the activity. The anchoring of support vessels and the installation of subsea equipment will be short term, involve turbidity increases for a few days, and be limited to several tens of meters. Pipeline burial will involve much larger volumes of sediment over periods of several weeks and, thus, involve much larger volumes of resuspended sediment.

Sessile organisms within several meters of the activity could be buried. Turbidity increases would tend to decrease photosynthesis initially and later result in a decrease in phytoplankton productivity in shallow sunlit depths. However, turbidity increases will have virtually no effect on phytoplankton at depths below 100 m. In shallow depths, phytoplankton growth might ultimately be stimulated as nutrients in the resuspended sediments become available and as the turbidity plume disperses.

Plankton exposed to discharge and sediment plumes will be temporarily affected. Benthic communities are likely to change as a result of altered sediment parameters (i.e., grain size) or burial by sediments or muds and cuttings solids. Acute mortality of marine organisms from platform discharges or sediment resuspension is not expected because of relative low toxicity, rapid mixing, and dilution of all discharges. Some marine organisms are expected to incorporate some metals and hydrocarbons into their tissues, which may result in subtle reproductive, metabolic, and biochemical changes of unknown significance.

Turbidity plumes might temporarily disrupt the normal behavior (e.g., swimming and feeding) of zooplankton and fish in the area. Fish might avoid areas of high turbidity but soon return to feed on, and be attracted to, benthic animals exposed by the sediment turnover.

The release of existing pollutants (e.g., metals and pesticides) back into the water column as a result of sediment resuspension may occur in areas where coastal and offshore sediments have elevated levels of pollutants.

The extent of negative impacts on benthic species from platform settling and anchoring will vary depending on the type of platform and on the number of wells drilled. Effects could be compounded because of the proximity of the holes to each other or reduced by the use of a common dumpsite. Other factors that could modify impacts include accumulated depth of disposed muds, dispersal of muds through time by currents, and recolonization of deposition areas over an extended drilling period. Groundfish and benthic crustaceans and mollusks are most susceptible to these impacts. Very low impacts are expected because of the localized nature of the activity.

Pipelines may disturb soft bottoms for an area 20 m wide along their axis. Anchors may also disturb soft bottoms by being dropped and pulled along the bottom when pipelines are being layed. The disturbance will not be continuous from pipeline to anchor, but will occur at a horizontal distance of three to seven times the depth of the anchor. Trenches and mounds, which apparently can remain for over a year in certain soft bottoms, can result from this activity. In bottoms consisting of coarser sediments, like sand, the mounds and trenches probably do not remain as long. Assuming the composition of the bottom sediments remains the same after the pipeline or anchor disturbance, impacts on the soft bottom communities would be short term.

Pipelines traversing hard bottoms would cause disturbances of the same dimensions given above for soft bottoms. Attached organisms could be crushed by the pipelines or anchors, and repopulation may have to originate primarily from larval settlement. The time required for the community to recover to its original population structure (species distribution and size and age distribution within the species) could range from 1 year for kelp to approximately 10 years for mussels.

b. Drilling Muds and Cuttings

Drilling muds and cuttings are discharged into the ocean as described in Chapter III, Sections B and C. The fate and effects of fluids have been discussed at length in the Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings (Courtesy Associates, 1980), Dames and Moore (1980), Neff (1981), Petrazzullo (1981), NAS (1983), and in the Panel Report on Assessment of Fates and Effects of Drilling Fluids and Cuttings in the Marine Environment. Direct impacts of drilling fluids and cuttings are due to smothering or toxicity of mud components. Experiments by Shinn et al. (1974) indicate short-term (acute) toxicity of approximately 500 ppm for the hard corals *Montastrea annularis* and *Agaricia agaricites*. The research indicated hard corals could survive short-term impacts within 6 m of a discharge site. However, other research (Hudson and Robbin, 1980; Thompson and Bright, 1980; Kune and Biggs, 1980) showed sublethal impacts could be very damaging to corals within an estimated distance of 3 m from the discharge.

Chronic or sublethal effects of drilling muds have been examined on at least 40 species of marine animals (Neff, 1985). Some species, such as reef corals, lobster larvae, and scallop embryos and larvae, showed sublethal responses to drilling muds at concentrations that were two orders of magnitude below the acutely lethal concentrations. Neff (1985) concluded that organisms in the water column (i.e., plankton) will never be exposed to drilling muds long enough to show even sublethal effects because rates of dilution of drilling muds are so rapid. However, recruitment of larvae exposed to sediments with high concentrations of drilling muds was reduced in laboratory (microcosm) experiments, suggesting that adverse impacts on benthic organisms in the immediate vicinity of the platform may occur because of the slight toxicity of deposited drilling muds. Bioaccumulation of barium and chromium and a slight accumulation of copper, cadmium, and lead from drilling muds have been reported. Deposition of drilling mud solids may cause changes in sediment texture or simple burial of organisms beneath the platform, and result in very localized high impacts.

Drilling muds and cuttings contain toxic components including trace metals, biocides, and petroleum hydrocarbons in varying compositions and con-centrations. Bacteriocides in drilling fluids can be quite toxic, having LC_{50} values of less than 1 ppm. Toxicity bioassays for marine organisms exposed in situ to drilling muds and cuttings show relatively high LC_{50} levels (the lethal concentration at which 50 percent of the organism tested survives when exposed to the test solution for a given period, commonly 96 hours). Salmonids had LC_{50}'s ranging from 4,000 to 190,000 ppm, and shrimp showed an LC_{50} of 1,400 ppm (B.C. Research, 1976; Dames and Moore, 1978). Other LC_{50} values for species in the Lower Cook Inlet COST well study including amphipods, mysids, isopods, and brine shrimp larvae ranged from 500 to 2,000 ppm (Dames and Moore, 1978).

The toxicity of drilling mud has been debated among groups concerned with OCS-related impacts. The present data, although having shortcomings in several cases, indicate that muds have low toxicity when compared to petroleum hydrocarbons, trace metals in wastewater, or industrial wastes. This conclusion is based primarily on short-term, 96-hour static bioassays of used drilling muds and drilling mud components. The most commonly used water-based drilling muds (offshore discharge of oil-based muds is prohibited) are classified as "slightly toxic" (based on the whole, undiluted mud) to "practically nontoxic" according to aquatic toxicity grades used by the international scientific community (Jones et al., 1986). Eight generic offshore mud systems with commonly used additives were tested at EPA's Gulf Breeze (Florida) laboratory. Using a 9:1 dilution (to simulate dilution of the mud system as it is discharged into the receiving water) of the suspended particulate phase, researchers found that the most toxic system had a LC_{50} of 27,000 ppm (using mysid shrimp as a test organism), whereas all the remainder systems were less toxic (Duke, 1984). The general NPDES discharge permit for the GOM requires that drilling fluids meet a LC_{50} of 50,000 ppm. Exceptions to this limit have been granted by EPA, on a case-by-case basis, for muds used in special drilling situations. Research has also included a number of sublethal and long-term (106-day) experiments with a number of invertebrates, crustaceans, annelids, mollusks). The sublethal and long-term study data tend to support the conclusion of low toxicity of muds, but some data indicate interference with growth in oysters and pecten clams at concentrations of 100 ppm. Differences in results among studies are probably due, in large part, to the differences in the methods of testing rather than differences in the toxicity of muds. There currently is no standard method for long-term testing of exposure of marine organisms to drilling muds.

It should be pointed out that any toxicity associated with drilling muds and cuttings (as opposed to their physical effects by possible smothering) is most likely attributable to the presence of diesel fuel used in mud as a lubricity agent. Trace metals in water-based muds may present some toxicity to marine organisms, but generally it seems that toxicity values are low (high ppm or ppt required to elicit toxic effects). Many organisms, making use of a class of proteins called metallothioneins, are able to bind up trace heavy metals allowing organisms to accumulate what would otherwise be stressful levels of metals. As in the case of shellfish, water quality changes may not kill the organism but may contaminate it so that it cannot be a safe food source for humans. Tainting of the flavor may also occur, making it undesirable for human consumption. These metals may also exhibit a toxic effect to consuming organisms higher in the food chain due to biomagnification (NERBC, 1976).

Since the magnitudes of the potential impacts are directly related to the concentrations of the muds and cuttings, factors that will increase dispersion are important impact-reducing determinants. The most important of these would be the magnitude and direction of currents within the water column and the water depth.

Approximately 90 percent of the releases of drilling muds and cuttings are transported toward the seafloor in the primary discharge plume. The remaining 10 percent, which are typically the lighter or smaller particles, form a surface plume that usually dissipates within 1,000 m of the discharge site. If the 90 percent that settle toward the ocean bottom encounter a pycnocline (zone of rapid density changes), a secondary plume may form. It is expected that this would occur in deeper water where a well-established thermocline may be present. The drilling cuttings would settle directly to the bottom in the vicinity of the well. However, the extent of dispersion would depend on water depth and water current velocity. Decreases in primary or secondary production from the elevated turbidity are expected to be minimal because of the localized and temporary nature of the discharge effects. It is estimated that any decrease in productivity is short term, localized, and indistinguishable from naturally occurring spatial or temporal variability.

The degree of impact of these discharges on benthic and demersal species depends greatly on local environmental conditions (e.g., water depths, currents, wave regime, and substrate) and on the nature and volume of the discharges including cutting sizes, discharge depth, and discharge rate.

Localized impacts on benthos from drilling muds and cuttings will be evident during the initial drilling when the involved fluids and solids are ejected at the sediment surface. Approximately 8,000 ft^2 (744 m^2) per well are expected to be covered by up to 1 m of drilling discharges. Impacts that result from drilling fluid discharges are extremely localized. They can include smothering of organisms around the borehole and some distance downcurrent depending on the hydrodynamics of the area, localized change of sediment granulometry, increase in body burdens of barium in local benthic invertebrates, interruption of filter-feeding patterns because of elevated levels of suspended particulates, and increased sedimentation rate around the well from routine or bulk discharges. The latter is highly variable depending on discharges, water depth, and current regime.

In the case of production platforms, the communities within sediment bottoms probably will recolonize after a period of time; however, the colonizing species may not be those organisms characteristic of the surrounding areas. Recolonization will come from within the buried sediments and from outside by larval settlement. Impacts from drilling muds and cuttings are of shorter duration than those from permanent platforms and are probably of less consequence. However, the impacts occur for at least as long as wells are drilled from the platform, or for about 6 to 8 years.

A significant interference with ecological relationships of the sea bottom ecosystem will occur in approximately a 1-kilometer radius around the platform for a period of less than 2 years. Due to burial effects, abundance levels of macrobenthos are temporarily reduced in the vicinity of the wellsite, and there is usually an accompanying increase in megabenthos abundance levels (NRC 1983). However, since impacts will probably remain localized, the impact on the generally soft bottom outside the affected area will be short term, lasting less than 1 year, with insignificant interferences with ecological relationships.

The potential impacts on plankton resulting from the release of muds and cuttings into the environment include the following: (1) increased turbidity causing decreased primary production because of reduced light levels, (2) increased particulate levels causing interference with or damage to filter-feeding apparatus, and (3) acute or chronic toxic effects from the constituents of the drilling muds.

c. Formation Water

Formation water may affect both water quality and marine life. The primary concern regarding biological effects of formation water centers on the trace metal content, hydrocarbon content, and oxygen demand (amount of dissolved oxygen removed from the ocean by chemical action) of this discharge.

Acute toxicity of formation water was investigated by Zein-Eldin and Keney (1978) and Rose and Ward (1981). The earlier study reported 96-hour LC_{50}values for juvenile white shrimp of 1,750-6,000 ppm formation water and a second set of data showing 96-hour LC_{50} values greater than 100,000 ppm. The first set of values were obtained using formation water treated with two biocides, whereas the second data set was obtained from untreated formation water. The lowest 96-hour LC_{50} values obtained by Rose and Ward were 7,000-8,000 ppm formation water for larval brown shrimp. This formation water had a high BOD relative to the conditions around the real discharge in the Buccaneer Oil Field (Gulf of Mexico). It seems, therefore, that acute toxicity of formation water may be associated principally with removal of oxygen from seawater or indirectly by biocides added to waters before discharge.

The long-term sublethal effects of formation water are unknown (beyond the lack of obvious effects in historical producing areas such as the Gulf of Mexico) although the sublethal effects of trace metals on organisms are known for a variety of metals and marine organisms (e.g., Reish et al., 1976; Oshida, 1977). Galloway et al. (1980), studying the effects of formation water on the fouling community on platforms in the Buccaneer Oil Field and the associated reef and demersal fishes, found reduced biomass and production levels restricted to 1 m vertically and 10 m horizontally in the fouling community on the platform. Galloway found elevated alkane levels in sheepheads collected near the platforms but less than normal histopathological anomalies (fish were "healthier" near the platforms). Crested blennies around the platforms showed results similar to the sheepshead; spadefish showed no evidence of petroleum or trace metal contamination attributable to Buccaneer Oil Field operations; and red snapper showed gill deformities in 62 percent of the fish collected. EPA (1985), in considering a declining catch-versus-effort in the fisheries industry in the GOM, notes that, although not definitive, the evidence raises an environmental concern with respect to discharges from oil and gas platforms. Other causes, such as overfishing, may also account for the decline in catch-versus-effort. However, more work is needed to understand the population dynamics of the red snapper and to determine if the correlation between red snapper gill abnormalities and formation water discharge is real.

d. Discharge Wastewater

Wastewater effluents from OCS-related facilities produce a wide range of responses in the receiving waters. Environmental responses produced will depend upon the quantity and kind of pollutants discharged or spilled. Heavy metals (such as zinc or copper), although often essential or nontoxic to organisms in very low concentrations, become toxic in higher con-centrations. Even if the concentration of a heavy metal in the water is not toxic, it may accumulate in tissue with ultimately lethal effects.

Ammonia can alter the pH of water, thus harming pH-sensitive organisms. Antifouling substances, which are added to cooling water to kill algae and bacteria, have similar effects on the organisms present. Suspended solids significantly decrease light penetration into the water, thus decreasing photosynthesis in aquatic plants. They also cause abrasive injuries, clog gills in fish, and smother eggs and larvae by blanketing the bottom. Suspended solids that settle on the bottom provide additional substrates for bacterial decay, leading to oxygen depletion of the bottom waters. Thermal discharges can alter the chemical nature of receiving waters in many ways. Solubility of dissolved oxygen, toxicity of heavy metals, and metabolic rates of aquatic organisms are affected by changes in water temperatures.

The environmental impacts associated with oil and heavy metal pollution in the marine environment include both toxic and sublethal responses. Juvenile forms of many species of marine fauna are particularly sensitive, and an age class may be totally eliminated by a specific dosage of oil or some heavy metal. Sublethal physiological alterations include depression of growth and photosynthesis in marine flora.

3. Air Quality

This section describes the most commonly emitted air pollutants associated with typical OCS activities. Included are nitrogen oxide

(NO_x), carbon monoxide (CO), sulfur oxide (SO_x), total suspended particulates (TSP), and volatile organic compounds (VOC), all of which are regulated by Federal and State agencies to prevent adverse effects of human health and welfare. Ozone is not emitted directly by any source, but is formed in a photochemical reaction in the atmospheric involving primarily VOC and NO_x.

Nitrogen oxide consists of nitric oxide (NO) and nitrogen dioxide (NO_2). Nitrous oxide and NO_2 are formed through the combination of oxygen and nitrogen in the air during combustion processes, and the rate of formation increases greatly with combustion temperature. Nitrogen dioxide is formed in the free atmosphere by the oxidation of NO.

Carbon monoxide is formed by incomplete combustion. It is mainly a problem in areas having a high concentration of vehicle traffic. Carbon monoxide is a serious health threat to humans when present in sufficient concentrations due to its preferential adsorption by blood hemoglobin.

Sulfur oxide is formed by the combustion of fuels containing sulfur. Emissions are usually in the form of sulfur dioxide (SO_2). Sulfur dioxide in the atmosphere can go through a series of chemical transformations, which may result in the formation of sulfuric acid droplets and sulfate particles. Entrainment of SO_x or sulfate particles into storm clouds may contribute significantly to reduced pH levels in precipitation (acid rain).

Total suspended particulate emissions are from combustion processes and sources that are associated with construction activities. Most particulates are less than 10 microns in diameter. However, all particulates 10 microns and less in size can cause adverse health effects and may also contribute to a degradation in visibility.

Fugitive sources of VOC emissions are crude oil storage and transfer operations, processing of hydrocarbon compounds, and incomplete combustion of fossil fuels.

Facilities used for the exploration, development, and production of oil and gas in OCS waters are subject to DOI air quality regulations (30 CFR 250.57). Examples of facilities include exploratory drilling vessels and production platforms. During production, multiple installations or devices are considered to be a single facility if they are directly related to the production of oil or gas at a single site. Any vessel used to transfer production or to support an OCS facility is considered part of the facility while it is physically attached to the facility. Crew boats, supply boats, and tankers while in transit to or from OCS facilities are not regulated by the DOI air quality regulations; however, in the Pacific Region, idling emissions from support vessels at the offshore facility are regulated by the DOI air quality regulations. Additionally, pile driver barges or other construction-related vessels are included while at platform.

The air quality regulations designed by DOI specify emission exemption levels. If a source exceeds the exemption level, air quality modeling is required to determine whether the emission would significantly affect onshore air quality. The highest annual total amount of emissions from the facility for each air pollutant is compared to an emission exemption amount. This exemption level is based on distance from shore. Exemption levels are established for CO, NO_x, SO_2, TSP, and VOC. Current and planned facilities with projected emissions below these levels are exempt from further regulatory requirements, unless the facility, in combination with other facilities in the area, would significantly affect the air quality of an onshore area (30 CFR 250.57-1(j)). The exemption level for CO is E = 3,400 D raised to the 2/3 power, where E is the emission exemption amount expressed in tons per year and D is the distance of the proposed facility from the closest onshore area of a State in statute miles. For TSP, NO_x, SO_2, and VOC, the exemption level is E = 33.3 D. The exemption levels apply to any offshore installation and related storage and processing facilities.

For any facility with projected emissions above the exemption levels for any pollutant other than VOC, an approved air quality model must be used to determine whether projected emissions from the facility would significantly affect air quality impacts onshore. If such projected emissions are above the DOI significance levels (table IV-5), the applicant would be required to apply Best Available Control Technology (BACT), an emission limitation based on maximum degree of reduction considering energy, environmental, and economic impacts.

Table IV-5
Signficance Levels (ug/m_3) Above Which
Best Available Control Technology Is Required

Air Pollutant	Average Time (Hours)				
	Annual	24	8	3	1
SO_2........	1	5	....	25	....
TSP........	1	5	....	....	....
NO_2........	1	....	....	....	....
CO	....	....	500	....	2,000

Any source with VOC emissions above the exemption level is considered to significantly affect the air quality of an onshore area for VOC and emission reductions would be required through the application of BACT (CFR 250.57-1(g)(3)).

If projected emissions from an OCS facility, except a temporary one, significantly affect onshore air quality of a nonattainment area (designated region in which pollutant concentrations in ambient air do not meet National Ambient Air Quality Standards [NAAQS]), the emissions shall be "fully reduced." This term means that the lessee's net emissions increase must be reduced to zero. This reduction shall be done through BACT and the application of additional emission controls or through the acquisition of offshore or onshore offsets (CFR 250.57-1(g)(1) and 250.57-1(g)(3)).

Onshore facilities are not under the jurisdiction of MMS. These facilities are regulated by the local air pollution control district (APCD). The EPA and the State regulatory agency are responsible for assuring that the APCD's implement a program that adequately addresses all provisions required by the Clean Air Act (CAA).

Impacts from offshore oil and gas development on onshore air quality depend on many factors including distance of the activity from shore, production rate, type of equipment used, mode of transport of crude oil, proximity to other oil and gas development activities, and degree of existing onshore air quality degradation. Tables IV-6 through IV-8 present emission rates typically associated with various OCS operations offshore California. The technical assumptions made in these calculations are described in detail in Pacific OCS Technical Paper No. 83-3 (FSI, 1983).

The type and relative amounts of air pollutants generated by offshore operations vary according to phase of activity. There are basically three phases: the exploration phase, development phase, and production phase. A more detailed discussion of emission sources associated with each phase is presented in Pacific OCS Technical Paper No. 83-8 (FSI, 1983). The various emission sources are described below.

Sources of offshore air emissions during the drilling of exploratory wells include diesel-fired engines that power the drilling units and engines that power the tug boats, crew boats, and supply boats. Pollutants primarily consist of NO_x, with smaller amounts of CO, VOC, and TSP. The development phase consists of platform installation, pipeline construction, and drilling of developmental wells. During the installation of a platform, air emissions are associated with derrick barges, tugboats, and cranes.

Pipeline installation results in similar types of emissions, but total amounts are much lower since they occur over a much shorter period of time. The drilling of development wells is initially performed by diesel engines; however, once production starts, natural gas turbines or reciprocating engines are used. The largest contribution to air emissions during development consists of NO_x, whereas emissions of CO, VOC, SO_x, and TSP are considerably smaller. However, NO_x emissions are reduced substantially once the diesel engines are replaced by natural gas turbines or reciprocating engines. Table IV-6 lists typical emission rates associated with exploration and development activities.

Onshore emission sources during the exploration phase would consist of vehicles transporting personnel and materials and support vessels operating in port. During the construction phase, typical onshore activities are construction of gas processing facilities and pipeline systems. Onshore emission sources during the production phase would consist of crude oil storage facilities, pipeline systems, gas processing plants, and refineries.

During oil and gas production, the primary source of emissions is from natural gas turbines or reciprocating engines that provide power for oil pumping, water injection, and gas compression. The emissions consist primarily of NO_x with lesser amounts of CO, VOC, TSP, and SO_2. Other sources of air pollutants include leakage of hydrocarbon vapors from oil-water separators, pump and compressor seals, valves, and storage tanks. Flaring may take place periodically to burn off excess gas, resulting in some emissions of SO_2 and NO_x. If the gas produced is high in hydrogen sulfide (H_2S), the gas would have to pass through a desulfurization unit. Table IV-7 shows offshore emissions from production facilities in the case where oil is shipped to shore via pipeline.

If barges or tankers are used to transport crude oil to shore, emissions of VOC result from tanker loading operations. Emissions of SO_2, NO_x, and TSP from the ship's engines occur during loading operations, tanker transit, and tanker operations in port. Emissions of VOC also occur during unloading and ballasting operations in port. Table IV-8 lists typical emissions from production activities in the case where oil is transported to shore via tanker.

Table IV-6
Typical annual air emissions for exploration and development activities

Activity	Pollutant Emissions (tons/years)					Notes
	VOC	NO_x	SO_x	CO	TSP	
Exploratory Drilling	28.0	175.6	14.0	34.0	14.5	NO_x emission values for power generation from Radian (1982). All other emission values obtained from FSI (1983). Assumes four 10,000-foot exploratory wells drilled, about 90 days for each well. Includes emissions from support vessels at site and during transit.
Platform Installation	8.5	192.0	13.0	34.4	10.7	Emission values from FSI (1983). Includes emissions from support vessels.
Pipeline Installation	1.8	31.6	2.1	6.1	2.0	Emission values from FSI (1983). Includes emissions from support vessels.
Development Drilling	7.9	106.2	4.6	40.4	5.1	Emission values from FSI (1983). Assumes eight 10,000-foot wells drilled per year. Includes emissions from support vessels.

Table IV-7
Typical annual air emissions for exploration and development activities

	Pollutant Emissions (tons/years)					Notes
	VOC	NO_x	SO_x	CO	TSP	
Offshore Platform	25.7	99.0	0.7	69.3	5.5	Emission values from FSI (1983). Assumes 12,000 barrels/day of oil and 16 million ft^3/day of gas produced.
Support Vessels	0.9	42.4	2.9	6.4	1.9	Emission values from FSI (1983). Assumes one crew boat trip/2 days and one supply boat trip/2 days. Includes emissions during transit for a 50-mile round trip.
Onshore Gas Processing	13.6	39.8	21.0	4.8	3.5	Emission values from Dames and Moore (1982). Assumes 60 million ft^3/day of gas.

