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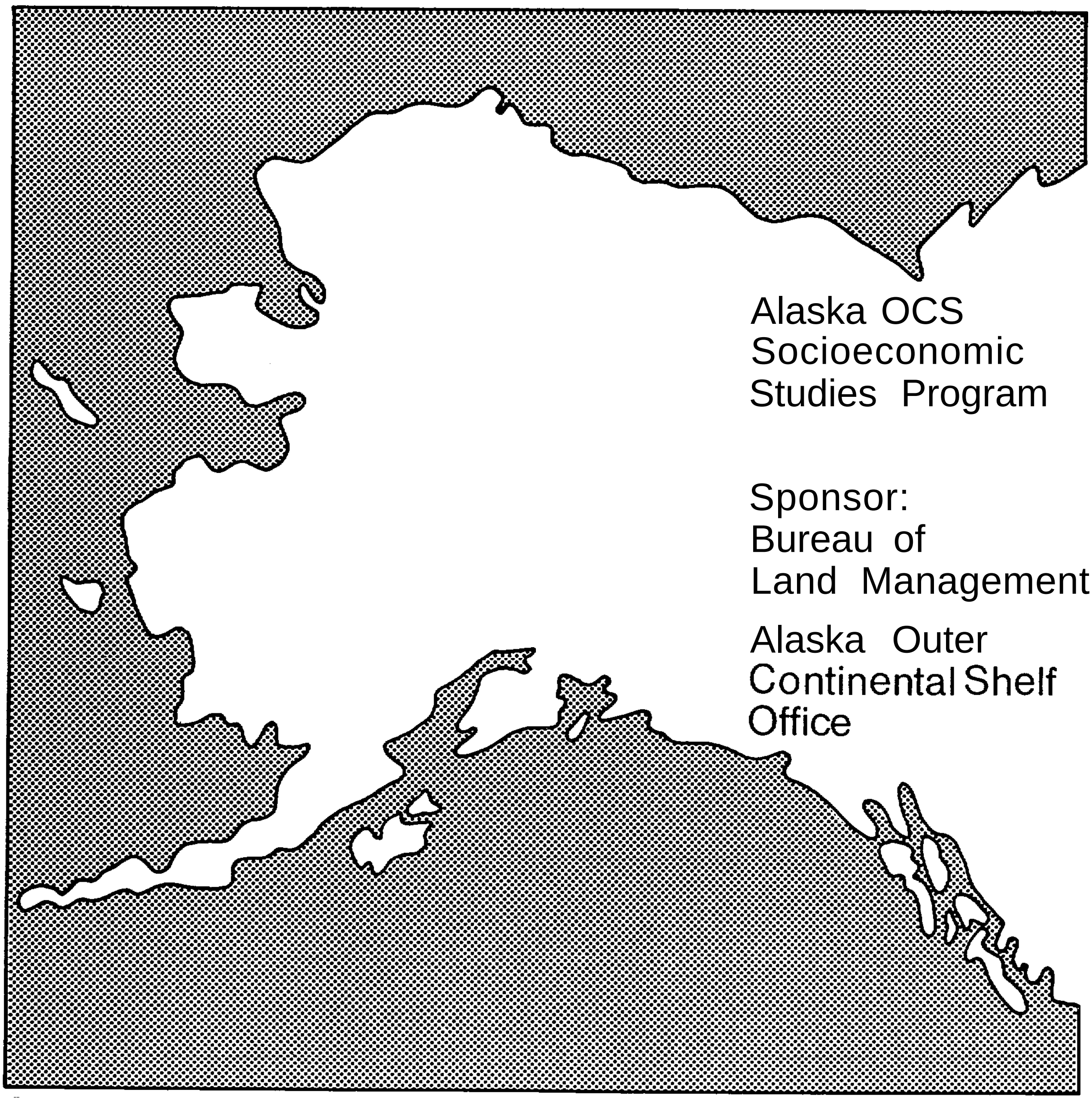
Technical Report Number 6A