Table IV-8
Typical annual air emissions for oil and gas production activities, tanker scenario

	Pollutant Emissions (tons/years)					Notes
	VOC	NO_x	SO_x	CO	TSP	
Offshore Platform	23.9	87.0	0.6	60.5	4.9	Emission values from FSI (1983). Assumes 12,000 barrels/day of oil and 16 million ft^3/day of gas produced.
Offshore Storage	158.3	2.2	10.2	0.5	1.2	Emission values from FSI (1983). Assumes 42 tanker trips/year.
Support Vessels	0.9	42.4	2.9	6.4	1.9	Emission values from FSI (1983). Assumes one crew boat trip/2 days and one supply boat trip/2 days. Includes emissions during transit for a 50-mile round trip.
Tanker Transit	1.1	25.7	91.6	1.8	5.9	Emission values from FSI (1983). Assumes 42 tanker trips/year, 600-mile round trip.
Tanker in Port	11.6	4.6	6.4	0.6	0.7	Emission values from FSI (1983).
Onshore Gas Processing	13.6	39.8	21.0	4.8	3.5	Emission values from Dames and Moore (1982).

a. Accidents

Accidental emissions include those associated with oil spills and blowouts with or without fires. These events would be very rare; however, the associated emissions to the atmosphere would be great. For an oil spill, the hourly emission rate of VOC per 1,000 bbl of oil spilled would be 28.5 tons for the first hour and 14.5 tons for the second hour (FSI, 1983). A blowout of 1,000 bbl/day of oil and 1 million ft^3/day of gas would result in emissions in the amount of 2,000 pounds/hour (lb/hr) of hydrocarbons and 33 lb/hr of H_2S. A blowout of the same size accompanied by a fire would reduce hydrocarbon emission to 670 lb/hr, but emissions resulting from combustion would include 46 lb/hr of NO_x, 417 lb/hr of SO_x, 670 lb/hr of CO, and 140 lb/hr of TSP (FSI, 1983).

If an oil spill is ignited immediately after spillage, the burn can combust the lighter fraction of crude oil that otherwise would evaporate. This lighter fraction constitutes approximately 33 to 67 percent of the total volume. On the other hand, incomplete combustion injects oily soot and minor quantities of other pollutants into the air.

b. Mitigation

Air emissions from OCS exploratory, development, and production activities may be mitigated through a number of different emission control measures. Nitrogen oxide emissions from diesel engines used for exploratory and development drilling can be reduced by fuel injection timing retard and/or by intake air cooling (the particular technique depending upon the make and model of the engine). Fugitive hydrocarbon emissions from exploratory drilling may be reduced by piping vapors to a flare system for incineration. Sulfur dioxide emissions from diesel engines on the platform and from support vessels may be reduced by requiring the operator to burn low-sulfur diesel fuel. Sulfur dioxide emissions from flaring during drill stem testing may be reduced by removing excess H_2S from the gas stream by a slurry system.

Nitrogen oxide emissions from gas-fired turbines used to drive electrical generators, gas compressors, and water injection pumps can be mitigated by injecting water into the combustion chamber of the turbine. Nitrogen oxide emissions from process heaters, glycol regenerators and amine regenerators can be reduced by using electric heaters (with power supplied through subsea cables), by using low NO_x burners, or by using waste heat recovery from turbines or diesel engines. Nitrogen oxide emissions from diesel engines may be reduced by turbocharging, with intercooling, or by fuel injection timing retard. Engines that have a precombustion chamber can have lower NO_x emissions by combustion chamber design. If the emission controls above do not reduce impacts satisfactorily, power may be supplied by onshore generated electricity using subsea power cables. However, the use of subsea cables may not be feasible at large distances from shore.

Fugitive VOC emissions can be reduced by using valves, seals, and other components that are designed to result in low gas leakage. Further reduction is assured by requiring the operator to conduct a rigorous maintenance and inspection program. Fugitive emissions from storage and transfer of fuel can be reduced by using balance lines.

In the case where crude oil is transported by tanker, use of a vapor balance line during tanker loading operations would eliminate most of the fugitive VOC emissions. Other possible measures include the use of a submerged fill pipe during tanker loading, or vapor-freeing empty cargo tanks while the tanker is in transit at sea. Use of tankers with segregated ballast would eliminate most VOC emissions when the tanker takes on ballast after unloading crude oil in port.

Sulfur dioxide emissions from gas-fired engines and heaters can be reduced by treating the gas before burning by removing H_2S. This treatment is accomplished by a slurry system that interacts chemically with the H_2S to remove it. Amine regeneration has been used successfully on platforms in the Pacific Region. The acid gas resulting from this process must be treated by a slurry mixture or a sulfur recovery system.

None of the emission control measures discussed above would eliminate all emissions. If emission controls are not sufficient to prevent significant deterioration of onshore air quality, the operator is required to obtain offshore or onshore emission offsets.

G. Impacts on the Socioeconomic Environment

1. Impacts on Employment and Demographic Conditions

Oil and gas exploration, development, and production activities on the OCS, as well as service and processing facilities onshore and offshore, may result in changes in the socioeconomic characteristics of the coastal region. The degree to which an area is affected by economic change depends primarily on the size and nature of the activities and the area's economic base. The important socioeconomic indicators are current levels of employment and income, the availability of housing and public services, and the existing oil and gas infrastructure.

The regional economic effect involves an initial impact and a secondary impact. The initial impact is defined as an initial change in final demand for a set of industries, whereas the secondary impact results in changes to all economic sectors from the initial impact.

Estimates of income, population, and housing are based on total or new resident employment using gross region or industry specific ratios, such as the average payroll per employee, population-employment ratio, or average housing units per population. Direct employment projections are based on the activities represented in the following list of parameters.

(1) Delineation and Exploratory Wells

(2) Development Wells

(3) Platforms

(4) Pipeline Landfalls

(5) Treating Facilities

(6) Marine Terminals and Storage Facilities

The level of socioeconomic impact of an area is measured by comparing the base case to the new resident employment and demographic results. Impact conclusions are based on the percent change from the base case conditions resulting from activity.

2. Impacts on Coastal Land Use and Water Services

During the exploratory phase, temporary support bases (5-10 acres each) may be needed. Due to the temporary nature of the exploratory phase and the availability of existing ports, land-use impacts are generally very low. Land-use impacts may occur if existing harbors need to be expanded to accommodate a temporary support base. Because of the competition for space in may of the smaller harbors, the possibility exists that increased activity may displace former users if a harbor cannot be expanded.

The construction phase may have variable land-use impacts depending principally on the size of the community and the availability of existing onshore oil and gas infrastructure. Land-use impacts may be low in larger communities that have available industrial land and adequate harbor facilities and that are already supported by existing oil and gas infrastructure. Smaller coastal communities that are not tied into the existing oil and gas infrastructure may need to devote land use to supporting pipelines, pipeline installation and service base, pumping stations, and gas processing and treatment plants. Induced impacts may include the need to construct additional housing, schools, water lines, sewer lines, and other community services to support the increased population. Land-use impacts may be high in small communities seeking to preserve tourism, fishing, and agriculture as their economic base.

During pipeline installation, damage to an area about 20 m wide could occur where the pipeline comes ashore. Recovery from this type of disturbance should occur within 2 years, with no toxic residues left in the area from the operation.

The production and decommissioning phases are anticipated to have low impacts on land use. Impacts are expected to be low during the production phase due to the lack of demand for additional land and the slackening of economic growth because construction activity is completed. During decommissioning, land-use impacts are expected to be low due to the shutdown of onshore facilities no longer needed to support offshore activities. Land no longer needed to support offshore oil and gas activities, therefore, becomes available for other uses, which lessens the need to develope additional land. Smaller communities can be expected to experience a greater economic downturn than the larger communities. On a percentage basis, smaller communities will have more developed industrial, commercial, and residential land become available for other uses than the larger communities.

The availability of freshwater tends to be a limiting factor for determining if a community can absorb additional population and economic activity. Potential impacts resulting from shortages in freshwater supplies would include rationing, building moratoriums, displacement of some industry and commercial activities, overdrafting groundwater supplies, saltwater intrusion, and/or the need for some users to supply their own water. The availability of and access to wastewater treatment facilities are not as critical as access to freshwater. If wastewater treatment facilities are stressed, building moratoriums may be instituted until additional capacity is constructed. Periods of peak flow can also cause excess wastewater to pass untreated through the system and be dumped into the ocean. This dumping can result in the degradation of water quality around the sewer outfalls.

3. Impacts on Recreation and Tourism

Oil spills, offshore structures, and pipelines can potentially affect recreational resources. Although use of recreational areas fluctuates dramatically with weather conditions, the trend is for a growth in use over time due mainly to population increases and increases in discretionary time and money. It is important to note that an impact on any of the recreational resources would affect the local economic conditions and could affect the other recreational resources in the area by both translocation of the recreationists and by making the resources less desirable.

A key factor in the level of impact on coastal recreation resources is the time of year the accident occurs. Although the summer is generally the peak season for coastal recreation and tourism, a spring beaching occurrence could potentially have even more serious impacts than a summer spill. Springtime planning for the popular summer vacation could be heavily influenced by adverse publicity associated with a particular beaching occurrence, causing recreation activities to shift to alternative areas.

Many recreation or tourism operators are small, marginally profitable enterprises. The loss of most or all of a summer season's income could not only cause the obvious loss of jobs and income, but also may undermine the viability of the enterprises for succeeding summer seasons. Moreover, people who vacation and/or periodically recreate in an alternative locale during that summer season may prefer the new locale and avoid the affected locale in subsequent years, even though the area was once again suitable for use. On the other hand, with a spill being localized, and given the tendency of people to select nearby, similarly situated areas as an alternative (if available), the net loss of participation on a regional and even county basis might be only marginal. Such effects were observed after the 1969 Santa Barbara Channel oil spill.

The peak summer tourist season would undoubtedly be disrupted in the event of a major oil spill, at least for the duration of spill beaching and cleanup operations. If a beach is relatively accessible, cleanup can be accomplished in a matter of days through the mechanical removal of oil-soaked sand. Efforts to replenish the sand, if necessary, could take an extended period of time.

A spill during the fall or winter season would not result in as significant an impact on coastal recreation and tourism because of seasonal reduction in demand. Additionally, an oil-beaching occurrence during this time of year would not significantly impact the following summer season's activity, assuming timely and effective cleanup activities as well as sufficient positive publicity of these activities.

Numerous actual oil spills have occurred that present the opportunity to examine and evaluate the impacts of a spill in a given situation with variables identified. These case studies, though not predictive of future oil spills, do provide illustrations of the nature and extent of impacts on various resources. Summaries of various historical spill studies are provided below, especially as they relate to the recreation and tourism industry.

The world's largest accidental oil spill, Mexico's IXTOC I, contacted coastal areas of Texas. The economic effects of the spill were examined in an MMS-funded study (Restrepo and Associates, 1982). This study found that total tourism and recreation losses were about $6.5 million, primarily in the communities of South Padre Island, Port Isabel, and Port Aransas. The losses were not distributed equally in the affected areas; rather, they were absorbed by a mall number of businesses close to the water's edge in the recreation-oriented areas. There is evidence that the recreation business loss at the water's edge was offset with additional recreation-related spending elsewhere in the area. Interviews with persons associated with waterfront businesses in the affected area indicated that losses occurred only in 1979; these losses did not continue for 1980 and 1981.

Studies of the January-February 1969 Santa Barbara oil spill indicated similar impacts (Mead and Sorensen, 1970). Short-term trade diversion occurred as a result of the spill, depressing the motel and restaurant business near the ocean in favor of the neighboring Goleta area. Overall tourist activity in the county, however, was not significantly affected by the spill, and, as a result, no social costs could be determined. Similarly, no measurable permanent damage to tourism occurred as a result of the IXTOC I spill offshore Mexico.

The wreck of the Amoco Cadiz in March of 1978 affected about 400 km (about 250 mi) of the Brittany coast of France. Studies by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (DOC, NOAA, 1983), indicated that economic losses to the tourist industry in the area totaled between $28 million and $60 million. Nonmarket-valued social costs associated with recreation in the area were estimated to be $13 million to $82 million.

Other spills have had little or no effect on local travel industries. The Argo Merchant that ran aground and sank approximately 29 mi southeast of Nantucket Island, Massachusetts (unrelated to OCS activity), resulted in no measurable losses to the tourist industry. No oil actually came ashore as a result of this spill. Tourist trade after the spill was as good as or better than the previous season (DOC, NOAA, 1977).

During the first 6 months of the United States' involvement in World War II, the waters within 50 mi of the U.S. Atlantic coast experienced the destruction of numerous merchant vessels and cargo ships by German U-boats. This destruction included the spillage of roughly 3.5 millon bbl of oil--the equivalent of 20 Argo Merchants, almost 1 per week for 6 months. Although the vast majority of this oil made its way out to sea and dissipated, significant amounts did contact the coastline. Although the exact impact of these World War II sinkings on the tourist and recreation industry has not been quantified, it can be stated with some certainty that, at least locally and in the short term, significant adverse economic impacts were experienced, especially on the New Jersey shore. However, available documentation (Campbell et al., 1977) indicates that the overall effects of the oil spills were "negligible," and the regional economy "survived with little difficulty."

Title III of the OCSLA, as amended, established an Offshore Oil Spill Pollution Fund. Through this fund, persons who sustain an economic loss as a consequence of oil pollution arising from OCS activities can be compensated. The regulations that implement this appear at 33 CFR Parts 135 and 136 and are administered by the USCG. Part 136 of the regulations sets forth the claims procedures. Thus, if OCS activities were to result in an oil spill that reached shore, owners and users of areas important for coastal recreation and tourism would be entitled to apply for compensation through this fund.

Recent concern has been expressed about the problem of trash and debris on shorefront recreational beaches. Some local governments of coastal Texas share this concern, as noted from newspaper reports. A special report on beach litter prepared by the State of Texas surmised that 75-90 percent of all the litter on coastal beaches comes from the marine environment. Because of predominant water current regimes, south Texas beaches are being impacted by debris and chemical drums from merchant marine, fishing, and oil and gas activities originating from the western GOM, the central GOM, and Mexican waters. The USCG, under provisions of the Superfund program, is tasked with removal, analysis, and disposal of potentially hazardous materials. Analysis of the contents of approximately 300 drums washed up on Texas beaches between December 1984 and October 1985 showed over 50 percent contained materials classed as hazardous, and many contained materials associated with oil and gas drilling operations. No deaths or injuries by beach users stemming from these drums have been recorded, but the potential for such incidence is considered high.

Approximately one-fourth (140 mi) of the Texas shorefront is composed of major recreational beaches. Tourism may be adversely affected by beach debris. Although oil and gas trash and debris are a part of this problem, its effect on visitation trends, recreational use, and enjoyment of Texas beaches is poorly understood.

The level of impact to recreational resources caused by an offshore platform is mainly visual and depends upon the distance of the platform from the shore and the recreational resources that are on the stretch of coast adjacent to the platform's site. The farther offshore a platform is located the lower the level of impact that will occur to the onshore resources. On the other hand there are positive effects of these structures. They form artificial reefs which attract fish and sport fishermen; they also serve as navigational aids and a haven for vessels in distress.

Pipelines, particularly pipeline landfalls, have the potential for adversely affecting the coastal recreation activities. Recreational beaches have previously been used for landfalls of pipelines. For example, in 1967, Transco constructed a natural gas pipeline connecting New Jersey and Long Island with the eastern landfall at Long Beach, New York. Long Beach is a sandy, heavily used, recreational beach on the southern shore of Long Island, about 15 mi from Manhattan. Installation of the pipeline at Long Beach occurred during September, so that there would be no conflict with peak summer recreational use of the area. The beach restoration was completed by the end of November, and the beach was available for recreational use the following summer. The landfall remains virtually unchanged and indistinguishable from its surroundings (NERBC, 1981).

Recreational beaches in other parts of the country have also been used as pipeline landfall sites. A pipeline landfall and beach crossing at Padre Island National Seashore in Texas removed 1,200 to 1,500 linear ft of shoreline from public beach use for approximately 2 to 3 weeks during the peak season. This construction phase disrupted access to heavily used areas and required detour routes. Two other pipeline landfalls, also constructed during peak season, did not present problems because of low usage levels in the affected areas. Burial of the pipeline in nearshore waters tended to attract sport fishermen. Most predictable adverse effects, such as disruption of public access or impacts on visual amenities, are temporary and associated with the construction phase. As long as construction is timed for an off-peak season for recreational use, and the site is restored to its previous condition, there should be little conflict between the landfall or right-of-way of the pipeline and the potential or actual recreational use of the land. Future pipeline landfalls may use directional drilling technology, further reducing the onshore impacts of pipeline construction.

4. Impacts on Archaeological Resources

Archaeological resources are prehistoric pertaining to the period of time before written records) and historic pertaining to the period of time for which written records exist) districts, sites, buildings, structures, or objects.

Prehistoric resources occur on the OCS as a result of the late Wisconsin ice-age lowering of sea level. This lowering of sea level exposed millions of acres of former seafloor, which were subsequently occupied by plants, animals, and then man. Prehistoric sites on today's OCS occur on similar landforms drowned stream canyons, ancient estuaries and lagoons, sediment-filled bays; and islands), as sites of a comparable age are found on land. These relict landforms occur shoreward of the 18,000 years before present shoreline.

Historic resources on the OCS, the majority of which are shipwrecks though sunken aircraft do occur, are due to various factors such as warfare, weather, and obstructions natural or manmade).

Archaeological resources occur on the seafloor and are buried in the seabed; thus, activities that disturb the seabed could alter or destroy these resources.

a. Geological Sampling

Geological sampling that takes place from anchored vessels may cause impacts as a result of anchors or anchor chains being dragged across prehistoric or historic resources.

b. Seismic Surveys

Seismic surveys, both prelease and postlease, may result in beneficial as well as negative impacts on prehistoric and historic resources. Identification of potential resources will aid in their management as well as provide important research information. The negative aspects are 1) if these resources are located, it could lead to their unauthorized exploitation; (2) if explosives are used, the emitted shockwaves could damage fragile historic resources, such as wooden hulled ships; and (3) if deep-tow instruments are employed, the tow-chain or tow-sleds could be dragged through surface prehistoric and historic resources.

c. Exploration and Development and Production Rig Replacement

Impacts from rig emplacement will vary according to the type of rig used.

(1) Semisubmersible

Semisubmersible impacts are due to the positioning anchors (8-10 anchors ranging from 10,000-45,000 lb) and occasional dragging across and cutting into the seafloor and seabed. The zone of impacts from anchors is calculated by applying the ratio of 8:1 (feet of chain required to water depth).

(2) Jack-Up

(a) Independent Leg

Impacts from this type of rig are from the leg supports (3-6 legs ranging in size from 4-10 ft in diameter), which may penetrate the seafloor for approximately 40 ft.

(b) Mat Supported

Impacts from this type of rig are from the steel mat (15,000-25,000 ft^2) that supports the rig legs. The penetration of the seafloor by the mat is approximately 5 ft.

(3) Submersible

Impacts are similar to those of jack-up rigs (see Section c(2) above).

(4) Prodution Platform

Impacts from production platforms vary. The area of impact is based on the size and number of piles used to support the jacket, and the size and number of piles depend on the composition and thickness of unconsolidated sediments at the seafloor.

(5) Artificial Islands

Impacts from gravel islands are equivalent to the size of the island, which can vary from 79,000 to 434,700 ft^2, the latter proposed for the Beaufort Sea.

In addition to considering the direct impacts of exploration and development and production activities, it is essential to assess indirect impacts from related activities such as supply boat or barge anchoring patterns and the potential for modern ferrous debris being accidentally deposited on the seafloor. The latter material may mask the magnetic signature of an historic shipwreck.

d. Pipeline Construction

Impacts on archaeological resources due to pipeline construction may be caused by several sources. When burial of a pipeline is required, the excavation of the trench may cause the impact. The anchors of the pipeline lay-barge may be the impacting agents (see Section c(1) above). Another impact is from the accidental loss of modern ferrous debris (see above).

e. Oil Spills

Impacts from oil spills on archaeological resources at the land-water interface occur when the hydrocarbons permeate the cell structure of organic material found in sites. Organic material is used in carbon-14 dating of sites.

The major component of the MMS archaeological resource protection program is based on the avoidance of potential resources. Avoidance may involve the partial redesign or relocation of a project to minimize the possibility of impacts on an archaeological resource. Avoidance can involve protection arrangements that preserve the resource in situ.

5. Impacts on Marine Vessel Traffic

Structures such as platforms could pose either a positive or negative impact to marine traffic. In a study conducted by the Transportation Systems Center, it was determined that 78 percent of all tanker vessel casualties in U.S. waters involving rammings, collisions, and groundings occurred at night or during periods of reduced visibility (DOC, 1981). While reduced visibility has the potential of increasing the number of collisions between vessels and offshore structures, platforms provide a benefit for safe navigation due to navigational aids that are mandated by the USCG.

For example, the vessel traffic lanes have been extended in Southern California as a result of the installation of oil platforms in the Santa Maria Basin, as they provide additional navigational aids (lights, horns, radar, etc.). The DOC (1981) conducted a computer-simulated study of vessel movements around offshore structures in the Santa Barbara Channel. When structures were placed (simulation) near the border of a traffic lane, vessel operators often performed evasive actions that increased the risk of collision with other vessels. The risk was increased when structures were located on opposite sides of the traffic lane so as to form a "gated" configuration. The need for such evasive maneuvers was considerably decreased by the placement of structures outside the USCG-designated 500-meter buffer zone, and when no permanent or temporary structures were placed within 1,000 m of the boundary of the traffic lane for 2 mi on either side of the structure bordering the lane (DOC, 1981).

6. Impacts on Military Uses

Portions of the water and air space of the oil and gas planning areas are used for various military operations essential to training, readiness, and support of national defense and security interests. These operations include training and testing activities such as submarine operations, gunnery practice, sea trials, radar tracking, warship maneuvers, and general operations. These activities normally take place in Fleet Operating Areas specially designated for such purposes that are under the control of the Department of Defense (DOD). These operating areas were established for training surface, submarine, and air units in addition to providing designated zones for testing explosives, aircraft, and ships.

While Fleet Operating Areas have no legal status, they are normally established in areas with superjacent airspace designated as a warning area. A warning area includes airspace of defined dimensions outside of U.S. territorial waters in which a hazard to aircraft exists. Drilling and production activities taking place in certain locations could interfere with military operations.

Structures such as platforms can have negative impacts on military activities when located in military operating or training areas. The physical structure of the platform presents an obstruction to submarine or surface ships and low flying aircraft. Aircraft carrier operations, for instance, require long unobstructed stretches of ocean where carriers may steer a steady course upwind while launching or recovering aircraft. Platforms or drill ship operations also severely restrict the firing of live ammunition in the vicinity. The presence of oil field workers may also cause the relocation of testing or operations having a classified nature. Finally, acoustical and electronic emissions from seismic operations, service vessels and helicopters, and platforms or drill ships can interfere with naval operations in nearby waters. Conflicts that may arise because of the differing requirements for mineral exploration and development, along with defense-related activities, are discussed. Mutually agreeable solutions are reached as early as possible in the planning process according to a Memorandum of Agreement between DOI and DOD. Most of these conflicts have traditionally been mitigated through coordination between the lessee and the appropriate military authority. In certain instances, prelease stipulations have been attached to leases within military operating areas.

7. Impacts on Subsistence Use Patterns

Impacts on subsistence resources could occur at two levels of severity: (1) lower level effects, which alter the normal distribution patterns of subsistence species, thereby possibly making them more difficult and expensive to harvest (a more likely occurrence), and (2) higher level effects, which reduce the population of subsistence species directly or reduce the number of those fit for human consumption for a specific period of time, either of which would reduce or eliminate desired harvest levels (a less likely occurrence). One characteristic of subsistence activities that may affect the level of effects is their high degree of seasonality. If a disturbance occurs immediately before or during a limited subsistence harvesting period, the effect on subsistence could be exacerbated. If a disturbance occurs outside of the limited harvesting period, the effect could be reduced.

Although subsistence harvesting relies on more nearshore resources and is more diversified than commercial harvesting, the overlapping subsistence and commercial resources can experience similar types of effects. Due to the interrelationships between commercial fishing and subsistence activities, such as using cash income from commercial fishing to purchase supplies or equipment to support subsistence, adverse effects on commercial resources can also indirectly affect subsistence.

Interference with subsistence activities consists of limiting or excluding access to certain areas; noise that causes game to flee or become wary; fouling or damaging of gear or equipment; increased probability of vessel collisions; reduced catch due to oil spills during fishing season or whale hunting season; and competition for services, materials, and equipment. Subsistence activities generally concentrate in nearshore areas, such as beaches, lagoons, and wetlands, which tends to reduce the probability or degree of adverse effects because many of the OCS activities occur farther offshore. Exceptions to this occur in areas where walrus are taken far from shore (such as St. Lawrence Island). Construction and siting of onshore facilities may affect subsistence harvesting of terrestrial resources. This may become particularly important if a major facility such as a pipeline is constructed. Possible benefits to subsistence activities include more commercial amenities in port communities and increased safety due to improved communication, increased air-sea rescue capabilities, and better access to harvest areas.

The socioeconomic effects deal with the number of new residents, workers living in enclaves, commuters expected in an area, and many of the possible effects that may result. New residents and enclave residents could be considered as possible competitors with the existing residents, either directly by participating in subsistence activities themselves or indirectly through sport hunting and fishing. Improved access to harvest areas for both local and nonlocal people may also increase subsistence and sport harvest competition. The results of added pressure on subsistence resources, such as shorter seasons, catch limitations, and reduction of close-in, easily accessible resources, could increase and induce additional hardship on long-term subsistence users. Impacts on subsistence felt in one planning area may spread into adjacent planning areas if the affected users travel beyond their traditional-use areas in search of better harvest opportunities.

Reduced or lost subsistence resources, particularly those that are heavily relied upon or are relatively inexpensive to harvest, will require replacement by other subsistence resources or by scarce cash (usually opportunities to earn cash in rural areas are very limited). In general, subsistence resources and uses nearest air and/or marine support bases, pipeline landfalls, terminal sites, and tanker routes will be the most susceptible to adverse effects.

H. Impacts on the Physical Environment on Oil and Gas Operations

Various conditions exist in nature that can be hazardous to oil and gas operations. If they are foreseen, special engineering procedures may allow operations to continue safely. In reviewing exploration and development and production plans (30 CFR 250.34), the MMS reviews, among other things, seismic records, geochemical information, oceanographic conditions, and meteorology to ensure as completely as possible that operations can be carried out safely. If special engineering procedures do not exist to control the situation adequately, the operations need to be moved to a different location or suspended until the state-of-the-art engineering allows exploitation of the resources under the adverse conditions. It is important that the adverse conditions be foreseen as the results could be pollution, damage, loss of equipment, or even loss of life.

1. Geologic Hazards

Geologic hazards are any existing or potential geologic features or processes that could inhibit the exploration and development of oil and gas resources. Most geologic hazards are potential rather than actual and continuous threats.

a. Seafloor Instability

Various conditions can result in sediment mass wasting, with some of the conditions being hazardous themselves. The basic criterion is known as the "angle of slide," which is a combination of the slope and the consolidation of the sediments. Sediments at angles less than 0.5 degrees have been known to fail in the GOM because of their underconsolidation. Sediments can be stable at angles of nearly 90 degrees if well consolidated or lithified, as evidenced by a pinnacle-like structure found in the North Atlantic.
Seismic activity, overloading, cyclic loading, and migrating shallow gas can drastically reduce the necessary angle of slide for given sediments and even cause liquefaction in horizontal sediments.

Currents in submarine canyons can undercut the canyon walls, and uplift associated with diapirs can oversteepen the slope allowing sediments to slump, slide, or generate turbidity currents.

Other types of seafloor instability, which are not as dangerous to drilling operations as mass wasting, include buried channels and sediment transport by currents. Buried channels are formed from lag deposits and other material filling erosional features cut into the seafloor by marine currents, mass wasting, or during subaerial exposure. They could cause a bottom-mounted structure that straddled the boundary between the buried channel and the surrounding sediments to topple because of load-bearing contrasts. Similarly, sediment transport, such as mobile sand waves and scour, could remove support from under part of a bottom-mounted structure again causing toppling.

b. Seismic Activityand Shallow Faults

Seismic activity is prevalent along the entire Pacific coast. The earthquakes occurring along this coastal arc are caused by the physical interaction between crustal plates. Numerous earthquakes ranging in magnitude from four to eight have been recorded during this century. The potential hazards associated with these magnitudes are ground motion, fault displacement, surface warping, seismic sea waves, ground failure, and consolidation of sediments. Any of these could cause the failure of a platform structure or a pipeline.

The potential for damage from ground motion is the greatest in areas underlain by thick accumulations of saturated, unconsolidated sediments. Sediments can be weakened, and other hazards as discussed under Seafloor Instability can be generated.

Large earthquakes can also produce wide areas of surface warping or deformation. Subsidence can also result from consolidation and/or lateral spreading of sediments. This type of hazard can lead to extensive flooding along coastal areas, damage to drilling equipment or platforms, and severing of pipelines.

Faults are considered to be active where they offset young (<11,000 years) sediments in regions of continuous sedimentation, where they offset the seafloor, or where they have a historic record of earthquake activity.

The presence of these faults can be quite hazardous to offshore drilling programs and bottom-founded oil facilities. Any movement along the features, such as that generated by an earthquake, could threaten the drill stem or could affect the stability of surficial sediments. Displacement of sediments could also occur. Slumps and turbidity currents could be triggered on the Continental Slope, causing the failure of pipelines. Perhaps more importantly, these faults can act as conduits if overpressured gas is encountered, allowing a blowout to bypass the oil rig or platform. This situation can make it extremely hard to regain control and can result in seafloor cratering, the loss of the rig, and spilled oil.

Seismic sea waves and seiches can be generated by sudden tectonic displacement of the seafloor or by large landslides triggered by seismic activity. In open water and in greater depths, seismic sea waves generally have no effect. In lesser depths, especially along identified coastlines and within enclosed bodies of water, they become a potential danger to any onshore or shallow-water facilities such as production platforms.

c. Vulcanism

The major threat from active volcanoes along the Pacific Coast and Alaska is the direct blast. However, other potential hazards that are related to this type of event and are also destructive are nuee ardente (incandescent cloud of gas and volcanic ash), mud flows, lava flows, bomb and ash fallout, seismic sea waves, and seiches.

d. Shallow Gas

Dissolved or undissolved gas either dispersed or in pockets can be a serious hazard to platforms, supports, pipelines, and subsea installations. Gas-charged sediment can contribute to low shear strength or promote liquefaction. Storm surges or seismic shaking, coupled with an upward release of gas, could trigger slides and subsidence. Their identification is important to any drilling program because of the danger of ignition or blowout. Shallow gas may weaken shallow geologic formations providing avenues of escape for high pressure fluids and gas from deeper formations.

e. Permafrost

Potential hazards associated with the presence of permafrost (in Alaska) include thaw subsidence and frost heave. Thawing produces undesired plasticity in the sediment, causing differential subsidence of the surface or lateral flow because of reduced bearing strength. This could cause differential settling of platform foundations, onshore service or processing facilities, and pipelines.

Fine-grained soils are more susceptible to frost heave than are coarse-grained soils. Thaw subsidence or frost heave may result in the uneven settling or uplifting of the foundations of structures, and this could endanger the operation that the structure was designed to perform.

Natural gas hydrates have been encountered in boreholes drilled not only in the arctic offshore and onshore environments, but also in holes drilled in the seafloor in many other areas throughout the world in recent years. Thus, the amount of experience associated with drilling through hydrate layers is increasing. To date, no adverse effects have occurred on the OCS as a result of encounters with gas hydrates.

f. Karst

Karst features are widespread but noncontiguous in distribution on the west Florida platform from the Florida Middle Ground to the Florida Keys and on the Blake Plateau. Surface expression of the karst is evidenced in some areas; whereas in other locales, subsurface karst is inferred from seismic anomalies. The karst consists of concentrations of dolines (sinkholes) formed by either solution of surface limestone or by collapse of underlying solution caverns and, in some areas, a rough barren topography of deep furrows or channels that reflect surface solution along joint patterns. Collapse of solution caverns beneath bottom-founded drill rigs or platforms, or the blowout of unsupported drill casing on production lines, is the major hazard from karst.

2. Physical Oceanography

Adverse physical oceanographic conditions are usually linked to meteorological conditions in some way. Oceanographic conditions can vary from occasionally to constantly adverse and from potential to continuous threats to operations.

a. Waves and Storm Surge

Adverse conditions from waves, with the exception of the seismic sea waves (discussed under Geologic Hazards above), result from storms at sea. Summer and early fall in the GOM and the Atlantic offer possibilities that tropical storms may affect the area through characteristically high waves (7-12 m) and storm surge. The Pacific area can occasionally be affected. Conditions appear to be harshest in the North Atlantic where tropical storms may result in wind speeds as high as 100 knots and wave heights greater than 40 ft.

Hurricane is the term used for a tropical storm with wind speeds over 63 knots. They vary considerably in intensity, track patterns, and behavior. Damage results from high winds and, particularly in the coastal areas, storm surge or tide, which is an abnormally high rise in the water level. Maximum surge height at any location depends on many factors including bottom topography, coastline configuration, and storm intensity. Storm surges and tides have reached 7 m (23 ft) above normal in the GOM. A recent example of a structure's failure to withstand severe storms is when oil island Esther in State of California waters was destroyed by high waves during high tide and a large storm surge. The reason for the failure is being investigated. Annual hurricane threats have been an important consideration to the petroleum industry since offshore operations began. Industry activities are ruled by the daily presence of the potential for such a phenomenon to occur. Though little or no damage may be incurred during such an event, evacuation and shutdown costs to industry can be costly.

Winter storm systems also cause high winds and waves. Waves from winter storms have been known to exceed 18 m (60 ft) in the North Atlantic due to the large amount of unobstructed, open water available. Physical oceanographic forces due to waves are believed to pose no threat to the physical integrity of drilling rigs or production platforms. Oil and gas structures are engineered to withstand 100-year expected storm waves. However, design of a structure does not seem to be the only determinant of its safety. The Ocean Ranger (floating) exploration rig, largest in the world and considered by many unsinkable, capsized during a storm on February 15, 1982, while operating offshore Canada. Designed to withstand winds up to 100 knots and waves of approximately 100 ft in height, it capsized in conditions well within its design capabilities: 90-knot winds and waves approximately 50 ft high. It was reported (Wall Street Journal, May 4, 1982) that, in addition to design faults, a broken porthole in the vessel during the storm combined with unpracticed evacuation procedures doomed the rig and its 83 crew members. Under wave conditions just described and considering the present level of cleanup technology, oil-spill cleanup would not be possible. Storms and the associated waves may halt some activities on rigs and platforms because of danger to personnel transfer from shore boats or the danger and spill hazards involved in offloading oil from platforms to tankers (if this method of transportation is selected). This danger is only expected to occur in seas of 3 m or greater.

b. Currents

Physical oceanographic forces due to currents are believed to pose no threat to the physical integrity of drilling rigs or production platforms, as oil and gas structures are engineered to withstand the maximum expected currents. Bottom currents are not expected to affect the transportation of oil and gas by pipeline. There has been concern, in the past, about the effects of the high-speed currents circulating around Georges Bank on drilling rigs operating in the area. However, no adverse effects have been noted from drilling operations that have already taken place. In the South Atlantic, the greatest concern appears to be extreme high-speed currents associated with the Gulf Stream. These currents may create difficulties for drilling rigs in terms of maintaining correct position over the wellhole; bending of the drill string may also occur in response to high-speed currents.

c. Sea Ice an Vessel Icing

Sea ice is the most constraining factor to the offshore development of petroleum hydrocarbon resources in arctic areas. The forces exerted by the sea ice depend upon such factors as the movement rate, strength, thickness, and type. With so many variables, an analysis of the mechanical behavior of the ice is complex. The constraints on oil and gas activities imposed by sea ice conditions have brought about technological advances and innovations since the beginning of hydrocarbon resource development in the arctic. Wells have been successfully drilled and completed from different types of drilling units in a variety of northern marine environments. Extreme winter temperatures and wind chill factors may also create problems in terms of ice accretion and superstructure icing. The formation of ice on superstructures is a complex process that depends on sea conditions, type of offshore drilling platform, atmospheric conditions, and ship size and behavior. Offshore oil exploration and production depend on moderately sized vessels for logistic and rescue support. Historically, sea spray icing in polar and occasionally North Atlantic seas has plagued vessels and has, in extreme cases, resulted in capsizing both fishing boats and moderately sized ships, with total loss of ship and crew.

3. Meteorology

Most of the adverse conditions created by meteorology have been described under the oceanography section. However, the winds associated with tropical storms, hurricanes, and northeasters can also cause delays in operation and possibly damage to offshore facilities.

Hurricane Camille, the most severe hurricane in recent Gulf history, attained top winds estimated at 324 km/hr with barometric pressure in her eye as low as 68 centimeters (26.6 in) of mercury. These storms occur mainly in the summer and fall months. They would disrupt construction and movement of crew or supply boats and helicopters. However, these conditions seldom persist for more than 2 or 3 days.

Restricted visibilities from fog could occasionally hinder the movement of helicopters, crew boats, and supply vessels. However, dense fog would seldom be expected to last long enough to cause significant delays in OCS operations.

Surface winds play a critical role in determining the movement of spilled oil and other pollutants in the marine environment, particularly at the surface. Wind-driven waves may be among the most serious weather-induced problems affecting offshore development.

V. OBSERVED EFFECTS OF THE OCS OIL AND GAS PROGRAM

A. Alaska Region

1. Physical Environment

a. Water Quality

(1) Effects of Geological Sampling

Water quality is altered and degraded in several ways during geological sampling activities. Bottom sampling and shallow coring cause sediment suspension and associated increase in turbidity. Deep stratigraphic testing, being similar to rotary drilling of exploratory wells, results in the additional discharge of drill muds and cuttings and the associated increase in levels of suspended solids and trace metals in the receiving water.

Effects on water quality resulting from bottom sampling and coring activities are limited to the immediate area of operation (DOI, U.S. Geological Survey (USGS), 1976). Because of dilution, dispersion, and settling, the effects of drill muds and cuttings on water quality are limited to the immediate vicinity of the discharge and generally not detectable beyond 2,000 m from the discharge (NAS, 1983; Houghton et al., 1980; Ayers et al., 1980a, b).

Geological sampling activities in the Alaska Region have been limited. Approximately 97 geological sampling permits have been issued over the period of 1969-1985, and 14 deep stratigraphic tests (COST wells) have been completed. Results of studies conducted in the Alaska Region (Houghton et al., 1980; ECOMAR, 1983; Jones and Stokes, 1983; and Tetra Tech, 1984) indicate that the effects of drill muds and cuttings discharges on water quality have been temporary, limited in spatial extent, and not accumulative.

In conclusion, no cumulative effects on water quality as a result of geological sampling have been identified.

(2) Effects of Discharge of Muds and Cuttings

Since 1975, approximately 500,000 bbl of muds (undiluted) and 200,000 bbl of cuttings (undiluted) have been discharged in the Alaska Region as a result of drilling 80 wells (including 14 COST wells). These wells and, in turn, the resultant discharges have been relatively widely distributed over eight planning areas. Results of studies conducted in the Alaska Region (Houghton et al., 1980; ECOMAR, 1983; Jones and Stokes, 1983; Tetra Tech, 1984) indicate that the effects of drilling muds and cuttings discharges on water quality have been temporary, limited in spatial extent, and not accumulative.

In conclusion, no cumulative effects on water quality as a result of the discharge of muds and cuttings have been identified.

(3) Effects of Oil Spills

There has been no oil and gas production from the Alaska OCS. One spill of 2 bbl occurred in the Norton Basin Planning Area in 1985. There have been no cumulative effects of OCS-related oil spills in the Alaska Planning Areas.

b. Air Quality

Table V-1 summarizes the emissions from exploration activities and oil spills that occurred in 1986. Exploration activities consisted of six wells, three drilled from drillships and three drilled from gravel islands. During 1986 no oil spills occurred.

Table V-1
Estimated emissions from exploration activities and oil spills, 1986

	Pollutant Emissions (Tons)				
Activity	NO_x	TSP	VOC	SO_2	CO
Exploration	445	92	15	41	80
Oil Spills	--	--	--	--	--

Because of the low level of emissions and the physical distance between exploration sites, the annual average onshore effects from these activities for NO_x were less than 1 microgram per cubic meter (ug/m^3).

2. Biological Environment

a. Lower Trophic Organisms

(1) Effects of Discharge of Muds and Cuttings

Approximately 500,000 bbl of muds and 200,000 bbl of cuttings have been discharged by exploratory and COST wells throughout all the Alaska Planning Areas. The effects of drilling muds and cuttings on benthic communities were studied in the Beaufort Sea by Northern Technical Services (1981) and in Lower Cook Inlet by Lees and Houghton (1980). No significant harmful effects were attributed to the drilling discharges. No long-term effects of the discharge of drilling muds and cuttings have been reported.

(2) Effects of Oil Spills

Only one small spill of 2 bbl has resulted from OCS activities in the Alaska Planning Areas. An international project that was co-sponsored by the MMS investigated the effects of experimental releases of crude oil and chemical-dispersed oil in the Canadian Arctic off Baffin Island. Sergy (1986) summarized the results of this study and concluded that no significant mortality on benthic organisms occurred as a result of the controlled oil releases. In addition, no significant changes in benthic community structures were detected. Sublethal behavioral and physiological effects on a few species of benthic invertebrates were observed (Mageau and Englehardt, 1984). No impacts of oil spills on lower trophic organisms have been recorded.

b. Fish Resources

(1) Effects of Discharge of Muds and Cuttings

Since 1975, some 80 wells (including 14 COST wells) have been drilled on the Alaska OCS. An estimated 500,000 bbl of muds and 200,000 bbl of cuttings have been discharged. These discharges have been relatively widely distributed over eight planning areas.

Neff (1987) states that any effects from these discharges can be expected to occur in the benthic community. He summarizes the results of a number of field and laboratory studies on this subject and concludes the following:

> In offshore oil and gas fields that have been in production for several years, impacts attributable to drilling fluid and cuttings discharges are difficult to identify, except immediately adjacent to platforms where a cuttings pile was formed and has persisted. This is despite the fact most of the production platforms monitored had drilled multiple wells and had discharged very large volumes of drilling fluids and cuttings. The exception to this generalization is the instance where oil-based drilling fluids were used to develop the field and large amounts of oil-contaminated cuttings were discharged.

It should be pointed out, however, that the discharge of oil-based muds is now generally prohibited on the OCS. Occasionally, special permission has been granted by the EPA to discharge muds containing oil, for example, when such lubricant is needed to free a stuck drill pipe. It is not expected that there would be any long-term cumulative effects on fisheries from the discharge of non-oil-based drilling fluids in high-energy offshore areas, and none have been observed.

(2) Effects of Oil Spills

Only one spill of 2 bbl has occurred as a result of OCS oil and gas activities. This spill has had no cumulative effect on fisheries resources.

c. Endangered or Threatened Species

(1) Effects of Seismic Surveying

Whales' responses to seismic noise are behavioral and short term, and they occur almost totally at distances less than 5 km from operating seismic vessels and disappear rapidly when operations cease (Ljungblad, et al. 1985).

(2) Effects of Support Vessel Traffic

The short duration and localized nature of endangered whales' flight and lesser behavioral responses to vessel traffic, as well as their observed tolerance to continuing vessel noise, have negligible lasting impacts on the comparatively few animals that may be affected. Similarly, the even shorter duration effects due to aircraft (which normally fly straight-line courses between origin and destination) limit those effects to seconds.

Noise from these moving sound sources is highly unlikely to disrupt or even significantly affect migration or other essential whale activities. Available information indicates that effects of noise from exploratory drilling would be minor, localized, and not likely to adversely affect many whales or their migration. In addition, the MMS operational guidelines and standards, mentioned relative to seismic surveys, apply to vessel and aircraft traffic as well and minimize or eliminate the adverse effects of these activities on the whales.

(3) Effects of Oil Spills

The lack of a major OCS activity-related oil spill since the 1969 spill in the Santa Barbara Channel has precluded field observations of any resultant effects on endangered whales. No oil-related mortality or observed effects on endangered whales resulted from the 1969 Santa Barbara spill, which occurred while the entire eastern Pacific gray whale population was on its annual northward migration (Brownell, 1971).

The MMS cannot guarantee that an OCS activity-related spill will never occur, but the calculated risk of a spill during Alaskan oil and gas exploration contacting at least one bowhead is less than 1 percent for proposed lease sales in the Beaufort, Chukchi, and Bering (Navarin Basin) areas (MMS unpublished summary analysis, November 1986). Also, the likelihood of an endangered whale remaining long in an oil spill is low, and the OCS operators' oil-spill containment and cleanup contingency plans required by MMS must be adequate to ensure minimal effect of spilled oil on endangered whales and other sensitive wildlife and their ecosystems. Other such wildlife includes threatened Arctic and endangered American peregrine falcons, which might be indirectly affected by spilled oil if they were to feed on oil-fouled prey. In view of the temporary, nonlethal observed effects of oil on whales, the low risk of whales and birds being exposed to spilled oil, and the measures required to minimize such exposure, it is unlikely that spilled oil will preclude successful whale migrations or significantly disrupt feeding, mating, and other essential whale and bird activities.

d. Marine Mammals

(1) Effects of Seismic Surveying

Effects of seismic surveying are discussed above in Chapter IV, Section E.1.b(2). Although avoidance reactions have been observed, no known significant impacts to marine mammals have been documented. The localized displacement of ringed seals near over-ice seismic surveys or shorefast ice is not significant in terms of total population numbers and distribution (Burns and Kelly, 1982).

(2) Effects of Support Vessel Traffic

The reactions of beluga whales to vessel and aircraft noise are short lived and local. Their reactions to noise from operating oil rigs in Cook Inlet and from simulation experiments elsewhere in Alaska are also localized and short lived, especially when sound levels remain constant.

Support vessels seldom, if ever, can operate in or near shorefast ice in the winter and early spring and are, therefore, unlikely to disturb ringed seals during their less mobile denning periods spent preferentially in this habitat. Fixed-wing aircraft and helicopters, likewise, are unlikely to affect ringed seals unless the aircraft are flying very low, circling or repeatedly overflying a lair locality, or landing on the ice. Seal displacement due to aircraft and humans (except perhaps by Natives hunting these animals) is less frequent and less significant than displacement caused by over-ice seismic surveys. The same is true for seal displacement due to artificial island construction and associated ice roads (Green and Johnson, 1983).

No effects of support vessel or drilling noise are documented for fur seals, walruses, or polar bears, although low-flying aircraft may disturb hauled-out seals and walruses and cause short-term flight responses in polar bears. Oil development may also cause female bears to try denning in less than optimal locations or to break out of dens sooner than normal, thereby potentially reducing cub survivorship (U.S. Fish and Wildlife Service, 1980). Sea otters in Alaska are not likely to respond to noise from support vessels, aircraft, or drilling operations (Riedman, 1984), and the risk of their colliding with the propellers of support vessels is minimized or eliminated by MMS operational guidelines and standards.

(3) Effects of Oil Spills

Potential impacts of oil spills are discussed in Chapter IV, Section B. Only one oil spill of 2 bbl has occurred as a result of

OCS oil and gas activities. This small amount of oil had no effects on marine mammals.

e. Coastal and Marine Birds

Several million birds representing about 150 species--including seabirds, waterfowl, shorebirds, passerines, and raptors--are found seasonally on or near the Alaskan OCS (Sowls et al., 1976). Most of these birds migrate to Alaska to nest in the coastal wetlands. The OCS is important for their feeding and staging. One of the primary effects from OCS activities on marine and coastal birds could result from oil pollution.

Substantial direct oil contact alone usually is fatal or, in addition to indirect effects, causes substantial bird mortality. Oiling of birds causes death from hypothermia, shock, or drowning. Oil ingestion through preening of oiled feathers significantly reduces reproduction in some birds and causes various pathological conditions (Hansen, 1981).

Major references pertaining to the potential effects of oil on birds in Alaska include the following: Hansen (1981), The Relative Sensitivity of Seabird Populations in Alaska to Oil Pollution; King and Sanger (1979), Oil Vulnerability Index for Marine Oriented Birds; Hartung and Hunt (1966), Toxicity of Some Oils to Waterfowl; and Ford, Wiens, Heinemann, and Hunt (1982), Modeling the Sensitivity of Colonially Breeding Marine Birds to Oil Perturbation: Murre and Kittiwake Populations on the Pribilof Islands, Bering Sea.

There have been about 60 exploratory wells drilled on the Alaskan OCS, but no development or production activities have taken place. There are no documented cumulative effects to marine and coastal birds from oil spills in the Alaska Region that can be directly attributed to OCS activities.

3. Socioeconomic Environment

a. Employment and Demographic Conditions

Towns and villages in many of the Alaskan OCS subregions have experienced some effects of OCS activities. These effects, however, have been either short term or minimal. Warehouses, docks, and airfields have been used by offshore operators, but these facilities were generally in-place and originally constructed for fishing, onshore oil production, or other industrial uses. In some cases such facilities have been improved--for example, airport facilities at Prudhoe Bay, the Pribilof Islands, and Yakutat. Further limiting the effects of OCS activities is the fact that the OCS oil and gas development process has proceeded only as far as the exploratory phase. In this phase, most employment results from prelease evaluation and surveys and the drilling of exploratory wells. Although both these activities are labor intensive, employment effects have been limited due to the lack of development. Also, the demographic effects are minimal because of the establishment of enclaves for the oil workers, such as the one at Yakutat for Gulf of Alaska exploration. More severe impacts are occurring because of the downturn in oil and gas activity in Alaska rather than the existence of it. Alaskan residents, including Alaskan Natives, depend on the cash economy created by the jobs associated either directly or indirectly with the oil industry.

b. Coastal Land Uses

The OCS activities in Alaska to date consist of seismic surveying and the drilling of COST wells and exploratory wells. These wells/ activities have been supported onshore by a number of facilities, some of which were expansions or alterations of facilities originally used for other purposes. Exploratory drilling in the Gulf of Alaska was supported from a facility developed at Yakutat. The community's desire to minimize all impacts resulted in the development of an enclave for the oil and gas workers. In the Bering Sea Subregion, several communities have experienced some activity to support the drilling of exploratory wells. These include Nome, Cold Bay, Dutch Harbor, Captain's Bay near Unalaska, and St. Paul. Offshore exploration in the Arctic Subregion Beaufort Sea area has been supported from facilities at the Prudhoe Bay enclave developed to support onshore production.

The attitudes of local communities toward growth and oil- and gas-related activities, as well as the existing infrastructure, play a major role in the location of support facilities. There were some cumulative impacts from alterations of land or changes in land use to construct facilities needed onshore to support exploration offshore Alaska. The nature of this impact must be determined considering the fact that facilities would not have been sited in communities not wanting them. Some communities welcome oil- and gas-related facilities based on their desire to have additional employment opportunities for their residents or an interest in upgrading an airstrip or port facilities.

c. Commercial Fisheries

(1) Effects of Seismic Surveying

There has been only one documented report of damage to fishing gear from a seismic vessel in this Region. In the spring of 1983, a vessel on lease to an oil company was claimed to have damaged several crab pots off Kodiak. The company reimbursed the claimant for damages.

The Oil/Fisheries Group of Alaska compiles and periodically updates the publication, Geophysical Operations in Fishing Areas of Alaska. The aim of the group is to improve communications and avoid conflicts between industries.

No significant cumulative effects from seismic activities on commercial fishing have been documented in the Alaska Region.

(2) Effects of Exploration Rigs

Potential effects of exploration rig emplacement on commercial fishing include the exclusion of boats and gear from the vicinity of these structures. It is estimated that an average exploration rig would preclude fishing vessels from about 1.03 mi^2 of area, including a safety buffer zone around the rig (Centaur Associates, 1984a).

There are no reports of problems to commercial fishing from exploratory rigs in this Region, and no cumulative effects have been identified.

(3) Effects of Oil Spills

No major oil spills have occurred as a result of OCS operations; thus, there have been no impacts on commercial fisheries.

d. Recreation and Tourism

Onshore recreational resources (fishing, hunting, hiking, sightseeing) are abundant. There are, however, few locations that provide access and transportation services to wild rivers and scenic landscapes. Some tourists visit such places as Lake Clark, Lake Iliamna, Cold Bay, Bethel, St. Paul, St. George, Barrow, and Prudhoe Bay.

Potential impacts to recreation and tourism may result from activities that increase population in an area and consequently increase competition for game animals and fish and decrease the opportunity for solitude. Property values may increase in areas of increased population. The visual qualities of an area may be changed if onshore or offshore structures are built.

The local economies and recreation of Nome have been studied. Exploration has not required significant or permanent increases in population, and no development and production has been proposed. No reports of impacts to recreation or tourism have been received.

In conclusion, there have been no discernible impacts on recreation and tourism related to OCS activities, and no cumulative impacts related to OCS activities have been identified.

e. Archaeological Resources

In the effort to minimize impacts to archaeological resources in the Alaska Region, the MMS (and its predecessors the Bureau of Land Management (BLM) and USGS) funded five studies:

1. Bering Land Bridge Cultural Resource Study, Final Report;

2. Western Gulf of Alaska Cultural Resource Study, Final Report;

3. Beaufort Sea Cultural Resource Study, Final Report;

4. Lower Cook Inlet Cultural Resource Study, Final Report; and

5. Alaskan Outer Continental Shelf Cultural Resource Compendium, Final Report.

These studies attempt, through the use of predictive models, to identify areas of the OCS where there is a high probability of archaeological resources. In these areas of high probability the lessee is required, through lease stipulation, to conduct a tract-specific archaeological resource survey. These studies are updated for each lease sale. The updates include analysis and synthesis of data--archaeological, geological and geophysical--generated since the preparation of the original study (or the last update). If a potential archaeological resource is located, a mitigation plan is developed. To date, nine archaeological surveys have been conducted in the Region.

There have been no reports of impacts to archaeological resources from OCS activities, and no cumulative impacts related to OCS activities have been identified.

f. Military Use Areas

There are no military use areas offshore Alaska where leasing has taken place.

g. Subsistence

Subsistence is a system of production and consumption based on the harvest of naturally occurring renewable resources. The resources are used for diet, clothing, tools, social exchange, and links with the cash economy.

Potential impacts on subsistence life styles may result from increased population introducing new styles to an area or from impacts on the plant or animal resources harvested for subsistence use. Impacts on resources may result from oil spills, noise, causeways, pipelines, drilling platforms, roads, and other onshore and offshore activities. Impacts could change the distribution of the resources so that some resources may become unavailable for subsistence use for some period of time.

There have been no reports of impacts to subsistence systems from OCS activities. Various studies to evaluate subsistence systems have been performed. Principal among these are Veltre and Veltre, 1981; Fienup-Riordan, 1983; Little and Robbins, 1984; Luton, 1985; and Burch, 1985.

In Alaska, effects on subsistence have been related to State onshore and nearshore development of oil and gas on the North Slope. Effects have included changes in hunting patterns and timing to accommodate employment and cash incomes. These changes have occurred in some North Slope communities. At Nuiqsut and possibly Kaktovik, the areas hunted have been changed due to the location of onshore facilities. There has been one report from Kaktovik of vessel traffic interfering with the whale harvest during the fall of 1985.

In conclusion, there have been no discernible impacts on subsistence systems related to OCS activities, and no cumulative impacts related to OCS activities have been identified.

B. Atlantic Region

1. Physical Environment

a. Water Quality

(1) Effects of Geological Sampling

Water quality is altered and degraded in several ways during geological sampling activities. Bottom sampling and shallow coring cause sediment suspension and associated increase in turbidity. Deep stratigraphic testing, being similar to rotary drilling of exploratory wells, results in the additional discharge of drill muds and cuttings and the associated increase in levels of suspended solids and trace metals in the receiving water.

Effects on water quality resulting from bottom sampling and coring activities are limited to the immediate area of operation (DOI, USGS, 1976). Because of dilution, dispersion, and settling, the impacts of drill muds and cuttings on water quality are limited to the immediate vicinity of the discharge and generally not detectable beyond 2,000 m from the discharge (NAS, 1983; Houghton et al., 1980; Ayers et al., 1980 a, b).

Geological sampling activities in the Atlantic Region have been very limited. Only approximately 20 geological sampling permits have been issued over the period of 1970-1985, and 5 deep stratigraphic test wells have been completed. Results of studies conducted in the Atlantic Region (ENDECO, 1976; Ayers et al., 1980a; Houghton et al., 1980; and Bothner et al., 1983, 1985) indicate, or strongly suggest, that the effects of drill muds discharges on water quality have been temporary, limited in spatial extent, and not accumulative.

In conclusion, no cumulative effects on water quality as a result of geological sampling have been identified.

(2) Effects of Discharge of Muds and Cuttings

Since 1976, approximately 1 million bbl of muds and 260,000 bbl of cuttings have been discharged in the Atlantic Region as a result of drilling 51 wells. The majority (about 68 percent) of the drilling activity and, in turn, discharge of muds and cuttings occurred in the Mid-Atlantic Region. Results of studies conducted in the Atlantic (ENDECO, 1976; Ayres et al., 1980a; Houghton et al., 1980; EG&G, 1982, and Bothner et al., 1983, 1985) indicate that the effects of drill muds and cuttings discharges on water quality have been temporary, limited in spatial extent, and not accumulative.

(3) Effects of Oil Spills

There has been no oil and gas production in the Atlantic Region. Since 1976, there have been three spills totaling 26 bbls as a result of OCS activities. No cumulative effects on water quality as a result of this small amount of oil have been identified.

b. Air Quality

In the Atlantic OCS Region, 51 exploratory and COST wells were drilled from 1976 to 1984 and none since then.

Because of the distance between exploration sites and the distance of the activities from land, the MMS estimates that the annual average onshore impacts from exploration activities were less than 1 ug/m^3 (i.e. below the significance level established by 30 CFR 250.57-1).

2. Biological Environment

a. Lower Trophic Organisms

(1) Effect of Discharge of Muds and Cuttings

Approximately 1 million bbl of muds and 260,000 bbl of cuttings have been discharged by 51 exploratory and COST wells throughout all the Atlantic Planning Areas. The effects of drilling muds and cuttings on benthic communities were studied in the Mid-Atlantic by Mariani et al. (1980) and in the North Atlantic (Georges Bank) by Battelle New England Research Laboratory and Woods Hole Oceanographic Institute (1985). No significant harmful effects were attributed to the drilling discharges. No long-range impacts of discharges have been reported.

(2) Effects of Oil Spills

Only three small spills totaling 26 bbls have occurred as a result of OCS activities throughout the three Atlantic Planning Areas. Any effects of this small amount of oil have long since abated, and no short- or long-term effects have been reported.

b. Fish Resources

(1) Effects of Discharge of Muds and Cuttings

Since 1976, an estimated 1 million bbl of muds and 260,000 bbl of cuttings have been discharged in the Atlantic Region as a result of drilling 51 wells.

Neff (1985) states that any effects from these discharges can be expected to occur in the benthic community. He summarizes the results of a number of field and laboratory studies on this subject and concludes the following:

> In offshore oil and gas fields that have been in production for several years, impacts attributable to drilling fluid and cuttings discharges are difficult to identify, except immediately adjacent to platforms where a cuttings pile was formed and has persisted. This is despite the fact most of the production platforms monitored had drilled multiple wells and had discharged very large volumes of drilling fluids and cuttings. The exception to this generalization is the instance where oil-based drilling fluids were used to develop the field and large amounts of oil-contaminated cuttings were discharged.

For further details, consult this article. Additionally, two MMS-funded studies (Blake et al., 1985 and Maciolek et al., 1986) detected no noticeable long-term effects from the discharge of muds and cuttings on fisheries resources.

It is not expected that there would be any long-term cumulative effects on fisheries from the discharge of non-oil-based drilling fluids (the discharge of oil-based muds is prohibited on the OCS) in high-energy offshore areas.

(2) Effects of Oil Spills

As a result of OCS oil and gas activities, three small spills totaling 26 bbls have been recorded in the Atlantic Region. Any possible impacts of these spills have long since dissipated.

c. Endangered or Threatened Species

(1) Effects of Seismic Surveying

The effects of seismic surveying on endangered whales were discussed above in Chapter IV, Section E.1.b. Approximately 300,000 line miles of seismic data have been run in the Atlantic Region. There has been no known disruption to whale feeding, migration, mating, and other whale activities.

(2) Effects of Support Vessel Traffic

General responses of threatened whales to support vessel traffic is discussed above in Chapter IV, Section D. There has been limited exploration in the Atlantic Region (5 COST wells and 46 exploratory wells). No impacts from associated support traffic are known. Neither did observation aircraft flying at altitudes as low as 50 m adversely affect feeding right whales in the Atlantic (Watkins and Schevill, 1979).

(3) Effects of Oil Spills

The effects of oil spills on endangered whales were discussed above in Chapter IV, Section B.9. Three small spills totaling 26 bbls have occurred in the Atlantic Region as a result of OCS activities. No impacts on endangered whales resulting from these spills were observed.

d. Marine Mammals

(1) Effects of Seismic Surveying

The potential effects of seismic surveying are discussed in Chapter IV, Section E. Approximately 300,000 line miles of seismic surveys have been run in the Atlantic Region. No significant impacts have been observed.

(2) Effects of Support Vessel Traffic

Five COST wells, 46 exploratory wells, and no development and production wells have been drilled in the Atlantic Region. There is no indication of any adverse impacts on marine mammals related to vessel traffic in support of these operations.

(3) Effects of Oil Spills

Three small spills totaling 26 bbls have occurred as a result of OCS operations. No effects on marine mammals have been reported.

e. Coastal and Marine Birds

Numerous species of marine and coastal birds are found along the coastal areas and on the Atlantic OCS. The region is used as a feeding area, migratory route, breeding area, and an overwintering area.

A potential impact from OCS activities on marine and coastal birds could result from oil pollution. Oiling of birds causes death from hypothermia, shock, or drowning. Oil ingestion reduces reproduction in some birds and causes various pathological conditions in all bird species tested.

Principal references pertaining to the impacts of oil on birds in the Atlantic Region include the following: Biderman and Drury (1980), The Effects of the Low Levels of Oil on Aquatic Birds; Clapp et al. (1983), Marine Birds of the Southeastern United States and Gulf of Mexico; Olsen (1984), Effects of Contaminated Sediment on Fish and Wildlife: Review and Annotated Bibliography; Holmes and Cronshaw (1977), Biological Effects of Petroleum on Marine Birds; Hartung (1967), Energy Metabolism in Oil-Covered Ducks; and Croxall (1977), The Effects of Oil on Seabirds.

There have been 5 COST wells and 46 exploratory wells drilled on the Atlantic OCS, but no development or production activities have taken place. There are no documented short-term or cumulative impacts on marine and coastal birds from oil spills in the Atlantic Region that can be attributed to OCS activities.

3. Socioeconomic Environment

a. Employment and Demographic Conditions

The OCS activities in the Atlantic to date consist of seismic surveying and the drilling of 5 COST wells and 46 exploratory wells. In the North Atlantic, 2 COST wells were drilled in 1976-77, and 8 exploratory wells were drilled during 1981-82. In the Mid-Atlantic, 1 COST well was drilled in 1975-76 and 1 in 1978-79, and 32 exploratory wells between 1978 and 1984. In the South Atlantic, 1 COST well was drilled in 1977 and 6 exploratory wells during 1979-80. To support these activities, very few workers were required onshore, so that the hiring of a few office workers or laborers locally would have had negligible effects on local employment. In addition, the demographic effects would be negligible because the offshore workers were mostly experienced workers from the Gulf Coast who traveled to the Region to work a 14-day on, 14-day off shift. They would return to their homes outside the Region during their time off. Any effects to employment ceased when exploratory drilling ceased. There are no cumulative effects on employment or demographic conditions in the Atlantic Region from OCS activities.

b. Coastal Land Uses

The only onshore facilities needed to date to support OCS activities in the Atlantic have been support bases for supply vessels and helicopters. Onshore support was provided from three coastal locations. A former Navy base at Quonset Point/Davisville, Rhode Island, was used for the North and Mid-Atlantic. Facilities at Savannah and Brunswick, Georgia, were used for the South Atlantic. Helicopter support for the Mid-Atlantic was provided from the Cape May County, New Jersey, airport. In all cases, existing facilities with adequate capacity were used for OCS activities in the Atlantic. Therefore, there were no impacts on coastal land uses at the time of use, and there are no cumulative effects to report.

c. Commercial Fisheries

(1) Effects of Seismic Surveying

There have been no official claims to the Fishermens Compensation Fund for damage to fishing gear resulting from seismic work. However, reports of damage to gear have been made to the MMS District Office. In these cases, when the company was at fault, the company made direct compensation to the fishermen. Overall impacts have been minor.

(2) Effects of Support Vessel Traffic

There have been no reports of impacts on commercial fishing activities by support vessel traffic in the Atlantic Region.

(3) Exploration Rig Emplacement

There were 46 exploration wells drilled in the Atlantic Region, and no drilling has occurred since 1984. There have been no reports of impacts on commercial fishing activities from exploration rigs in the Atlantic Region.

(4) Effects of Offshore Use Conflicts

Centaur Associates (1981) conducted an extensive assessment of space-use conflicts between the fishing and oil and gas industries on the OCS in the Atlantic planning area. The potential impacts include exclusion from fishing areas, vessel traffic and gear conflicts, vessel and gear damage, short- and long-term damage to fish stocks and their marketability. No impacts on the commercial fishing industry have been reported.

(5) Effects of Oil Spills

No major oil spills have occurred, and no impacts on commercial fishing have been reported.

d. Recreation and Tourism

Coastal recreational activities popular in the Atlantic include swimming, scuba diving, windsurfing, sunbathing, beach hiking, boating, fishing, hunting waterfowl, birdwatching, and whale watching. Participation in all of these activities is high. Major State and Federal parks, wildlife refuges, and recreation areas cover large expanses of the coastline and many barrier islands. Tourism is a major component of local economies, estimated in billions of dollars and millions of people. Potential impacts on recreation and tourism may result from activities that cause land-use competition, visual effects, and oil-spill impacts.

No new onshore facilities or pipelines have been built to support offshore exploration and, because there is no production, no pipelines have been constructed. Offshore rigs and ships were temporarily in the Region and were not visible from shore. No oil spills have affected the shore.

In conclusion, there have been no discernible impacts on recreation and tourism related to OCS activities, and no cumulative impacts related to OCS activities have been identified.

e. Archaeological Resources

In the effort to minimize impacts to archaeological resources in the Atlantic Region, the MMS (and its predecessors BLM and USGS) funded two studies:

1. Summary and Analysis of Cultural Resource Information on the Continental Shelf from Bay of Fundy to Cape Hatteras, and

2. A Cultural Resource Survey of the Continental Shelf from Cape Hatteras to Key West.

These studies attempt, through the use of predictive models, to identify areas of the OCS where there is a high probability for the occurrence of archaeological resources. In these areas of high probability, the lessee is required, through lease stipulation, to conduct a tract-specific archaeological resource survey. These studies are updated for each lease sale. The updates include analysis and synthesis of data--archaeological, geological, and geophysical--generated since the preparation of the original study (or the last update). If a potential archaeological resource is located, a mitigation plan is developed. To date, no archaeological surveys have been conducted in the Region.

There have been no reports of impacts on archaeological resources from OCS activities, and no cumulative impacts related to OCS activities have been identified.

f. Military Use Areas

Portions of the water and air space of the Atlantic OCS and adjacent shoreline are used for military operations essential to training, readiness, and support of national defense and security interests. These operations include training and testing activities such as submarine operations, gunnery practice, sea trials, radar tracking, warship maneuvers, and general military operations. These activities usually take place in areas specifically designated for such purposes under the control of the DOD. These areas include the Boston Operating Area; Air Force Warning Area W-506; Narragansett Bay Area; Operating Areas of the U.S. Fleet offshore Norfolk, Virginia; Warning Areas of Cherry Point, Charleston, and Jacksonville; and the Eastern Space and Missile Center at Cape Canaveral. The National Aeronautics and Space Administration operates from the Wallops Island Flight Center and the John F. Kennedy Space Center at Cape Canaveral.

Potential conflicts in military use areas concern interference of military and commercial emissions of electomagnetic signals, falling debris from rocket and missile launches, ship and aircraft traffic, and collisions.

These potential conflicts have been mitigated through cooperation between the lessee and the appropriate military authority. In certain instances prelease stipulations have been attached to leases within military operating areas. No conflicts have been reported.

In conclusion, there have been no conflicts or impacts in military use areas related to OCS activities, and no cumulative impacts related to OCS activities have been identified.

C. Gulf of Mexico Region

1. Physical Environment

a. Water Quality

(1) Effects of Geological Sampling

Water quality is altered and degraded in several ways during geological sampling activities. Bottom sampling and shallow coring cause sediment suspension and associated increase in turbidity. Deep stratigraphic testing, being similar to rotary drilling of exploratory wells, results in the additional discharge of drill muds and cuttings and the associated increases in levels of suspended solids and trace metals in the receiving water.

Effects on water quality resulting from bottom sampling and coring activities are limited to the immediate area of operation (DOI, USGS, 1976). Because of dilution, dispersion, and settling, the impacts of drill muds and cuttings on water quality are limited to the immediate vicinity of the discharge and are generally not detected beyond 2,000 m from the discharge source (NAS, 1983; Houghton et al., 1980; Ayers et al., 1980a, b).

Geological sampling activities in the GOM Region have been limited. Approximately 80 geological sampling permits have been issued over the period of 1970-1985, and two deep stratigraphic tests (COST wells) have been completed. Results of studies conducted in the GOM Region (Ward et al., 1979; Ayers et al., 1980b; Middleditch, 1981; and Bedinger, 1981) indicate that the effects of drill muds and cuttings discharges on water quality have been temporary, limited in spatial extent, and not accumulative.

In conclusion, no cumulative effects on water quality as a result of geological sampling have been identified.

(2) Effects of Support Vessel Traffic

Water quality is degraded by support vessel traffic primarily through the introduction of petroleum hydrocarbons from fuel spillage and by the discharge of treated sewage.

Fuel spillages from support vessels are generally chronic and unintentional discharges associated with craft refueling. Richardson et al. (1975) estimate that each fueling of a pleasure craft at a recreational marina results in the spillage of one fluid ounce of gasoline or diesel fuel. Discharge of sewage from support vessels is through the use of marine sanitation devices. In both cases, fuel and sewage discharges, water quality may be threatened only in highly populated, confined harbors and anchorages with a large amount of marine traffic. The contribution of these discharges from OCS support vessels appears to have been limited, such that the effects (e.g., increase in suspended sediment) on water quality have been local and temporary, lasting 2-6 months concurrent with activity.

(3) Effects of Platform and Rig Emplacement and Removal

A general assessment of the effects on water quality from these activities can be determined from the impacts described for two OCS platforms in the Santa Maria Basin off California (Arthur D. Little, 1985). During the installation of offshore platforms, sediment disturbance and suspension result from pile-driving and anchoring and from dredging when foundations for production platforms are prepared. Sanitary (chlorinated) sewage, containing conventional pollutants such as BOD, is discharged from workboats. During platform and/or rig removal, the same materials (suspended solids and treated sewage) are released, but in lesser amounts. Impacts to water quality are local and temporary, usually several months or less in duration.

Currently in the northern GOM, there are about 3,400 oil and gas offshore platforms and other structures on the Federal OCS. Historically, about 30 platforms have been removed annually. No cumulative effects on water quality from the erection and removal of these and other structures in the GOM have been documented.

(4) Effects of Discharge of Muds and Cuttings

The MMS estimates that since 1954, approximately 108 million bbl of muds and 76 million bbl of cuttings have been generated and discharged in the GOM as a result of drilling 23,793 oil and gas wells and 105 sulfur wells. Over the 32-year OCS Program, it is estimated that a yearly average of approximately 3.4 million bbl of muds and 2.4 million bbl of cuttings have been discharged in the GOM, primarily in the Central GOM Planning Area off Louisiana. Results of studies conducted in the GOM Region (Ward et al., 1979; Ayers et al., 1980b; Middleditch, 1981; and Bedinger, 1981; NAS, 1983) indicate, or strongly suggest, that the effects of drill muds and cuttings discharges on water quality have been temporary, limited in spatial extent, and not accumulative.

In conclusion, cumulative impacts on water quality resulting from the discharge of muds and cuttings have not been demonstrated. Such impacts, if they exist, are of a minor and temporary nature. Impacts on wetlands, are discussed in Chapter V, Section C.2.f.

(5) Effects of Construction of Onshore Facilities

The procedures and environmental impacts related to OCS onshore facility construction have been reviewed in NERBC (1976). Land clearing and earth movement during construction have been identified as promoting nonpoint surface runoff containing elevated levels of suspended solids (organic and inorganic) and possibly heavy metals. This runoff may affect nearby streams and rivers; however, these effects are limited by erosion and runoff control procedures employed during construction. Adverse impacts on water quality are temporary and localized.

For the GOM Region, no cumulative impacts on water quality resulting from OCS construction of onshore facilities have been identified.

(6) Effects of Discharge of Produced Formation Water

Approximately 6 billion bbl of produced water have been generated from OCS activities in the GOM since 1954 (MMS estimate). Within an area south of Timbalier Bay, Louisiana, which historically has had the highest concentration of oil and gas activity, the produced water discharge has been estimated at 0.5 to greater than 1.5 million gallons per square mile per year (DOC, NOAA, 1985). In April 1982, an unpublished report entitled "The Discharge of Water Pollutants from Oil and Gas Exploration and Production Activities in the GOM Region" by Gianessi and Arnold (NOAA) estimated that for a representative year, approximately 685,000 bbl of produced waters were discharged. Approximately one-half of this amount was piped to onshore locations where it was treated and subsequently discharged to onshore waters. The monitoring studies conducted at the Buccaneer Gas and Oil Field (Middleditch, 1981) showed the rapid dilution of produced water in offshore waters of the GOM. The studies by Mackin (1971) and others suggested the existence of more extensive impacts on water quality from long-term discharges in shallow coastal areas (typically, depths of 2-3 meters). Neff (in Boesch et al., 1985) concludes that, based on several large investigations, few impacts occur in deeper waters of the Gulf of Mexico or off Southern California.

In conclusion, minor overall cumulative impacts on water quality are likely to have resulted from the discharge of produced water. These long-term impacts are poorly defined at this time and are probably limited to shallow-water receiving areas and, in offshore areas, to the immediate vicinity of continuous produced water discharge points (platforms).

(7) Effects of Pipeline Construction

As of June 1986, approximately 16,000 mi of pipeline have been permitted (right-of-way granted) on the OCS in this Region, primarily off Louisiana. Between 80 and 90 percent of these lines are estimated to lie in water depths shallower than 200 ft and, therefore, require burial below the seafloor. On the basis that 2,300-6,000 yd^3 of sediment are displaced per mile of pipeline buried, it is estimated that up to 85 million yd^3 of sediment have been displaced from pipeline burial in the GOM. Only short-term, localized effects on water quality are known to have resulted from these activities.

In conclusion, no cumulative effects on water quality as a result of pipeline construction have been identified offshore. Impacts of pipeline construction in wetlands are discussed under Wetlands (page V-26).

(8) Effects of Oil Spills

Over the period of 1976 through 1985, approximately 27,000 bbl of oil were spilled in the GOM from the approximately 9,300 oil spills reported from OCS oil and gas operations in the Gulf. Only 4 of these spills were over 1,000 bbl, but these accounted for roughly half of the total volume spilled during this time period (Cotton, 1986).

Investigations into the ecological effects of petroleum production in the central GOM (Ward et al., 1979; Bedinger and Kirby, 1981) and the comprehensive reviews of short- and long-term effects of offshore oil and gas development (Boesch and Rabalais, 1985; NAS, 1985) have not indicated a cumulative effect on water quality. Although some residual hydrocarbon accumulation was suggested with reference to sediment contamination, neither the oil releases from large spills (acute, episodic events) nor the numerous chronic discharges were demonstrated as being accumulative.

In conclusion, no cumulative effects on water quality as a result of oil spills have been identified.

b. Air Quality

Table V-2 summarizes the emissions from all direct and support activities for oil and gas operations in the GOM during 1986.

Table V-2

Estimated Emissions from Direct and Support Activities, Gulf of Mexico, 1986[1]

Activity	Pollutant Emissions (Tons) NO_x	TSP	VOC	SO_2	CO
Vessel Traffic	64,468	6447	1805	7736	5619
Platform Installation (165 platforms) and Removal (78 platforms)	122	12	3	15	32
Pipeline Construction 505 miles)	1,263	126	35	152	328
Oil Spills (413 barrels)	--	--	28	--	--
Exploration Drilling (263 wells)	1,915	191	56	226	455
Development/Production Drilling (370 wells)	2,694	270	78	318	710
Production from 1,211 emitting platforms (2)	102,935	509	56,541	745	21,679

(1) These estimates are based on samples taken at older, more pollution prone platforms.

(2) Out of 3,425 production platforms.

The MMS is conducting two air quality studies related to the cumulative impacts of the OCS oil and gas activities in selected study areas in the Gulf of Mexico. The first study will assess the impacts on onshore concentrations of the inert pollutants from OCS facilities in three study areas off Louisiana. Work is being completed on the data collection phase of this study. Once the appropriate data are developed, a modeling analysis will be conducted.

The second study involves evaluating data resources in onshore and offshore areas to assess the onshore impacts on photochemical pollutant concentrations from OCS facilities. The data requirements for this modeling analysis include extensive air quality meteorological and source emissions data.

In the GOM there are a total of 3,425 platforms producing oil and gas, of which there are 1,211 platforms containing sources that emit air pollutants. These platforms are distributed over an area of 30,000 mi^2 off Texas and Louisiana. The total NO_x and VOC emissions from these platforms were 11.1 percent and 7.1 percent, respectively, of the total onshore emissions in the coastal parishes and counties in Texas and Louisiana.

Of the 1,211 platforms, 1,039 platforms are adjacent to Louisiana and emit 22 percent and 16 percent, respectively, of the onshore NO_x and VOC emissions from the coastal parishes. The remaining 172 platforms are adjacent to Texas (i.e., more than 10 miles from shore) and emit 3 percent and 1.5 percent, respectively, of the onshore NO_x and VOC emissions from the Texas coastal counties.

In 1977, EPA designated the following Louisiana coastal parishes (i.e, more than 3 miles from shore) as nonattainment areas for ozone: St. Bernard, Orleans, Jefferson, Lafourche, St. Charles, St. Mary, and Lafayette. The MMS has learned that the Louisiana Department of Environmental Quality is proposing to redesignate these coastal parishes as attainment areas for ozone and the remaining criteria pollutants (personal communication from Gus von Bondungen).

If OCS sources were contributing to onshore exceedances of the NAAQS, exceedances would be experienced in these coastal parishes. The MMS believes the proposed redesignation of the coastal parishes as attainment is an indication that the OCS is not causing or contributing to the exceedance of any of the NAAQS. As noted, MMS will continue its air quality modeling studies to verify this assumption.

2. Biological Environment

a. Lower Trophic Organisms

(1) Effects of Discharge of Muds and Cuttings

Since 1954, approximately 108 million bbl of muds and 76 million bbl of cuttings (MMS estimate) have been produced throughout all the GOM Planning Areas. The effects of drilling muds and cuttings on benthic communities were studied in the central GOM (Bedinger, 1981; Ward, et al., 1979). No significant effects were attributed to the drilling discharges. Sediment samples collected further than 500 m from production platforms showed no evidence of barium or sodium montmorillonite (principal drilling fluid materials), indicating that long-term accumulation of drilling discharge material had not occurred (Bedinger, 1981). A study conducted in the GOM by the Offshore Operators Committee showed that alternatives in ocean water quality are highly localized and of short duration even during high rate, high volume discharges (Ayres, et al. 1980b). No long-term effects of discharges have been demonstrated.

(2) Effects of Discharge of Produced Formation Water

Approximately 6 billion bbl of produced waters have been generated from OCS activities in the GOM since 1954. One field study in the GOM investigated the environmental effects of produced formation water discharge in the Buccaneer Field. This study showed that produced water discharges exert chronic effects on benthic organisms near production platforms (Middleditch, 1981). The generally elevated levels of hydrocarbons and other chemicals in sediments over wide areas in the GOM hamper efforts to delineate the actual areal extent of such effects (EPA, 1985). Middleditch (1984), in an assessment of the ecological effects of produced water discharge from offshore oil and gas platforms, concluded that any effects would probably be minor and limited to a small area.

In conclusion, although water column and benthic organisms in areas surrounding production platforms have been negatively impacted by discharged produced formation water, the areal extent of such impacts is minimized by dilution and mixing in the offshore environment.

(3) Effects of Pipeline Construction

As of June 1986, approximately 16,000 mi of pipeline have been permitted (rights-of-way granted) on the OCS in the GOM. Since 1979, construction has averaged about 600 mi per year. It has been estimated that for every mile of pipeline constructed, 6 acres of sea bottom are disturbed. In the immediate vicinity of the pipeline construction, some lower trophic organisms will be disturbed or destroyed. Although no specific studies have been conducted to quantify these impacts, they are thought to be highly localized and rapid recovery would be expected. No long-term impacts have been identified.

(4) Effects of Oil Spills

In the 10-year period of 1976 through 1986, four spills of more than 1,000 bbl of oil were attributed to OCS activities in the GOM Planning Areas. The total volume spilled by these four incidents was approximately 12,000 bbl. An investigation of petroleum production platforms in the central GOM concluded that although long-term hydrocarbon contamination occurred in the immediate vicinity of the platforms, no significant biological effects were apparent (Bedinger, 1981). The amount of oil spilled in the GOM is small. Given the natural processes that degrade petroleum and thereby reduce the toxicity, no cumulative impacts on lower trophic organisms would be expected.

b. Fish Resources

(1) Effects of Discharge of Muds and Cuttings

Since 1954, an estimated 108 million bbl of muds and 76 million bbl of cuttings have been generated as a result of drilling over 23,000 oil and gas wells and 105 sulfur wells. The National Research Council (1983) concludes that most water-based muds (the discharge of oil-based muds into marine waters is prohibited) used in the United States "have low acute and chronic toxicition to marine organisms" and that "the bioaccumulation from drilling fluids . . . is observed to be small in the field." Although some effects on fisheries resources may occur in the immediate vicinity of the discharge, these are transitory, and long-term effects have not been identified.

(2) Effects of Produced Formation Waters

Approximately 6 billion bbl of produced water have been generated from OCS oil and gas activities since 1954. Gallaway (1981) concluded that produced waters were only slightly toxic, and direct effects occur only in the area within a few meters of the outfall. No documented impacts to fisheries resources have been reported in the GOM.

(3) Effects of Oil Spills

In the 10-year period, 1976 to 1985, only four spills of more than 1,000 bbl of oil were attributable to OCS oil and gas activities. The volume spilled over this 10-year period totaled approximately 12,000 bbl. The biological effects of petroleum have been extensively studied. An ecological investigation of petroleum production platforms in the central GOM concluded that, although long-term contamination of the area by hydrocarbons had occurred, no significant biological effects were apparent (Bedinger, 1981). The NAS (1985) concluded that "there is no clear indication so far that commercially important fish stocks have been severely disrupted by either chronic or catastrophic oiling of their environment." There is no evidence in the GOM to indicate that fisheries resources have been depleted by OCS-related oil spills.

c. Endangered or Threatened Species

(1) Effects of Support Vessel Traffic

The West Indian manatee inhabits the rivers, bays, and estuaries of the eastern GOM from Cedar Key, Florida, south to Key West. Manatees are vulnerable to boat collisions. No collisions related to OCS activities are known, and the limited amount of exploration activity that has occurred in the eastern GOM has made the possibility of impact unlikely.

(2) Effects of Platform Removal

Platforms and other structures, such as well jackets and caissons, are most efficiently and economically removed by using explosive charges. In the GOM Region, five species of sea turtles, all of which are protected under the Endangered Species Act (ESA), may be found in the vicinity of OCS platforms and structures. This presents the possibility that individuals of an endangered or threatened species may be killed or injured during a platform or structure removal. No direct observations of sea turtle injuries or fatalities resulting from the removal of OCS structures by explosives are available. However, indirect evidence from stranding records have indicated that some turtles may have been killed as a result of explosive blasts; most likely from structure removals in State territorial waters. The MMS is currently consulting with NMFS under Section 7 of the ESA, on a removal-by-removal basis, to assure that protected sea turtle species suffer no adverse effects as a result of explosive structure removals in the GOM. Typical measures which are presently taken to protect sea turtle species include: pre-blast diver surveys; aerial and surface-observer surveys by NMFS personnel; staggering of the individual charges to minimize cumulative blast effects; and post-blast surveys for injured individuals. No sea turtles are known to have been adversely affected by recent structure removals performed under the consultation process. In addition to mitigating the potential impacts on sea turtles for ongoing removal activities, MMS and NMFS are investigating procedures to determine the overall potential risk to sea turtles species from structure removals on the OCS, and to minimize any potential effects on these species.

(3) Effects of Oil Spills

Oil spills contacting a turtle nesting beach during egg incubation or hatching periods would cause significant turtle mortality. Sea turtles, especially juveniles, snap at or attempt to swallow any object of appropriate size, such as tar balls. Ingestion of tar balls has been recorded and could result in turtle mortality. The volatile, soluble, and tar fractions of an oil spill could affect the lungs of sea turtles reducing ventilation and reducing time for feeding. Ingestion of oil could affect the gastrointestinal tract. Oil coating the head and eyes could affect the orbital salt glands that may affect many physiological processes. No damage to sea turtles as a result of oil spills from OCS oil and gas activities has been documented.

Brown pelicans are susceptible to oil spills because they dive for fish, and their feathers could become coated with oil. No damage to brown pelicans from oil and gas activities has been documented.

d. Marine Mammals

(1) Effects of Seismic Surveying

The potential effects of seismic surveying are discussed in Chapter IV, Section E. Approximately 365,000 line miles of seismic surveys related to OCS oil and gas activities have been permitted by the MMS in the GOM. No significant impacts on marine mammals have been reported.

(2) Effects of Support Vessel Traffic

There exists a potential for collision between marine mammals and OCS oil- and gas-related support vessels. The OCS-related vessel traffic is estimated to be 3 percent of the total traffic in the central GOM and lesser amounts in the western and eastern Gulf. The level of OCS-related collisions with marine mammals is unknown; no injuries or mortalities have been reported.

(3) Effects of Platform Removal

Over the period 1976-1985, an average of 40 platforms per year have been removed from the OCS in the GOM. The usual method of removal involves the use of explosives to sever the legs of the platform below the seafloor. Recently, concern has been raised over possible effects to porpoises from the use of explosives. The MMS is funding research to better understand the potential problem and is working with NMFS to ensure that the requirements of the Marine Mammal Protection Act are not violated. Under current procedures, the MMS enters into a formal Section 7 consultation pursuant to the ESA with NMFS for each platform removal action.

(4) Effects of Oil Spills

The potential impacts of oil spills on marine mammals is discussed in Chapter IV, Section B. No injury or mortality to marine mammals from OCS oil- and gas-related oil spills have been observed.

e. Coastal and Marine Birds

Numerous species of coastal and marine birds use the coastal and offshore areas of GOM. Approximately 5-9 million migratory waterfowl overwinter in the Gulf coastal wetlands.

An adverse impact could occur if marine and coastal birds contacted oil. Such contact could result in matting plumage that can reduce flying and swimming abilities, loss of buoyancy, hypothermia, shock, and reduced reproduction (Hunt, 1985; Nero and Associates, 1983; and Clark, 1984).

Major references pertaining to the potential impacts from oil on birds in the GOM include the following: Clap, Morgan-Jacobs, and Banks

(1982), Marine Birds of the Southeastern U.S. and Gulf of Mexico; King and Sager (1979), Oil Vulnerability Index for Marine Oriented Birds; Holmes (1984), Petroleum Pollutants in the Marine Environment and their Possible Effects on Seabirds; Avery et al. (1980), Avian Mortality at Man-Made Structures, An Annotated Bibliography; and Albers (1978), The Effects of Petroleum on Different Stages of Incubation in Birds Eggs.

There are no documented cumulative impacts to marine and coastal birds from oil spills in the GOM Region that can be attributed to OCS activities.

f. Wetlands

The loss of the Nation's wetland resources in Louisiana has been occurring at the rapid rate of 1 percent annually (approximately 50 mi^2/yr, or 32,000 acres/year in Louisiana). The wetlands are an important environmental value because of their great productivity and diversity, ecological importance as nursery and rookery grounds, fishing interest, critical habitat for threatened and endangered species, status as the largest fur-producing area for North America, hydrologic utility in terms of flood control, contribution to improved water quality, and flow stabilization for streams and rivers. Wetland loss is the result of a combination of manmade and natural factors, including sedimentation rates, submergence, canalization, as well as secondary effects such as salt water intrusion and soil waterlogging. Important factors contributing to the creation of open water and the loss of wetland areas are the combined impact of sediment deprivation due to construction of dams and reservoirs along the upper tributaries of the Mississippi River, channelization of the lower Mississippi for flood control and navigation, State and OCS oil and gas activities such as access canals and the withdrawal of resources, and natural submergence of as high as 9 to 13 millimeters/yr due to eustatic sea level rise and geologic subsidence.

The OCS activities do not directly impact the wetland areas along the coast other than for specific construction of navigation canals for transport of OCS oil or gas, or pipeline rights-of-way transporting oil or gas from the OCS to onshore areas. The MMS has funded a study (Turner et al., 1988) through Louisiana State University to investigate the factors and processes that contribute to wetlands loss in Louisiana. The study evaluated the relative importance of the causative factors that contribute to wetlands loss and the involvement of OCS-related activities. The study estimated that the total direct impacts of OCS oil and gas activities from 1955 to 1978 resulted in 4-5 percent of the total loss of wetlands in Louisiana. Sixteen percent of wetland loss in Louisiana is reported to be due to direct impacts from State and OCS spoil banks, navigational channels, pipeline canals, and facilities. The direct impacts from OCS pipeline and navigational channels are as much as 32 percent of the total 16 percent net increase in spoil and canal area. The majority of wetland use is by onshore and coastal State and local interests.

The MMS funded study also estimated indirect impacts to the wetlands. As stated in the report, OCS development accounted for an estimated 5-18 percent of all indirect impacts or 4-13 percent of the total wetland loss. Combining the direct and indirect impacts, OCS development accounted for 8-17 percent of all wetland loss. Land use changes and oil and gas canals and spoilbanks (OCS and non-OCS) accounted for 13 percent and 30-59 percent, respectively, of the total wetland losses.

Besides the stated GOM study, the MMS has funded studies to understand the effects of aircraft overflights on wetland geese in Alaska and to perform baseline studies in lagoonal areas in California. One ongoing study in the GOM Region is titled "Importance of OCS Activities on Sensitive Coastal Habitats", funded through Coastal Environments, Incorporated. This study is designed to evaluate OCS pipeline crossings on barrier islands and associated wetlands along the Gulf Coast. Beginning in FY 1988, the GOM Region is sponsoring a 2-year study on "Mitigation of Wetland Impacts Due to OCS Oil and Gas Activities." In this new study, a variety of marsh management techniques will be evaluated as tools for reducing wetlands loss.

These mitigation measures include the use of new techniques such as backfilling, double ditching, and plugging of canal entrances in order to encourage revegetation of the canal. Most of the deleterious effects on the wetlands that are evident today in the GOM Region are the result of early development before the use of these more environmentally sound methods. The new study will reevaluate these techniques and possibly propose other ones.

Current trends, as suggested by studies presently underway by the U.S. Fish and Wildlife Service, indicate that rates of wetland loss are increasing in localized areas. Proper mitigation of OCS oil and gas activities, such as pipeline backfilling, double ditching, and others, are reported to reduce impacts on sensitive wetlands from pipelines to negligible levels. In conclusion, the cumlative impacts from OCS activities to the wetland areas around the GOM are small relative to the total wetland loss problem.

3. Socioeconomic Environment

a. Employment and Demographic Conditions

The oil and gas industry, of which OCS activities are a significant part, is a major source of employment and revenues in the States of Louisiana and Texas. Anything that affects the oil and gas industry can have drastic effects on employment within these States and significantly affect both the private and public sector of local and regional economies. It is estimated that OCS-related activities account for approximately 190,000 jobs, with an annual payroll of over $4 billion.

The employment impact of OCS activities can be addressed in three distinct categories: direct, indirect or secondary, and induced. Direct employment associated with the oil and gas extraction industry consists of those workers involved in oil and gas exploration activities and production operations, including geophysical surveys, exploratory and development drilling, and well operations and maintenance. Contract field services, such as acidizing, cementing, mud services, well logging, and perforations, are also included in the direct employment category. These activities are covered under the U.S. Government's Standard Industrial Classification (SIC) Code 13 - Oil and Gas Extraction. It is estimated that employment in this category is approximately 24,000, with an annual payroll of over $850 million.

Indirect or secondary oil and gas employment includes workers in the refining, oil field machinery and equipment manufacturing, pipeline transportation, gas production and distribution, and wholesaling of petroleum and petroleum products industries. These activities are covered under SIC Codes 29, 3533, 46, 492, and 517. It is estimated that employment in this category is approximately 120,000, with an annual payroll of over $3 billion.

The direct and indirect employment discussed above creates additional employment not related to OCS activities. This type of employment is referred to as induced employment because jobs in this category are induced or supported by expenditures of direct and indirect workers. Products and services in this category are sought by all workers and households regardless of occupation. Based on MMS analysis for proposed Federal OCS oil and gas lease sales, it is estimated that one job in the induced employment category is created for every three direct and indirect jobs. Based on this, it is estimated that approximately 48,000 jobs in the consumer goods and service sector of the area exist because of OCS activities.

b. <u>Coastal Land Uses</u>

The infrastructure for oil and gas production in the GOM is the most developed in the world. It includes oil refineries, petrochemical and gas processing plants, supply bases for offshore services, platform construction yards, pipeline yards, and other industry-related installations. This infrastructure is highly concentrated in the coastal areas of Louisiana and eastern Texas, and to a lesser extent along the southern half of the Texas Gulf coast and east of Louisiana as far as Mobile, Alabama. Because of this existing infrastructure, most recent onshore support or processing needs resulting from offshore activities are accommodated without new construction. Of course, the construction of the existing facilities altered coastal land uses. Although there would have been of necessity, some cumulative impacts on coastal land use, no facility could be constructed without receiving many approvals at the Federal, State, and local levels. See also the sections on wetlands and recreation for cumulative impacts to coastal land uses in these categories.

c. Commercial Fisheries

(1) Effects of Seismic Surveying

There have been no reports of impacts to commercial fishing operations from seismic surveying in the GOM Region.

(2) Effects of Support Vessel Traffic

There have been no reports of impacts to commercial fishing activities from support vessel traffic in the GOM Region.

(3) Effects of Platform and Rig Emplacement and Removal

As of January 7, 1987, the MMS Gulf of Mexico Regional Office reported that there were 3,821 active "structures" (including production platforms and pumping stations) in the GOM. A production platform could exclude vessels from an area of about 0.26 mi^2 (Centaur Assoc., 1984a). If all these structures were production platforms, commercial fishing vessels could potentially be excluded from about 993 mi^2 of space.

One documented report of a fish kill as a result of platform removal by explosives has been recorded by the GOM Regional Office. This incident took place in July 1986 in the West Cameron Area offshore of Louisiana (Stechmann, 1986). No quantitative data on this kill are available. The species involved were red snapper, amberjack, spadefish, and jacks.

A number of studies have documented the enhancement of fisheries by artificial reefs (offshore platforms, in this case). Much of this information is summarized in a report by Ditton and Auyong (1984). This report attempted to summarize use patterns of offshore platforms by fishermen in the GOM. Recreational fishermen were the main users; however, commercial fisheries for snapper in the Bay and Cameron regions and for snapper, croaker, and trout in the Delta region were reported.

There is no well-documented evidence to show any cumulative effect on commercial fishing, either positive or negative, by platform emplacement or removal. However, there are strong indications that offshore platforms have increased the carrying capacity of the environment in the GOM, enhancing some fisheries.

(4) Effects of Offshore Use Conflicts

Potential effects of offshore use conflicts on commercial and recreational fishing include exclusion from fishing areas, vessel traffic and gear conflicts, vessel and gear damage, and short- and long-term damage to fish stocks and their marketability.

There have been a number of claims by commercial fishermen under Title IV of the OCSLA Amendments. The Fishermen's Contingency Fund has verified and paid out the following claims for vessel and gear damage due to oil and gas industry activities in this Region:

Year	Number of Claims	Dollar Amount
1983	22	128,621
1984	115	474,057
1985	112	614,536
1986	135	843,727

Information before 1983 is not available.

(5) Effects of Pipeline Construction

It has been estimated that spatial loss from pipeline construction could be up to 0.5 mi^2 per mile of pipeline (Centaur Assoc., 1984b). Boesch and Robillard (1985) estimate that over 15,625 mi have been emplaced in the GOM. Spatial loss from actual construction is temporary.

Boesch and Robillard (1985) reviewed the potential effects on coastal habitats from oil and gas activities. In this report, pipelines are said to be one of the causes of long-term damage to wetlands. Many commercial fish species in the GOM depend on wetlands during one or more stages of their life cycle.

In conclusion, no direct cumulative effects to commercial fishing from pipeline construction have been documented. The loss of coastal wetlands that provide critical habitat for many species of fish and shellfish is a potential problem.

(6) Effects of Oil Spills

These effects are discussed under Chapter IV, Section B.6, Impacts of Oil Spills on Fish.

d. Recreation and Tourism

Coastal recreational activities popular in the GOM include swimming, scuba diving, windsurfing, sunbathing, beach hiking, boating, fishing, hunting waterfowl, and birdwatching. Participation in all of these activities is high. Major State and Federal parks, wildlife refuges, and recreation areas cover large expanses of the coastline and many barrier islands. Tourism is a major component of local economies, regionally estimated in billions of dollars and millions of people.

Potential impacts to recreation and tourism may result from activities that cause visual effects, land-use conflicts, and oil-spill impacts. The emplacement of platforms can adversely affect the aesthetic nature of the coastline when constructed close enough to shore to be seen and to obscure a relatively large portion of the natural environment (Nassauer et al., 1982).

The GOM contains the largest concentration of offshore platforms. Approximately 230 large platforms are located in State and Federal waters in sight of the coast of Louisiana, and an additional 46 are located within view of the Texas coast. In addition, 19 clusters consisting of numerous small platforms, many within sight of each other, are found in view of the Louisiana coast, while 2 such clusters are found off Texas. Approximately half of these structures are in Federal waters. The remaining Gulf Coastal States have not had extensive development off their coasts.

Two studies have been performed to examine the impact of the sight of platforms from the coast (University of Illinois, Urbana, 1982; Dornbush, 1987). The University of Illinois study showed that visitors most disliked nearby facilities that obstructed the view of the natural environment and facilities or structures at any distance and that were not neat and clean. There have been no data collected to indicate that the residents, businesses, or visitors to the coastal areas of the GOM are adversely affected by the sight of offshore structures. The presence of such large numbers of structures offshore, combined with the presence of onshore facilities and numerous pipeline and navigation canals, has changed the character of the central and western Gulf Coast, but the contribution of the OCS to that change has not been determined.

Some of the trash which is washed up on the beach, especially in Texas and Louisiana, comes from OCS oil and gas activities. The proportions that are related to oil and gas activities and to other activities, e.g. shipping, military activities, fishing, and boating, are not known with certainty. A report prepared by the Center for Environmental Education (1987), however, estimates that 10 to 15 percent comes from offshore oil and gas operations and that through the efforts of the Texas General Land Office, the MMS, and the oil and gas operators themselves, that percentage is being rapidly reduced. The oil and gas industry, through the Offshore Operators Committee, have mounted an intensive campaign to eliminate trash generated by their operations and also operations carried out by subcontractors. In addition, the MMS regulations (30 CFR 250.40) prohibit the discharge of trash and other solid waste materials associated with OCS operations.

More than 4,000 platforms in State and Federal waters, over 1,000 of which are navigationally marked and have lighted structures, serve as navigational aids and even refuges in storms. For a long time recreational, fishermen have been attracted to these platforms. Platforms, although manmade, act in the same manner as a reef in the ocean, attracting numerous species of fish, many of which are of interest to recreational and even commercial fishermen (Witzing, 1984). Most recreational fishing and scuba diving take place within 20 mi of shore, and up to 70 percent of all types of fishing takes place around oil and gas platforms (Ditton and Auyong, 1984). The construction of large numbers of platforms near the coast of Louisiana and Texas has led to a substantial growth in recreational fishing with substantial benefits to Gulf Coast States near enough to the platforms to take advantage of the fishing opportunities provided.

Since the platforms nearest the coast were generally emplaced earliest, up to 30 years ago, some of them are now being removed. Removal of those platforms will reduce the number available for recreational fishing, thereby reducing the beneficial cumulative impact on that activity.

The placement of rigs and platforms near the coastline in the central and western GOM coastal areas has contributed to the high level of impact on the aesthetic nature of the region, but the contribution of OCS rigs and platforms to that impact is unknown. The placement of platforms near the coast has resulted in a high beneficial impact to recreational fishing and diving. The construction of refineries, pumping stations, service bases, and construction yards can adversely affect the aesthetic nature of a coastal area when they are constructed outside of urbanized or industrialized areas and change the nature of a relatively large part of the local natural environment (University of Illinois, Urbana, 1982).

The production of offshore equipment for the OCS and foreign oil and gas fields, the transportation of OCS oil and gas along with imported oil, and the refining and processing of OCS and imported oil and gas have been responsible for major changes in the character of Gulf Coast industrial cities, towns and villages, and some formerly natural areas. The contribution of the OCS to this growth and alteration of the aesthetic aspect of the area is unknown. In some areas (Morgan City, Louisiana, for example), the nature of the town has changed from a small, rail, agriculture- and fishing-oriented town to one of the major oil industry construction bases in the country. Whether such changes are viewed as an undesirable degradation of the aesthetic character of the area, or merely as an adjunct to normal urbanization and industrialization, is speculative.

The impacts of construction of onshore facilities, when combined with canal construction; onshore oil and gas operations; and the sight of offshore platforms, have changed the character of large sections of the central and western Gulf Coast. However, the contribution of the OCS to this change is unknown.

Over 400 pipelines have crossed the beaches, but the number of pipelines built in the coastal marshes is not known. Over 40,000 wells have been completed onshore in coastal Louisiana, most of which have pipelines connecting them to other lines, wells, refineries, or pumping stations. Almost all pipelines are buried. On beach areas and coastal plains, rehabilitation efforts are usually successful in removing most of the visible effects of the pipeline construction. In coastal marshes and swamps, pipeline channels remain long after construction and often contribute to further change in the remainder of the area (Turner, Constanza, and Scaife, 1982). The central GOM coastal area, mostly in Louisiana, is crisscrossed with many pipeline channels resulting from onshore, State offshore, and OCS oil and gas activities. These channels and nearby areas are altered because of the presence of the channels and canals and have thoroughly altered the aesthetic nature of the swamps and marshes, in some cases almost completely changing their natural and visual aspects. Pipeline construction has greatly affected the aesthetic nature of the coastal areas of the central GOM, but the contribution of the OCS activity to that impact is unknown.

Oil spills reaching coastal recreational areas affect aesthetics and recreation by coating beaches and making them unpleasant; this results in reduced economic intake for local recreation-oriented businesses. The loss is usually immediate but does not extend beyond the removal of the oil and fouled coastal materials (Restrepo, 1982).

In order for cumulative effects on recreation or aesthetics in a recreation area to accrue from oil spills, more than one spill would have to occur and affect the same area before the effects of the first spill had dissipated. This situation has never occurred. Cumulative impacts could also occur if a large enough number of oil spills contacted various recreation areas along a coastline and affected the recreation industry along the entire coastline. This has not occurred either; therefore, there have been no cumulative impacts from oil spills.

In conclusion, there have been cumulative impacts on recreation and tourism related to OCS activities, but the level of these impacts cannot be separated from onshore oil and gas impacts, impacts from activities in State waters, and impacts from other industrial growth.

e. Archaeological Resources

In the effort to minimize impacts to archaeological resources in the GOM Region, four studies were funded:

1. Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf,

2. Sedimentary Studies of Prehistoric Archaeological Sites,

3. Prehistoric Site Evaluation on the Northern Gulf of Mexico Outer Continental Shelf: Ground Truth Testing of the Predictive Model and,

4. An Archaeological Investigation to Reevaluation Cultural Resource Management Zone I in the Gulf of Mexico and to Provide an Interpretive Framework for the Analysis of Magnetometer Data.

These studies attempt, through the use of predictive models, to identify areas of the OCS where there is a high probability for the occurrence of archaeological resources. In these areas of high probability, the lessee is required, through lease stipulation, to conduct a tract-specific archaeological resource survey. These studies are updated for each lease sale. The updates include analysis and synthesis of data--archaeological, geological, and geophysical--generated since the preparation of the original study (or the last update). If a potential archaeological resource is located, a mitigation plan is developed. To date, 1,998 archaeological surveys have been conducted in the Region.

Because of mitigation and avoidance of potential sites, there have been no reports of impacts to archaeological resources from OCS activities, and no cumulative impacts related to OCS activities have been identified.

f. Military Use Areas

The GOM is divided into 12 Warning Areas. The water and air space are used for many activities including live firing aerial gunnery, trailing wire antenna activity, flares and chaff drop tests, B-52 G-model low-level flights, carrier maneuvers, carrier pilot training, and optics and sound testing.

Potential conflicts in military use areas concern interference of military and commercial emissions of electromagnetic signals, falling debris, ship and aircraft traffic, and collisions between rigs or vessels. Commercial fishermen and recreational boaters also use these same areas.

These potential conflicts have been mitigated through cooperation between the lessee and the appropriate military authority. In certain instances, prelease stipulations have been attached to leases within military operating areas.

While no direct conflicts (collisions with platforms, damages to military or oil and gas equipment, etc.) have been reported, areas formerly available for unrestricted military maneuvers have been greatly reduced through the slow expansion of areas occupied by platforms in the central and western parts of the Gulf. Some areas currently designated by DOD for training or operations which are underlaid by oil and gas resources have been subjected to leasing, exploratory activity, and platform construction. In the western part of the Gulf, the northern portions of the areas W-228 and W-602 have been the sites of considerable exploration and platform construction, slightly reducing the military's unrestricted use of those areas. In the eastern portion of the Gulf, extensive oil and gas operations have not taken place in designated operating and training areas. Leasing has taken place, however, and the DOD, unable to determine when plans of development will be filed by lessees, must take into account in their planning process that some parts of operating or training areas may have to be withdrawn from unrestricted use.

In conclusion, although there have been no direct conflicts with military use in the GOM, the area available for military activity has been restricted.

D. Pacific Region

1. Physical Environment

a. Water Quality

(1) Effects of Geological Sampling

Water quality is altered and degraded in several ways during geological sampling activities. Bottom sampling and shallow coring cause sediment suspension and associated increase in turbidity. Deep stratigraphic testing, being similar to rotary drilling of exploratory wells, results in the additional discharge of small amounts of drill muds and cuttings and the associated increase in levels of suspended solids and trace metals in the receiving water.

Effects on water quality resulting from bottom sampling and coring activities are limited to the immediate area of operation (DOI, USGS, 1976). Because of dilution, dispersion, and settling, the impacts of drill muds and cuttings on water quality are limited to the immediate vicinity of the discharge and are generally not detectable beyond 2,000 m from the discharge (NAS, 1983; Houghton et al., 1980; and Ayers et al., 1980a, b).

Geological sampling activities in the Pacific Region have been limited. Approximately 70 geological sampling permits have been issued over the period of 1963-1985, and 2 deep stratigraphic tests (COST wells) have been completed. Results of the Tanner Bank study (ECOMAR, 1978) off California and the State-sponsored NPDES permit monitoring indicate, or strongly suggest, that the effects of drill muds and cuttings discharges on water quality have been temporary, limited in spatial extent, and not accumulative.

In conclusion, although temporary and localized effects have occurred, no significant cumulative effects on water quality as a result of geological sampling have been identified.

(2) Effects of Discharges of Muds and Cuttings

Since 1963, approximately 2.9 million bbl of muds and 1.4 million bbl of cuttings have been discharged in the Pacific Region as a result of drilling 917 wells. Over 95 percent of the drilling activity and, in turn, discharge of muds and cuttings occurred in the Southern California Planning Area (primarily the Santa Barbara Channel). Results of the Tanner Bank study (ECOMAR, 1978) off California and the

State-sponsored NPDES permit monitoring indicate, or strongly suggest, that the effects of drill muds and cuttings discharges on water quality have been temporary, limited in spatial extent, and not accumulative.

In conclusion, although temporary and localized effects have occurred, no significant cumulative effects on water quality as a result of discharge of muds and cuttings have been identified.

(3) Effects of Construction of Onshore Facilities

The procedures and environmental impacts related to OCS onshore facility construction have been reviewed in NERBC (1976). Land clearing and earth movement during construction have been identified as promoting surface runoff containing elevated levels of suspended solids (organic and inorganic) and possibly heavy metals. This runoff may affect nearby streams and rivers; however, these effects are limited by erosion and runoff control procedures employed during construction. Adverse impacts on water quality are temporary and localized.

The impacts on ground and surface water quality from onshore construction in the Pacific Region have been addressed in various environmental impact statements or reports (e.g., Arthur D. Little, 1985; URS, 1986) in response to Federal and State requirements. Although potential for significant impacts as a result of the use and operation of gas facilities has been identified, these impacts have been mitigated by the use of desalination plants and other conservation methods.

In conclusion, no significant cumulative impacts have been identified.

(4) Effects of Discharge of Produced Formation Water

An estimated 105 million bbl of formation water have been discharged to date from OCS activities in the Pacific Region. This volume was discharged into the Santa Barbara Channel and offshore Los Angeles/ Long Beach Harbors at an approximate average rate of 7 million bbl per year since 1968. Long-term localized or areawide impacts from formation water discharges have not been studied in the Pacific Region. However, it is believed that rapid dilution of discharged produced water in offshore waters, similar to that noted in the Gulf of Mexico studies (Middleditch, 1981), has been occurring. Thus, beyond the immediate mixing area of the discharge, no long-term impacts on water quality are believed to have occurred.

In conclusion, only minor and localized impacts on water quality are likely to have resulted from the discharge of produced water. These poorly defined impacts are limited to the immediate vicinity of continuous produced water discharge points (i.e., platforms).

(5) Effects of Pipeline Construction

A total of 164 mi of OCS pipelines have been constructed in the Pacific Region through December 1986. Pipelines are not buried (with one exception, described below) in this region to reduce the danger of rupture during earthquakes. The amount of turbidity created during pipeline construction is, therefore, limited. The only burial along the course occurs when the pipeline traverses the approximate 20-foot depth contour line, through the intertidal zone, and onshore. The suspended sediment associated with the pipeline construction is limited and settles rapidly.

In conclusion, temporary and localized impacts on water quality have occurred. No significant cumulative impacts to water quality have been identified.

(6) Effects of Oil Spills

Since 1970, less than 200 bbl of oil have been spilled in the Pacific Region as a result of OCS oil and gas operations (MMS OCS Events File). Little information on water quality impact is available with reference to the Santa Barbara Platform A oil spill, which initially released 10,000 to 70,000 bbl of oil. The period of blowout lasted 10 days. However, the results of the Amberg et al. (1973) study of intertidal organisms indirectly suggest that there was no significant, continued impact on water quality from this spill. In this study, 10 rocky intertidal beaches in southern California, which were initially surveyed for 12 months following the 1969 Santa Barbara spill, were reinvestigated in 1972. Seepage of oil from Platform A is presently continuing at a rate of approximately 360 bbl per year. This rate constitutes a minor portion of the natural seepage that is estimated to be about 40-670 bbl per day from the Santa Barbara Channel.

In conclusion, no significant cumulative impacts on water quality resulting from oil spills have been identified.

b. Air Quality

(1) Effects of Activities

Table V-3 summarizes the emissions from all direct and support activities for oil and gas operations in the Pacific Region during 1986. Based on in-house MMS modeling analyses, the onshore impacts from individual facilities and cumulatively from several facilities in a common area was less than 1 ug/m^3 for the inert pollutants. At the present time, an inert pollutant air quality model is being developed to calculate onshore impacts from mobile sources on the OCS.

Air emissions from OCS oil and gas operations are also being monitored by the Santa Barbara County Air Pollution District in implementing its Air Quality Attainment Plan. Emissions data for 1986 are not yet available. These data, when complete, will be considered in subsequent annual updates of this report.

Table V-3
Estimated Emissions from Direct and Support Activities, Pacific, 1986

Activity	Pollutant Emissions (Tons) NO_x	TSP	VOC[1]	SO_2	CO
Vessel Traffic[2]	703	71	20	43	183
Pipeline Construction (36 miles)[3]	90	9	2	11	23
Exploration Drilling (3 wells)	86	4	2	4	9
Development/Production (15 production and 2 processing facilities)	649	21	1,0694	228	143
Oil Spills (9 barrels from activities and 365 barrels from site of 1969 Santa Barbara spill)	--	--	27	--	--

1. Does not include fugitive hydrocarbon emissions.
2. MMS estimates of air emissions for crew and supply boats to and from Pacific OCS platforms--December 1, 1987.
3. Assumes 250 bbls of fuel oil per mile and based on emission factors from table 3.4-1, Compilation of Air Pollution Emission Factors, EPA, 1985.
4. Total hydrocarbon emissions - a small percentage of this is VOC.

The Joint Interagency Modeling study (JIMS), a cooperative air quality study for the Santa Barbara Channel area, assessed the future cumulative impacts of emissions from OCS activities (including support vessel travel) on onshore ozone concentrations in Santa Barbara and Ventura Counties. Three distinct meteorological scenarios, using detailed site-specific data, were studied. The analyses included all the existing facilities included in table V-3 and several proposed or planned for installation and operation in 1990 and 1995. For meteorological scenarios similar to the three analyzed by JIMS, it is established that the maximum onshore impacts from existing (1985) OCS operating facilities have been less than 1 part per hundred million for ozone. This estimation is based on the results of JIMS, the lower number of existing operations (as compared to the number analyzed by JIMS), and the locations of these operations.

(2) Effects of Oil Spills

In FY 1986 in the Pacific Region, three small oil spills amounting to a total of 9 bbl of oil occurred. In addition, an estimated 365 bbl of oil seeped from the site of the 1969 Santa Barbara blowout that year. This seepage resulted in air emissions of 26.5 tons of VOC.

2. Biological Environment

a. Lower Trophic Organisms

(1) Effects of Discharge of Muds and Cuttings

Since 1963, approximately 2.9 million bbl of muds and 1.4 million bbl of cuttings have been produced throughout all Pacific Planning Areas. The effects of drilling muds and cuttings on benthic communities were studied on Tanner Bank off southern California by ECOMAR (1978) and in State waters off California by Nekton, Inc. (1984). No significant harmful effects were attributed to the drilling discharges from these exploratory operations. To the present, no studies have been conducted that have monitored the long-term effects of muds and cuttings discharges from development and production facilities, although a long-term monitoring program, funded by MMS, is currently being conducted in the Santa Maria Basin that will address long-term effects.

The field studies to date have shown that impacts are temporary and localized, and no significant long-term adverse effects on lower trophic organisms by the discharge of muds and cuttings have been identified. Long-term studies are in progress, and new information will be added to subsequent reports as it becomes available.

(2) Effects of Discharge of Produced Formation Water

No field studies in the Pacific Region have been conducted on effects of formation water discharges on marine organisms. One field study in the Gulf of Mexico investigated the environmental effects of produced formation water discharges in the Buccaneer Field. This study showed that produced water discharges exert chronic effects on benthic organisms near production platforms (Middleditch, 1981). The generally elevated levels of hydrocarbons and other chemicals in sediments over wide areas in the GOM hamper efforts to delineate the actual areal extent of such effects (EPA, 1985). Middleditch (1984), in an assessment of the ecological effects of produced water discharges from offshore oil and gas platforms, concluded that any effects would probably be minor and limited to a small area.

In conclusion, although water column and benthic organisms in areas surrounding production platforms have been impacted negatively by discharged produced formation water, the areal extent of such impacts is localized and minimized by dilution and mixing in the offshore environment. No significant cumulative effects have been identified.

Long-term studies are in progress and new information will be added to subsequent reports as it becomes available.

(3) Effects of Pipeline Construction

No specific studies have been conducted in the Pacific Region to quantify the impacts of pipeline construction on lower trophic organisms. However, this issue is addressed in every development EIS where pipelines are a part of the development plan. In the Pacific Region, pipelines are not buried due to the greater susceptibility of buried pipelines to potential damage from earthquakes. This factor limits the amount of sediment disruption resulting from pipeline construction activities, thus limiting the mechanical damage to the benthos and turbidity effects in the water column. In the Pacific Region, the total length of all pipelines (offshore) attributed to OCS development is 164 mi as of December 1986. No toxic materials are involved in pipeline construction, and the burial and turbidity impacts are limited in extent. Localized impacts to hard (rocky) substrate habitats and communities occurred due to pipeline anchoring activities associated with Platform Harvest.

In conclusion, localized impacts on lower trophic organisms have resulted from pipeline construction. No significant cumulative effects have been identified, however.

(4) Effects of Oil Spills

Between 1963 and 1986, over 601 development wells and over 317 exploratory wells were drilled on the Pacific OCS. The only major spill attributable to OCS development in the Pacific Region is the blowout of Platform A in the Santa Barbara Channel in 1969. The effects of this spill on the various trophic levels and habitats of the Santa Barbara Channel were studied intensively, and the results of the studies were compiled by Straughan (1971). There was no conclusive evidence of any major effect caused by the Santa Barbara spill on the phytoplankton. Oil dispersants used in cleanup were shown to reduce phytoplankton's productivity. The recovery period from this effect depended on the currents and rate of dilution, as well as on the type and quantity of dispersants used (Oguri and Kanter, 1971). The study of the oil-spill effects on zooplankton was hampered by the lack of prespill comparative data. Consequently, no effect of the spill on the zooplankton was demonstrated or refuted. Inference from the phytoplankton study indicated that the zooplankton would not have suffered a major decline in population or species diversity (McGinnis, 1971).

An attempt was made to determine effects of the spill on benthic invertebrates through comparison of postspill samples with results from the earlier "State Study" conducted by the Allen Hancock Foundation. A marked decline in benthic standing crop was observed, especially in the echiurid worm Listriolobis pelodes, which forms dense beds on the seafloor only off the Santa Barbara coast. This decline, however, was not attributed directly to the spilled oil. Fauchald (1971) proposed several causes for the differences observed in benthic standing crop. These included heavy rainfall in the winter of 1969, drilling on the L. pelodes beds, the spilled oil, and an increase of sewage discharge. No significant effects on sandy beach intertidal invertebrates were attributed to the oil spill.

Trask (1971) concluded that variations in intertidal fauna were correlated more with natural removal and deposition of sand than with the amount of oil in the sand. Instances of smothering of rocky intertidal invertebrate species were observed on mainland and island shores. Since no predisturbance data were available, it was not possible to estimate the extent of damage accurately (Nicholson and Cimberg, 1971). Although quantitative studies were not conducted, observations of the rocky intertidal species 2 years after the spill indicated that communities had returned to "normal" conditions.

In conclusion, although temporary and localized impacts have occurred, no cumulative effects related to OCS activities on the Pacific OCS have been identified for lower trophic organisms.

b. Fish Resources

(1) Effects of Seismic Surveying

This topic is discussed below under Commercial Fishing. There is some preliminary indication that seismic surveys may affect the integrity of rockfish aggregations reducing the catch-per-unit effort (see Chapter V, Section D.3.c). This possible effect is being further studied. The MMS is currently participating in a study, together with the fishing, oil, and seismic industries, and other Federal and State agencies, to determine the effects of airgun sounds on eggs and larvae of the northern anchovy. This study is being funded by the American Petroleum Institute and the State of California. Results of this study are not yet available. Also, a Dungeness crab study is now underway under the direction of the California Department of Fish and Game. Larvae have been exposed to an airgun array under field conditions in Puget Sound. Funding for this study is not all from the OCS program. Other contributors are the Federal Government of Canada, the province of British Columbia, the Western Oil and Gas Association, the State of California (major source), the National Coastal Resources Institute, and individual oil companies. Actual significant change to the resource has not been identified.

(2) Effects of Discharge of Muds and Cuttings

Since 1963, an estimated 2.9 million bbl of muds and 1.4 million bbl of cuttings have been generated by drilling in the Pacific Region. Extensive research has been conducted on the effects of drilling muds and cuttings. The NRC (1983) concluded that "based on laboratory and field studies to date, most water-based drilling fluids . . . have low acute and chronic toxicities to marine organisms." There is no indication that fish resources have incurred significant adverse effects from the discharge of drilling muds and cuttings in the Pacific Region.

(3) Effects of Discharge of Produced Formation Water

An estimated 105 million bbl of formation water have been discharged to date from OCS activities in the Pacific Region. Gallaway (1981) conducted studies, offshore Texas in the Buccaneer Gas and Oil Field between 1976 and 1980, of the chemical nature and environmental effects of produced water discharge. He concluded that produced waters were only slightly toxic and that direct effects occur only in the area within a few meters of the discharge. Given the rapid dilution of the produced water and similarity in composition to normal marine waters, the effects of the discharge of formation water would be expected to be limited. No significant cumulative effects to fisheries resources have been documented.

(4) Effects of Oil Spills

One major spill occurred in the Pacific Region in the Santa Barbara Channel in 1969. It has been estimated that a total of 10,000-70,000 bbl of oil were lost from the initial blowout and subsequent seepage (see table IV-1). No effects on fish populations were noted by the California Department of Fish and Game. A temporary reduction in fish catches after February 1969 was due more to the difficulties associated with fishing in oily water than to oil-related fish kills (Straughan, 1971). Ebeling et al. (1971) also found no noticeable effects on fish in the Santa Barbara Channel after the spill. The NAS (1985) concluded that "a direct impact on fishery stocks has not been observed." No significant damage to fisheries resources has been documented in the Pacific Region.

c. Endangered or Threatened Species

(1) Effects of Seismic Surveying

The effects of seismic surveying are discussed in detail above in Chapter IV, Section E. Gray whales and possibly humpback whales are sometimes present in offshore California. Studies funded by MMS (Malme et al., 1984) found that there was a likelihood that migrating gray whales would deflect their swimming paths if within 2.5 km of an operating airgun array. There has been no known significant effect on essential whale activities such as migration, mating, and feeding.

Observations of sea otters during the above experiment demonstrated no observable response.

In conclusion, temporary shifts in swimming paths of gray whales have been observed; no significant cumulative effects, however, have been identified.

(2) Effects of Support Vessel Traffic

Studies funded by the MMS (Malme et al., 1984) found that migrating gray whales deflected their course in the presence of the research vessel and in response to low-flying-helicopter noise. There have been no reported collisions (i.e. physical contact) between marine support vessels and any threatened or endangered species in this Region (Dana Seagers, NMFS, personal communication).

Helicopters will cause brown pelicans and California least terns to disperse temporarily from their roosts if the helicopter path passed low over them. This disturbance is temporary, and the birds typically return to their original spot once the disturbance has passed. There is some speculation that repeated disturbances will cause the birds to abandon a favored roost, but this has not been documented.

In conclusion, temporary and localized disturbances have occurred; no significant cumulative effects, however, have been identified.

(3) Effects of Oil Spills

Brownell (1971) provides a discussion about seven whales and four dolphins that were reported dead on California beaches after the start of the Santa Barbara oil spill. Although newspaper reports speculated that the above whales had died as a result of the spill, Brownell was unable to find evidence to support these conclusions. Although oil was found in one of the dead whales' mouth and on the baleen plates, none was found in the gastrointestinal and respiratory tracts. Brownell concluded that the amount of oil on this whale could be considered normal for a dead animal that floated at sea for some time before stranding. Based on a review of available information (including an analysis of tissues from other stranded whales and dolphins that was unable to detect the presence of crude oil) and a review of historic records, Brownell concluded that the number of gray whale strandings in 1969 did not differ significantly from that of previous years. This conclusion is significant since the entire northward migration of gray whales passed through (or westward around) the Santa Barbara Channel while it was contaminated in 1969.

Brown pelicans were among birds killed by the 1969 Santa Barbara spill, and the Point Reyes Bird Observatory reported in 1985 two pelican deaths associated with the January 1984 Puerto Rican oil spill (not OCS related). No OCS oil-spill-related mortality has been documented for peregrine falcons or California least terns. Neither are any Guadalupe fur seals known to have been oiled.

In conclusion, significant impacts to endangered and threatened species from oil spills have not been identified.

d. Marine Mammals

(1) Effects of Seismic Surveying

Potential impacts of seismic surveying are discussed in Chapter IV, Section E. No damage to marine mammals has been documented.

(2) Effects of Support Vessel Traffic

There have been no reported collisions (i.e. physical contact) between marine support vessel traffic and any marine mammals in this Region (Dana Seagers, NMFS, personal communication). Marine mammals (primarily the California sea lion) are frequently observed hauling out on mooring buoys off platforms. These animals do not appear to be disturbed by aircraft or vessel traffic to and from the platform. Comparably, harbor seals that customarily haul out at the base of a pier used by support vessels in Carpenteria have apparently habituated to crew boat and support vessel activity, although they now haul out primarily at night.

In conclusion, there are no significant cumulative impacts to marine mammals from support vessel traffic.

(3) Effects of Oil Spills

The potential impacts from oil spills are discussed in Chapter IV, Section B. Over 100 elephant seal pups were coated with oil, sand, and detritus when crude oil from the Santa Barbara oil spill washed up on a rookery at San Miguel Island (Le Boeuf, 1971). In a review of the effects of the spill on this species, Dr. Le Boeuf reported that few sick animals were noticed by other investigators (Simpson and Gilmartin), and no petroleum was detected in either the tissue of two dead seals examined (one of which was not coated with external oil) or the blood taken from live animals. Given that 90 percent of the pups had been weaned prior to the spill and were no longer suckling, Dr. Le Boeuf ascertained that most of the animals were unlikely to have ingested oil. Based on his own observations, which included the tagging of 58 weaned pups and 5 yearlings which had at least 75 percent of their bodies coated with oil, Dr. Le Boeuf concluded that " . . . the crude oil which coated many weaned elephant seals at San Miguel in March and April 1969, had no significant immediate nor long-term (1-15 months later) deleterious effect on their health."

Three dead sea lions were also reported by the California Department of Fish and Game following the Santa Barbara spill (Brownell and Le Boeuf, 1971). No autopsies were performed, and no attempt was made to link these deaths with the crude oil spill.

The MMS is not aware of other reports of injuries or mortalities to marine mammals as a result of OCS oil and gas activities.

e. Coastal and Marine Birds

The coastline of California contains a large and varied population of marine and coastal birds. There are about 30 significant species whose population varies as a result of migrations, nesting events, and appearance of winter and summer residents.

A detrimental impact to marine and coastal birds would occur if contact is made with oil. Direct contact with oil could result in matting of plumage, that can reduce flying and swimming abilities; loss of buoyancy, which can cause exhaustion resulting in drowning; loss of insulation, which can cause loss of body heat; and increased physiological stresses and reproductive failures due to ingestion or accumulation of toxic petroleum hydrocarbons (Hunt, 1985; Nero and Associates, 1983; and Clark, 1984). Long-term or sublethal effects of oil include delayed and depressed egg laying, reduced hatching, and reduced growth rate due to poor nutrient uptake (Hunt, 1985).

There has been only one "actual" (or documented) impact to birds from oil spills in the Pacific Region that is directly attributed to OCS activities--the 1969 Santa Barbara oil spill. During this spill, a total of 3,686 birds were recovered dead due to oiling. There were no estimates made of the birds that may have perished on the open water and failed to drift ashore, although their number was probably high. Most of the dead birds recovered were loons and grebes. Cormorants and pelicans were the second most common found dead. Shorebirds appeared to be the least affected by the spilled oil.

Principal investigations pertaining to the impacts on birds from the Santa Barbara oil spill include the following: Drinkwater, Leonard, and Black (1971), Santa Barbara's Oiled Birds, Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill 1969-1970; and Straughan (1971), Oil Pollution and Sea Birds, Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill 1969-1970.

Surveys conducted following this single large spill in 1969 (Santa Barbara) indicated that bird numbers in the affected area remained relatively stable despite the oil spill. Most birds found during these postspill surveys appeared to avoid oil-contaminated areas and were found either in flight, on the shoreline, or resting in open spaces of water that appeared to be free of all oil.

In conclusion, temporary impacts to marine and coastal birds have occurred as a result of oil spills. However, no significant cumulative effects are apparent.

3. Socioeconomic Environment

a. Employment and Demographic Conditions

The Central and Northern California and Washington-Oregon Planning Areas experienced limited exploration in the 1960's. There were 12 exploratory wells drilled off central California, 7 off northern California, and 12 off Washington-Oregon. To support exploration, very few workers are needed onshore, so exploration activities have had minimal effect on local employment or demographic conditions. There are no cumulative effects on employment and demographic conditions from these activities at this time.

The southern California area is a producing region. The MMS funded a study by Centaur Associates on the Cumulative Socioeconomic Impacts of Oil and Gas Development in the Santa Barbara Channel Region: A Case Study. This study (Centaur, 1984) concluded that from 1960 to 1983 Santa Barbara and Ventura Counties underwent significant economic and demographic growth. "Oil and gas development played a relatively small role in that growth, and, in the absence of oil and gas development, the growth in the two counties would have been very similar. Federal oil and gas activity was shown to have a slightly greater impact than State oil and gas activity, although neither can be construed as a dominant force in the development of Santa Barbara and Ventura counties" (p. 19). Thus, there are limited positive cumulative effects on local employment in the Southern California Planning Areas.

To ensure that demographic effects do not stress the local infrastructure, the counties of Santa Barbara, Ventura, and San Luis Obispo have joined together in the development and application of a socioeconomic monitoring and mitigation program. Applicants for permits for major oil and gas and pipeline projects are required to participate in this program. The intent of the program is to verify the information and impacts identified in the Environmental Impact Report/EIS process and to monitor them over time. Through this process, the counties visualize being able to require compensation needed to offset potential adverse impacts on the local economy as they occur.

In summary, MMS studies indicate that actual cumulative impacts on the local economy are minimal and positive. Additional monitoring as a part of the local permitting process continues to refine this information.

b. Coastal Land Uses

Although there was limited exploration in the Central and Northern California and Washington-Oregon Planning Areas during the 1960's, there is no offshore activity in those areas at this time. There are no cumulative effects on coastal land use in these planning areas from OCS activities.

The Southern California Planning Area is a producing region, and many OCS facilities are sited there. These facilities include supply bases, pipelines, marine terminals, and oil and gas processing plants. Kaiser Steel operates two platform fabrication facilities in Napa and Fontana and two assembly yards in Oakland and Vallejo for platforms used offshore southern California. All facilities that are constructed onshore to support or process offshore production must comply with Federal, State, and local regulations, land-use plans, policies, and controls in order to obtain approvals. Therefore, these facilities comply with numerous requirements designed to mitigate significant environmental impacts. Where impacts cannot be directly mitigated, the local jurisdiction has required offset measures, such as the purchase of comparable lands for parks and recreational use. Thus, no adverse cumulative impacts on coastal land use from OCS activities in the Pacific Region have occurred to date.

c. Commercial Fisheries

(1) Effects of Seismic Surveying

Early accounts from commercial fishermen had indicated that acoustic signals produced by actively working geophysical vessels elicit a fright response in some commerical fish species causing them to disperse and, thus, reduce their catches. A preliminary study on this issue performed by Greeneridge Sciences, Inc. (1985), suggested that acoustic seismic surveys may affect the degree of aggregation of rockfishes (Scorpaenidae) and the catch per unit effort (CPUE) for the fishery. A more recent study by Battelle and BBN (1987) demonstrated that both the CPUE and catch value of rockfish harvested by hook and line were substantially reduced in an area (about 50 percent) by the acoustic signals from a single seismic airgun. Generally, behavioral observations indicated that rockfish species did not exhibit a startle response at sound levels below 200 dB relative to 1 micropascal at 1 m and did not exhibit an alarm response below 180 dB (relative to 1 micropascal at 1 m). However, rockfish reactions to airgun noises varied appreciably with species. For some species, such as olive and black rockfish, the startle response (a protective mechanism and not necessarily negative) was at a sound level between 200 and 250 dB relative to 1 micropascal at 1 m. However, no startle response was indicated for the vermillion rockfish at the highest sound level tested (207 dB relative to 1 micropascal at 1 m). For those species that did demonstrate a startle or alarm response, the individuals returned to their pre-sound behavioral patterns within minutes after the noise was terminated. The authors of the study suggested that some subtle changes in behavior may become evident at about 161 dB relative to 1 micropascal at 1 m, but that the observations provided evidence that rockfish may become habituated to the sound and demonstrate no further response. Field experiments (Battelle and BBN, 1987) demonstrated that the harvest of rockfish by hook and line decreased to approximately 50 percent of control levels during airgun operations. The fish, however, were exposed to levels not experienced (relative to length in time of exposure) during actual seismic operations, and the recovery time was not evaluated. Based on the available evidence, the number of fish in the area near seismic operations could be reduced. This reduction would be most evident if a number of vessels are concentrated in a relatively small area. However, the effects, in addition to being proximate to the operation, should be short-term and not affect the regional commercial fishery.

One specific claim from 1984 through 1986 has been submitted to the Fisherman's Contingency Fund in this region for damage to fishing gear as a result of seismic activities. This resulted in a payment of $9,000 to the commercial fisherman. Additional claims for gear damaged by seismic activities have been submitted directly to industry. However, because MMS was not involved, no documented records indicating the extent of the claims are available.

In conclusion, some local and short-term effects but no significant long-term impacts on commercial fisheries have been identified as a result of seismic activities.

(2) Effects of Platform and Rig Emplacement and Removal

One offshore storage and treatment facility and 20 operational OCS platforms are currently (as of December 31, 1986) in place in the Pacific Region. Each platform is estimated to exclude fishing (primarily trawls) from approximately 1 mi^2 surrounding the platform. However, individual fisherman may increase this area by fishing farther away and adding an additional safety buffer. The actual amount of precluded area may be higher for some types of fishing such as drift gill nets and less for others such as hook and line. The following table estimates the total area lost to commercial fishing based upon the areal exclusion of existing platforms and fishery techniques.

SPECIES	AREA (SQUARE MILES) LOST TO COMMERICAL FISHING
Halibut	9
Ridgeback shrimp	9
Spot prawn/rockfish	2
Rockfish	3

Operations involved in installation or removal of platforms may exclude fishermen from a relatively larger area (about 3 mi^2). However, these operations are of short duration (approximately 3 to 6 months) and not expected to substantially increase long-term cumulative impacts to commercial fisheries.

In some areas, if platforms are located closely together, the area of spatial exclusion may be greater than the sum of the area excluded by each individual platform. This is especially true if there are gathering lines interconnecting the platforms. Under this scenario, the trawl fishery loses the capability of fishing between the platforms outside of the individual buffer zones. In addition, the existence of debris from oil and gas operations may exclude additional space or increase the operational hazards of the trawl fishery. Current assertions by commercial fishermen suggest that considerable areas in the Santa Barbara Channel have been excluded from historical trawl grounds because of platforms, pipelines, and debris. The area with the highest density of platform and pipelines occurs within the eastern Santa Barbara Channel in an area of commercial trawling for shrimp and halibut. Currently, there are no estimates available for the economic loss to fishermen because of spatial exclusion.

Information on the potential beneficial aspects of platforms on commercial or recreational fishing is limited. A recent study by MBC (1987) indicated that some platforms are used by recreational fishermen and sport divers. In addition, ECOMAR Inc. has, since 1980, harvested approximately 800 tons of mussels for the restaurant and wholesale trade from six OCS platforms.

In conclusion, limited local impacts on commercial fisheries have occurred in this Region as a result of platform and rig emplacement.

(3) Effects of Offshore Use Conflicts

There have been several claims filed by commercial fishermen under Title IV of the OCSLA and Amendments. The Fishermen's Contingency Fund has reimbursed fishermen for gear and vessel damage as a result of oil and gas industry activities in this Region for the following amounts:

YEAR (FY)	NUMBER OF CLAIMS	DOLLAR AMOUNT
1984	11	31,255
1985	4	8,258
1986	3	20,135

Information on damage before 1984 is not available.

Centaur Associates (1981) conducted an extensive assessment of space-use conflicts between the fishing and oil and gas industries. The authors indicated that the impacts, although typically localized and limited, included exclusion from fishing areas, vessel and gear damage, and short- and long-term effects on fish stocks.

Based on spatial exclusion from known fishing areas, limited insignificant cumulative impacts have occurred on the commercial fishing industry.

(4) Effects of Pipeline Construction

Problems have been documented for the Grace-to-Hope and the Hillhouse-to-Henry pipelines. The Grace-to-Hope pipeline was installed in 1980.

The pipelines are approximately 11.5 mi in length, and the construction and anchoring corridor was approximately 1 mi wide. Anchor scars and mud mounds were created by the lay barge along much of the construction corridor. Soon after construction, trawl fishermen complained they could not use the area for halibut and ridgeback shrimp trawling due to mudding of their gear. In 1983, experimental trawling indicated the area was passable by trawl gear. Although no official estimates have been made, it appears that, in the worst case, approximately 11-12 mi^2 were excluded from use by trawlers (halibut and shrimp) for nearly 3 years. The loss of resource, in poundage and value, from this incident is unknown (Centaur Assoc., 1984b).

The Hillhouse-to-Henry pipeline was constructed in 1979-1980. The existing pipeline is 2.5 mi in length. After its installation, trawl fishermen (halibut/shrimp) complained of hanging their gear on the wooden spacers used in construction. These spacers were located at 110-foot intervals along the entire pipeline length. An annual inspection of the line in August 1982 indicated that wooden spacers had disintegrated and that obstructions no longer existed. Although there is no official estimate, in the worst case, approximately 1-2 mi^2 were excluded from trawl fishing for up to 2 years.

A number of MMS studies have examined the potential impacts of oil and gas industry activities on commercial fishing (Centaur Assoc., 1981, 1983, 1984a, 1984b, 1985; E. R. Combs Inc., 1981, 1982; University of Alaska, 1980a, 1980b, 1980c). It was estimated that spatial loss from pipelines could be up to 0.5 mi^2 per mile of pipeline (Centaur Assoc., 1984b). The Pacific Regional Office reports that there are currently about 65 mi of pipeline right-of-way corridors occupied by oil, gas, or produced water pipelines. Spatial preclusion from construction is only temporary.

In conclusion, temporary impacts but no significant long-term cumulative impacts to commercial fishing from pipeline construction have been documented in this Region.

(5) Effects of Oil Spills

A major oil spill occurred in this region in 1969 in the Santa Barbara Channel. Reductions in fish catch were reported after the spill by fishermen. However, Straughn (1971) reported that the reduced catches were probably due to reduced fishing efforts in oil-contaminated waters rather than to a loss of resource. The spill also interfered with normal use of Santa Barbara Harbor. No estimate is available for lost catch or lost fishing access during the Santa Barbara spill. Long-term catch data for the Santa Barbara area (Straughn, 1971) suggest that catches were reduced in February and March 1969 just after the spill, but were higher than the previous 4-year average from April through July 1969.

The Santa Barbara spill of 1969 is the only major oil spill resulting from OCS oil and gas activities. See Chapter IV, B.6, for a discussion of effects of oil spills on fish and shellfish.

d. Recreation and Tourism

Coastal recreational activities popular in the Pacific include swimming, scuba diving, windsurfing, sunbathing, beach hiking, clam digging, boating, fishing, hunting waterfowl, birdwatching, and whale watching. Participation in all of these activities is high. Major State and Federal parks, wildlife refuges, and recreation areas cover large expanses of the coastline and many coastal islands. Tourism is a major component of local economies, regionally, estimated in billions of dollars and millions of people.

Potential effects to recreation and tourism may result from activities that cause visual effects, land-use competition, and oil-spill impacts. Two studies looked at recreation in the Pacific: (1) Granville Corp., 1981, Inventory and Evaluation of California Coastal Recreation and Aesthetic Resources, Pacific OCS Technical Paper No. 81-5.; and (2) Dornbusch and Co., 1987, Impacts of Outer Continental Shelf (OCS) Development on Recreation and Tourism, 5 vols.

Up to 1986, 20 platforms have been installed within 5 to 15 mi of the southern California coastline, and several onshore facilities have been installed in the coastal zone. These platforms (primarily those within 5 mi of the coast) can be seen from the scenic highways and have altered the visual environment along the coast. Studies conducted to date on tourism and recreation have not indicated changes in usage, however, due to the presence of these platforms.

Oil spills may impact beaches making them unpleasant or unusable. This results in reduced economic intake for local recreation-oriented businesses. The loss is usually immediate but does not extend beyond the removal of the oil (Restrepo, 1982). The Santa Barbara spill has been estimated to have reduced beach attendance by approximately 774,000 visitor days in the 12 months following the spill at a cost of \$3.15 million. Tourism has not decreased in Santa Barbara and Ventura Counties. Instead, there has been a marked increase in tourism (about 350 percent [Dornbusch 1987; Santa Barbara Chamber of Commerce, 1971]) in this area, which has the most intense offshore oil and gas activity in the Pacific Region. The only recorded decrease in tourism occurred during the oil shortage of 1974 and, to a lesser degree, in 1979.

In conclusion, there have been no discernible impacts on recreation and tourism related to OCS activities, and no significant cumulative impacts related to OCS activities have been identified.

e. Archaeological Resources

In the effort to minimize impacts to archaeological resources in the Pacific Region, the MMS (and its predecessors BLM and USGS) funded two studies:

1. An Archaeological Literature Survey and Sensitivity Zone Mapping of the Southern California Bight, and

2. California Outer Continental Shelf Archaeological Resource Study from Morro Bay to the Mexican Border.

These studies attempt, through the use of predictive models, to identify areas of the OCS where there is a high probability of archaeological resources. In these areas of high probability, the lessee is required, through a lease stipulation, to conduct a lease-specific archaeological resource survey. These studies are updated for each lease sale. The updates include analysis and synthesis of data--archaeological, geological and geophysical--generated since the preparation of the original study (or the last update). If a potential archaeological resource is identified, the operator is required to avoid the resource or conduct additional studies to determine its significance.

To date, 36 archaeological surveys have been conducted in the Region. All operators to date have chosen to avoid the potential resources identified. Post-plots of the anchor locations reviewed by the MMS confirm that the resources are not affected. Therefore, no cumulative impacts related to OCS activities have been identified.

f. Military Use Areas

The Pacific coastal area contains several military use areas. In the northwest, off Washington, Oregon, and northern California, extensive use of the ocean is made for gunnery practice, bombing, live firing, and submarine transit lanes. In central California, flight training, anti-submarine warfare training, and submarine transiting take place along the coast, the Anchor Bay Military Operating Area being the most important use area. The key military facilities involved include the Western Space and Missile Center at Vandenberg Air Force Base, the Pacific Missile Test Center at Point Mugu, the Naval Shipboard Electronic Systems Evaluation Facility at Long Beach, the Marine Corps at Camp Pendleton, Fleet Area Control and Surveillance Facility at San Diego, and naval facilities on San Clemente Island and San Nicolas Island. The water and air spaces are used for many activities including live firing aerial gunnery, trailing wire antenna activity, missile testing, carrier maneuvers, pilot training, transit lanes, in-flight refueling, and submarine testing and training.

Potential conflicts in military use areas concern interference of military and commercial emissions of electromagnetic signals, falling debris, ship and aircraft traffic, and collisions between rigs or vessels. Commercial fishermen and recreational boaters also use these same areas.

Potential direct conflicts have been mitigated to the satisfaction of DOD and DOI in the past through cooperation between the lessee and the appropriate military authority. In certain instances, prelease stipulations have been attached to leases within military operating areas. Only very small portions of operating area W-532 and the Pacific Missile Test Center in southern California actually have platforms within them which restrict free use in those areas by the military. In both cases, the area containing oil and gas structures is a very small portion of the operating areas. In various other military areas, only leasing has taken place, but no structures have been built. In those areas, DOD must always take into account during planning that areas in which military operations and training have taken place freely in the past could be restricted by oil and gas operations.

In conclusion, direct conflicts between DOD and MMS have been resolved, and only a minor restriction of free use of the OCS by the military has occurred.

VI. Perspectives

This chapter attempts to place in perspective the environmental effects of OCS oil and gas activities relative to other activities that take place on or near the OCS. The magnitudes and volumes of effects described in Chapter V are merely absolutes that need to be placed in some context so that the environmental implications of the effects will be meaningful to the reader.

Too often the documents--EIS's, reports on activities, or public media stories--related to the OCS Oil and Gas Leasing Program consider the program in isolation from the rest of the activities that affect the marine environment. This type of treatment could leave the erroneous impression that OCS activities are the significant source of stress or create the most severe stress to the environment. This is rarely the case, as OCS activities are but one of many uses for the offshore environment and its resources. Any negative effects of OCS oil and gas activities must not be ignored or minimized, but it is important to consider OCS impacts in the context of all the other natural and human-induced factors that affect the offshore and nearshore environment. Also, the positive impacts of OCS activities must be considered.

A. Water Quality

The discharge of drilling fluids and cuttings from OCS oil and gas operations has been of concern to the interested public and some environmental and conservation groups for some time. Both field and laboratory studies have been conducted which examined the effects of drilling muds and cuttings discharge from exploratory operations. The results of these short-term studies showed no detectable acute or sublethal effects on the environment (NAS, 1983; Neff, 1985). Research is in progress on the long-term effects of drilling discharges from developmental programs. This concern has arisen due to the particulate matter as well as the metallic and chemical constituents of drilling fluids. The particulate material in drilling fluids is actually a clay mineral that is mined in various locatibns around the United States. The clay is processed very little in its journey from mine to drilling platform so that, when it is manufactured into a drilling fluid on the platform, it is still the same basic, naturally occurring mineral as when it was extracted from the earth. These minerals also occur in areas which are not mined and, like all other exposed soils and rocks, are eroded and carried down rivers and streams to the sea. Thus, the clays that form the bulk of a drilling fluid discharge are also a component of the normal outflow from rivers.

It may be instructive to compare the relative masses of drilling fluid discharges to sediment discharges from rivers. It is estimated that 1.07 million tons of muds and 0.76 million tons of cuttings from OCS operations are discharged into the GOM annually. By comparison, the

Mississippi River discharges about 50 billion tons of sediments per year. This annual amount is about 900 times more than the amount GOM Federal activity has contributed over 30 years. The California OCS shows a similar situation. Between 1971 and December 1986, about 0.485 x 106 tons of drilling fluids have been discharged into the sea. The Santa Clara River, located near the City of Ventura in the eastern Santa Barbara Channel, discharges an estimated 3 x 106 tons of sediment per year or about six times more sediment per year than the 15-year record of drilling discharges.

The metallic and chemical components of drilling discharges form a relatively small portion of the total, except for one or two additives. One additive that may comprise a significant proportion is barite or barium sulfate. This is used as a weighting agent which allows the operator to add weight to the mud mixture without adding very much volume. This is essential to well control in preventing blowouts. The only metals of concern are barium and those which may be termed impurities. Two metals in the impurity category are regulated by the EPA in their NPDES permits--cadmium and mercury. Others are innocuous or are of very low concentration and show no environmental degradation.

There are several other sources of metal input into the ocean from other human activities which add to the total loading in the environment. For example, the use of leaded gasoline creates lead which eventually arrives in the sea from the atmosphere or from the general runoff from rains. Also, many nonpoint discharge sources, such as storm drains, contribute some metals to the oceans. These sources are difficult or impossible to quantify. However, major sewage discharges in southern California have been examined for their metallic contributions to the environment. For example, the major wastewater discharges in the Santa Barbara Channel added the following estimated metals in metric tons in 1980: Silver, 0.814; Arsenic, 0.623; Cadmium, 0.575; Chromium, 1.198; Mercury, 0.038; and Lead, 0.53 (A. D. Little, 1985). In contrast, the estimated metric tonnage of metals discharged from a developmental OCS program (2 platforms, approximately 120 wells) over a 3- to 4-year drilling program is as follows: Chromium, 0.044; Cadmium, less than 0.003; Lead, 0.030; and Mercury, 0.001 (A. D. Little, 1985). The metal loading from just the quantifiable source, the wastewater treatment plants, is one to two orders of magnitude greater than that contributed by a developmental drilling program in the California OCS.

Barite occurs naturally in the environment. In southern California coastal areas, it occurs in evaporite outcrops. Evaporites are mixtures of minerals left from the evaporation of water in enclosed basins. These form when the concentration of the elements changes as the water decreases. Since the level of the seas and lakes has risen and fallen over geologic time, these evaporite outcrops may presently occur either beneath the surface of the sea or on dry land above sea level in layered strata that may have since been bent and folded. This is the case for some evaporite outcrops that exist in the Santa

Monica Mountains and in the coastal range around the Santa Barbara Channel. The total amount of barite discharged from a drilling program may approach 140 metric tons above ambient levels (A. D. Little, 1985). However, the concentration of this barite discharge, once it arrives on the seafloor and is resuspended and moved about by ocean currents, is less than the barite that is derived from the erosion and deposition from natural sources.

Another source of concern is the accidental discharge of oil into the marine environment. In January 1969, a blowout from an OCS platform in the Santa Barbara Channel offshore California released 10,000 bbl of heavy crude oil within 10 days. The immediate concern and most visible impacts were noted for marine and avian fauna that came into contact with the spill, even though the damage was not as severe as was predicted. Once the immediate threat was over, concern shifted to the possible long-term pollution effects of the spill. As noted in Chapter V, the anticipated, long-term biological effects have not been observed. The spill prompted a major overhaul of oil-spill regulations and technologies in an effort to ensure against future blowouts and other spills. The record strongly suggests that the effort has succeeded exceptionally well. Since 1970, when the first major regulatory and technological changes were made, oil and gas operations on the OCS have spilled little oil, as shown below:

Spill Source	Spilled Oil (1971-86)
Blowouts in California	0 bbl
California OCS operations (accidental crude oil spills)	100 bbl
Blowouts in rest of OCS	850 bbl
Continued seepage from 1969 blowout	21,000 bbl

To put these numbers into perspective we offer a comparison with the various other sources and amounts of spilled oil during the same January 1, 1971, to December 31, 1986 period.

Source of Discharged Oil into U.S. Waters	(1971-1986) Spilled Oil
California OCS operations (accidental crude oil spills)	100 bbl
OCS blowouts (none in California)	850 bbl
Providence, Rhode Island, motorists changing crankcase oil and disposing improperly	4,800 bbl
California OCS operations (all causes)*	26,000 bbl
OCS operations throughout the United States (accidental crude oil spills)	64,000 bbl
Tanker Alvenus (Venezuelan crude)	66,500 bbl
Tankers (crude oil and refined product)	2,000,000 bbl
Los Angeles's Hyperion Wastewater Treatment Plant (includes oils and greases of various types and origins)	2,100,000 bbl
Known California natural oil seeps	2,400,000 bbl
13 California wastewater treatment plants (San Luis Obispo through San Diego)	5,000,000 bbl
Rivers emptying into Gulf of Mexico	25,000,000 bbl

* spills; seepage from blowout site since 1969; discharges with produced water.

Oil spilled from OCS operations was put into perspective in the NAS volume on Oil in the Sea: Inputs, Fates, and Effects, published in 1985. The NAS concluded that offshore oil and gas production contributes only 1.5 percent of the petroleum entering the marine environment. Even taken in isolation, the amount of oil spilled as a result of OCS activity must be compared to the 7.5 billion bbl of oil and condensate and 77 trillion ft^3 of gas produced from the OCS.

B. Air Quality

Understanding the MMS air quality program requires some background into the requirements of the OCSLA. Congress, in drafting the language of the OCSLA, recognized that the emissions from the OCS sources should be considered differently from onshore emissions as regulated under the CAA. The reason for this difference is that the public may be immediately exposed to emissions from onshore sources of air pollution. Because of this, the CAA requires that emissions be measured and controlled at their source.

The OCSLA, however, recognizes that the public is not immediately exposed to emissions from platforms located at least 3 mi offshore and, in some cases, over 100 mi from shore. Because of this, OCSLA requires that the MMS consider the impact OCS air emissions have on <u>onshore</u> air quality. This regulatory approach acknowledges the natural dilution of pollutants as they move downwind of their source. Accordingly, for facilities whose projected emissions exceed a certain threshold value (dependent upon distance from shore), MMS requires air quality modeling to determine whether the facility would significantly affect onshore air quality. If the facility is predicted to significantly affect onshore air quality, emission controls are required.

Air quality is of particular concern in southern California because of the special meteorological conditions encountered there and problems the onshore areas are experiencing in attaining the NAAQS. Attention has been focused on the offshore oil and gas industry for this problem because OCS emissions programs are administered separate and apart from the onshore air quality programs. The evidence does not support contentions that OCS activities are causing significant air quality problems onshore.

In 1986, the DOI, EPA, and California Air Resources Board completed an extensive joint air quality modeling study of the effects of present and future OCS emissions on ozone levels in Santa Barbara and Ventura Counties (ozone being the critical air quality issue in southern California). For the days (selected for anticipated high impacts) that air quality was modeled, the study found that the OCS sources did not contribute to a violation of State or Federal air quality standards for ozone. At most, OCS emissions increased onshore ozone levels by 10 percent of the national standard in only one area. Despite this, that area's ozone level still was below both the State and Federal standards. Modeling results for inert pollutants are similar, indicating that OCS emissions of these pollutants do not exceed the significance levels established in MMS regulations.

C. <u>Marine Mammals and Endangered Turtles</u>

The potential effect of oil and gas operations on marine mammals is a public concern. This topic must be addressed in great detail in EIS's and frequently is the most heavily reviewed portion of the document. The effects addressed are theoretical because no actual severe impacts from oil and gas operations have yet been noted.

The offshore oil and gas industry is heavily regulated and carefully watched in terms of its possible effects on marine mammals. If endangered or threatened species migrate into an area of oil and gas operations, those operations may have to be shut down. Also, in some cases (e.g., in Alaska, during whale migrations), operations are carefully monitored during certain seasons when the mammals are present in the area.

Marine mammals and endangered turtles are required to be treated with far more sensitivity by the oil and gas industry than by traditional maritime interests. Tuna fishermen, particularly those fishing under foreign flags, inadvertently, yet, routinely net and destroy great numbers of porpoise in order to capture the tuna that are usually in the vicinity. Marine mammals such as seals or sea otters are considered unwanted compeditors by some fishermen who sometimes retaliate. Whale watching vessels routinely cruise among whale pods for the pleasure of the tourists on board. Vessels associated with oil and gas operations, on the other hand, may actually be required to avoid the vicinity of the animals or to even stop their engines if whales are visible.

Fishermen inadvertently catch marine turtles in their nets where they frequently drown. Efforts to enforce the use of turtle excluder devices by fishermen have met with stiff resistance. In contrast, the OCS oil and gas industry has been required by the MMS to drastically altered how it removes old platforms to protect endangered turtles, fish, and marine mammals.

On the whole, the oil and gas industry is required to exercise far more care to prevent potential harm to marine mammals than other industries using the Nation's coastal waters. Most of the harm suffered by marine mammals and endangered turtles has come from industries or activities other than OCS oil and gas operations.

D. Birds

Following the Santa Barbara oil spill in 1969, slightly over 3,600 birds were recovered dead due to oiling. Undoubtedly, more birds perished on the open water and failed to drift onshore. This is the only documented incident of bird mortality directly related to OCS oil and gas activities. Improved oil development technologies over the last 17 years have substantially lessened the probability of an oil spill from offshore activities. The oil and gas industry has funded bird recovery programs, altered vessel and aircraft traffic, and supported bird deoiling stations. As a comparison Heinonen (1985) reports that fishermen's gill nets capture and drown 500,000 sea birds each year.

E. Fish

Some commercial fishermen, especially in California, have objected to the OCS Oil and Gas Program stating that OCS activities disperse fish, making them more difficult to catch, and preclude fishing in the area occupied by platforms and pipelines. These minor impacts should be compared with the impacts of present commercial fishing practices on fish resources.

As a result of fishing efforts, mortality of young and/or less desirable species occurs in some U.S. fisheries. This problem is most evident in those fisheries that rely on a bottom-tended methods (trawl, gill net, etc.) for harvesting the catch. However, other methods, such as longlines, are also known to capture undersized targeted individuals or individuals of a species that is not economically marketable. In the trawl fisheries for the most common species of groundfish (cod, haddock, hake, flounder, pollock, etc.), this additional mortality is referred to as "by-catch" and contributes to the incidental or discard mortality on a fishery stock.

Essentially, when a trawl is fished for a particular species or group of species, much of the catch is comprised of undesirable, undersized, or low-market-value species. In most instances, the undesirable and low-market-value species are discarded overboard because the fisherman is unable to market the fish or prefers to save space for more economic species. Likewise, the smaller individuals for more economically valuable species are discarded either because of U.S. fishery management regulations, which prohibit their possession, or because of an implicit size of acceptability imposed by the fish processing industry. Regardless of the reason, the by-catch of these species or individuals contributes to the total mortality on the species stocks.

Although some of the more rugged species--such as the mollusks and crustaceans--may survive the culling process, nearly all of the commercially important finfish species do not. Much of their mortality can be attributed to net trauma and the culling process used when fish are landed. In general, the combination of all the factors in capturing, boarding, and culling these individuals contributes to the high mortality rate of discarded by-catch.

It is likely that the by-catch or discard mortalities are responsible for the decline in some fish stocks. In the northeastern United States, many of the skate stocks have declined concurrent with the increased fishery effort for economically important groundfish. Although these species are designated as underutilized and are not considered an economic species, skate inhabit the same locations as cod, haddock, and flounder, which are heavily fished by the northeastern trawl fisheries. An appreciable number of skates are typically captured with each trawling effort.

It has been estimated that 300,000 metric tons of by-catch result from shrimp trawling annually in the GOM (Gulf Coast Research Laboratory, Ocean Springs, Miss), whereas, the average annual shrimp catch in the GOM for the years 1981 through 1985 has been approximately 108,423 metric tons (NMFS, 1987). Much of this by-catch is dumped back into the sea, although injured or dead. First year individuals of estuarine-dependent species, such as croaker and spot, make up the larger portion of the by-catch; their populations are severely impacted by trawling activities. Juvenile reef fish, such as groupers and snappers, make up a smaller portion of the by-catch but are also severely impacted.

In summary, the by-catch or discard mortality inherent in the fishing industry is considered to be a serious problem and continues to affect the level of fish stocks for many of the most important fish species in the United States.

F. Bottom Disturbance

Each drillship, exploration rig, and platform placed on the OCS disturbs some of the bottom directly beneath the structure and around it where anchors are set to hold the vessel or structure in place. There is always a danger that archaeological resources, such as historic shipwrecks, may be damaged or that the anchoring or structure placement will damage a biologically important community located on the sea bottom. In order to prevent such occurrences, each major oil and gas operation, including the placement of pipelines, must be preceded by a bottom survey designed to locate resources requiring protection. Oil and gas operators are required to avoid any such resources. This precaution can be contrasted with the totally uncontrolled anchoring practiced by thousands of ocean-going, fishing and recreational vessels. Unless an area has been declared a national marine sanctuary, any vessel is free to anchor in almost any part of U.S. coastal waters. The only vessels subject to control for the protection of environmental areas are those engaged in oil and gas operations. As an example, vessels engaged in oil and gas operations around the Flower Garden Banks of the western GOM are not allowed to anchor on the coral encrusted tops of the banks. The coral communities are monitored by MMS regularly to make sure that nearby oil and gas operations are not affecting them. Much of man's knowledge of the kinds of organisms found on that bank resulted from research funded by MMS. Up until now, the only damage that has been discovered has been serious damage caused by anchor chains and anchors from cargo and fishing vessels. In another instance, treasure hunters destroyed large portions of another bank by dynamiting the coral under the mistaken impression that a treasure vessel had been encrusted and buried on the bank.

Although much attention is focused on protection of biological communities on the sea bottom from oil and gas activities, far more damage to bottom communities is caused by active fishing vessels that employ bottom trawls, clam dredges, etc.

G. Beach Debris

In recent years, much attention has been paid to the amount of manmade material found floating in the world's oceans and coming ashore--particularly plastics. This has become a serious problem along the beaches of the GOM, especially along the Texas coast. The DOI recognizes that, with the large number of persons performing day-to-day work and support functions on OCS oil and gas leases in the Gulf, material will be lost accidentally or in emergency or storm situations. Some material may be intentionally but illegally disposed of overboard. Several years ago, studies in the Gulf suggested that the offshore oil and gas industry might be responsible for as much as one-third of the debris that accumulated on Texas beaches. Padre Island National Seashore on the south Texas coast was particularly hard hit with assorted debris. Recent evidence however, indicates that the situation is improving. Mr. Tony Amos, a Research Associate at the University of Texas Marine Science Institute at Port Aransas, has been regularly surveying the beach at Mustang Island, Texas, for over 10 years. He has noted that items associated with offshore oil and gas industry have definitely declined in the last year or two (MMS, 1988, 88-0035, page 44).

In response to this problem, several groups have taken action to stem the tide of marine debris in the Gulf. That group includes the Texas General Land Office (TGLO) and the Center for Environmental Education, who together have organized successful voluntary beach cleanups and public awareness programs. In addition, the MMS has established and is chairing the Take Pride Gulf-Wide Task Force. This consortium of Federal, State, industry, and environmental organizations is dedicated to finding ways to curtail marine debris at its source and is emphasizing a voluntary, educational campaign to bring about change. With the encouragement of MMS, the Offshore Operators Committee (OOC), representing the offshore oil and gas industry, produced a videotape illustrating the debris problem and the situations to which the industry may be contributing. It has been distributed to and widely used among OCC member companies as a training aid. The MMS has written to over 100 geophysical companies who do business in the Gulf, advised them of the debris problem, and asked for their support in reducing the incidence of marine debris, including observance of a "nothing overboard" policy. The MMS GOM regional office has also "adopted" a 1.3-mile stretch of beach in LaFourche parish, Louisiana, and turned out 160 employees, family, and friends for a cleanup of that beach on September 19, 1987. The oil and gas industry has supported and participated in such cleanup efforts in Texas and Louisiana and appears ready to do even more. These efforts reinforce MMS regulations which require that the oil and gas industry refrain from discharging nonpermitted materials into the ocean and require that equipment and tools be indelibly marked with company identification so that lost items can be traced to their source.

The expected implementation of Annex V of an international treaty (MARPOL) would ban the dumping of plastics into the ocean and has the potential to significantly reduce marine debris. To be effective, all industries and users of the Gulf must change their waste disposal practices including some that rest on centuries of tradition. The U.S. ports will have to be prepared to handle volumes of trash that will no longer be disposed of in the ocean; significant logistical, economic, and enforcement questions will have to be resolved.

An October 1987 report submitted by the TGLO to the U.S. delegation to the International Maritime Organization estimates that only 10-15 percent of the beach debris comes from offshore oil and gas operations (both State and Federal). It further indicates that the combined efforts of the TGLO, MMS, and the offshore operators are rapidly reducing that percentage.

The MMS will continue to work with the offshore oil and gas industry operating in Federal waters to further its marine debris track record. The task force will likewise continue to work with other Gulf industries and user groups and expand its effort to promote marine debris abatement in the GOM.

H. Benefits

Aside from the obvious benefits discussed in Chapter I of contributing to our national defense and national economy and providing a direct source of revenue to our treasury, there are numerous benefits of the OCS Oil and Gas Program that are often overlooked.

OCS operations benefit communities within a short geographic range of drilling and production activities. Some of these benefits can be categorized as improvements in onshore infrastructure. For example, in Prudhoe Bay, two airfields able to accommodate Boeing 737 aircraft have been built. Also, because of OCS activities, selfsufficient, power generating stations have been built. Both of these types of facilities are generally accessible to the surrounding communities. In Nome, Alaska, OCS fire fighting capabilities augmented the local staff and equipment during the period of exploratory drilling. Furthermore, state-of-the-art sewage and waste treatment plants have been built, which are available for use by the entire community. In these places, as well as others, harbor and boat docks and medical facilities are improved by the presence of OCS activities. Although not an onshore facility, Mukluk Gravel Island has become a staging and emergency base for native hunters and fishermen in Alaska. On a smaller scale, oil companies find themselves contributing to the support of local sports teams (DOI, MMS Alaska Regional Office, 1987).

Other identified benefits are the cooperative efforts of oil companies with other commercial groups such as fishermen and whalers. The best documented of these is the "Oil/Whalers Group" initiated by an oil company to prevent conflict with the subsistence whaling activities of the Inupiat Eskimos (Alaska Oil and Fishing Industries, 1984) (Oil/Whalers Working Group, 1986). The whaling season is short (from late August to early October) and, yet, important to the lifestyle of two native villages. Oil companies felt it necessary to know the whereabouts of the 30-40 whalers to minimize impact on their hunting. Emphasizing that philosophy, several oil companies, along with a geophysical survey company, outfitted some of the whale boats with satellite navigation devices and radios. The whalers were trained to use the equipment to pinpoint and communicate their exact location so seismic or other similar OCS activities would not interfere with native hunting during the whaling season.

The presence of the oil companies provides facilities for search and rescue of parties in trouble, and companies have established networks that furnish that public service. Two recent incidents (1986) used the radio and navigation equipment discussed above. In one case, a whaler shot off his hand, but was medivaced by an oil company to an Anchorage medical facility and was saved. In the second case, 19 whalers were stranded on a tiny island that became inundated by high seas; these people were helicoptered to safety by an oil company.

A benefit, which is mandated by the National Contingency Plan, is that each oil company must have equipment ready for cleanup of an oil spill. Companies network among each other and the USCG to clean up a spill should it occur (Alaska Clean Seas (ACS), 1987) (Clean Gulf Associates, 1987). Formal organizations have been developed in the GOM (Clean Gulf Associates), in Alaska (ACS and Cook Inlet Response Organization), and in the Pacific (Clean Seas, Clean Coastal Waters, Clean Bay, and the Pacific Regional Strike Team). For example, ACS is an oil-spill cooperative comprised of 14 oil companies. The cooperative procures oil-spill equipment, trains members in cleanup procedures, and researches oil-spill response technology. In 10 years of operation, no large spills have occurred that have required an ACS response; small spills can and have been handled by the company responsible.

Another positive aspect of OCS oil and gas development is the expanded acreage for attachment of marine populations provided by offshore rig structures (Driessen, 1987). Populations of algae, anemones, barnacles, mussels, and scallops increase when provided these artificial reef structures. Commercially harvested mussels are taken from some of the platforms offshore California. In turn, as these newly formed ecosystems are established, fish (including commercial and sport species such as bass, rockfish, barracuda, grouper, mackerel, marlin, seatrout, and snapper) appear taking advantage of the new habitat. These communities serve commercial and recreational fishermen as well. In warmer waters, angelfish, blennyfish, butterflyfish, and damselfish populate the area. Because of the presence of these populations, the recreational aspect of the site is enhanced for scuba diving.

Considering the intensive use of the coastal and offshore areas of the United States, the OCS Oil and Gas Program contributes relatively minimal negative impacts to the environment while it provides significant benefits to the Nation's economy and defense.

VII. ABBREVIATIONS USED

ACS	Alaska Clean Seas
APCD	Air Pollution Control District
APD	Application for Permit to Drill
BACT	Best Available Control Technology
bbl	Barrel
BLM	Bureau of Land Management
BOD	Biological Oxygen Demand
CAA	Clean Air Act
CFR	Code of Federal Regulations
CO	Carbon Monoxide
COE	Department of the Army, Corps of Engineers
COST	Continental Offshore Stratigraphic Test
CPUE	Catch Per Unit Effort
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
dB	decibel
DOC	Department of Commerce
DOD	Department of Defense
DOI	Department of the Interior
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESP	Environmental Studies Program
FERC	Federal Energy Regulatory Commission
ft	Feet
FY	Fiscal Year

G&G	Geological and Geophysical
GOM	Gulf of Mexico
H_2S	Hydrogen Sulfide
in	Inch
INC	Incident of Noncompliance
JIMS	Joint Interagency Modeling Study
km	Kilometer
LNG	Liquified Natural Gas
m	Meter
mg/l	Milligram Per Liter
mi	Mile
MMS	Minerals Management Service
NAAQS	National Ambient Air Quality Standard
NAS	National Academy of Science
NERBC	New England River Basin Commission
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NOAA	National Oceanic and Atomospheric Administration
NO	Nitric Oxide
NO_x	Nitrogen Oxide
NO_2	Nitrogen Dioxide
NTL	Notice to Lessees
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OOC	Offshore Operators Committee
PINC	Potential Incident of Noncompliance

ppb	Parts Per Billion
ppm	Parts Per Million
ppt	Parts Per Thousand
RTWG	Regional Technical Working Group
SIC	Standard Industrial Classification
SO_x	Sulfur Oxide
SO_2	Sulfur Dioxide
SPR	Strategic Petroleum Reserve
TGLO	Texas General Land Office
TSP	Total Suspended Particulates
TSS	Traffic Separation Schemes
ug/m^3	Microgram Per Cubic Meter
U.S.C.	United States Code
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
VOC	Volatile Organic Compounds
yd	Yard

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IX. CONSULTATION AND COORDINATION

Draft copies of this report were sent for review to the following agencies and groups.

States

Alabama*
Alaska*
California*(1)
Connecticut*
Delaware*
Florida
Georgia*
Louisiana*
Maine
Maryland*
Massachusetts
Mississippi
New Hampshire
New Jersey*
New York*
North Carolina*
Oregon
Pennsylvania*
Rhode Island
South Carolina
Texas
Virginia*
Washington

Interest Groups

Alaska Oil & Gas Association*
American Petroleum Institute*
Center for Environmental Education
Conservation Foundation
Environmental Policy Institute
Friends of the Earth
Greenpeace, USA
National Audubon Society*
National Ocean Industries Association
National Resources Defense Council*
National Wildlife Federation
Oceanic Society
Offshore Operators Committee*
Sierra Club
Western Oil & Gas Association

Federal Agencies

Corps of Engineers*
Department of Energy*
Environmental Protection Agency*
Fish and Wildlife Service*
Marine Mammal Commission
National Oceanic and Atmospheric Administration*
National Park Service*
U.S. Coast Guard

*Received comments
(1) Also received separate comments from the County of Santa Barbara

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