Alaska OCS
Socioeconomic
Studies Program

Sponsor:
Bureau of
Land Management
Alaska Outer
Continental Shelf
Office

Beaufort Sea Region Petroleum Development Scenarios Executive Summary

The United States Department of the Interior was designated by the Outer Continental Shelf (OCS) Lands Act of 1953 to carry out the majority of the Act's provisions for administering the mineral leasing and development of offshore areas of the United States under federal jurisdiction. Within the Department, the Bureau of Land Management (BLM) has the responsibility to meet requirements of the National Environmental Policy Act of 1969 (NEPA) as well as other legislation and regulations dealing with the effects of offshore development. In Alaska, unique cultural differences and climatic conditions create a need for developing additional socioeconomic and environmental information to improve OCS decision making at all governmental levels. In fulfillment of its federal responsibilities and with an awareness of these additional information needs, the BLM has initiated several investigative programs, one of which is the Alaska OCS Socioeconomic Studies Program.

The Alaska OCS Socioeconomic Studies Program is a multi-year research effort which attempts to predict and evaluate the effects of Alaska OCS Petroleum Development upon the physical, social, and economic environments within the state. The analysis addresses the differing effects among various geographic units: the State of Alaska as a whole, the several regions within which oil and gas development is likely to take place, and within these regions, the various communities.

The overall research method is multidisciplinary in nature and is based on the preparation of three research components. In the first research component, the internal nature, structure, and essential processes of these various geographic units and interactions among them are documented. In the second research component, alternative sets of assumptions regarding the location, nature, and timing of future OCS petroleum development events and related activities are prepared. In the third research component, future oil and gas development events are translated into quantities and forces acting on the various geographic units. The predicted consequences of these events are evaluated in relation to present goals, values, and expectations.

In general, program products are sequentially arranged in accordance with BLM's proposed OCS lease sale schedule, so that information is timely to decision making. In addition to making reports available through the National Technical Information Service, the BLM is providing an information service through the Alaska OCS Office. Inquiries for information should be directed to: Program Director (COAR), Socioeconomic Studies Program, Alaska OCS Office, P.O. Box 1159, Anchorage, Alaska 99510.

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ALASKA OCS SOCIOECONOMIC STUDIES PROGRAM

BEAUFORT SEA PETROLEUM DEVELOPMENT SCENARIOS FOR THE STATE-FEDERAL AND FEDERAL OUTER CONTINENTAL SHELF

EXECUTIVE SUMMARY

Prepared for

BUREAU OF LAND MANAGEMENT
ALASKA OUTER CONTINENTAL SHELF OFFICE

Prepared by

DAMES & MOORE

May 1978

Job No. 8699-009-20

NOTICES

1. This document is disseminated under the sponsorship of the U.S. Department of the Interior, Bureau of Land Management, in the interest of information exchange. The U.S. Government assumes no liability for its content or use thereof.

2. This is a final report designed to provide preliminary petroleum development data to groups working on the Alaska OCS Socioeconomic Studies Program. The assumptions used to generate offshore petroleum scenarios may be subject to revision.

3. The units presented in this report are metric with American equivalents except for units used in standard petroleum practice. These are barrels (42 gallons, oil), cubic feet (gas), pipeline diameters (inches), wel 1 casing diameters (inches), and wel 1 spacing (acres).

ALASKA OCS SOCIOECONOMIC STUDIES PROGRAM
Beaufort Sea Petroleum Development Scenarios
For the State-Federal and Federal Outer Continental Shelf

Prepared by

DAMES & MOORE

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This report summarizes the findings of Technical Report No. 6 of the Alaska OCS Socioeconomic Studies Program - Beaufort Sea Petroleum Development Scenarios for State-Federal and Federal Outer Continental Shelf which formulates and details a set of petroleum development scenarios for the planned joint State-Federal and subsequent Federal OCS oil and gas lease sales.

Twenty-four skeletal scenarios are constructed through a combination of U.S.G.S. resource estimates and locational data from an independent geologic assessment. These are subject to a parametric economic analysis to assess their economic viability. Five scenarios, selected as representative of the range of geographic locations and resource levels, are detailed according to technology, facility, material and manpower requirements, and scheduling. A detailed review of Arctic petroleum technology, environmental conditions, locational and logistical problems establishes the framework of the scenarios.

The scenarios provide the "project description" for the assessment of socioeconomic impacts of Beaufort Sea OCS petroleum development which are examined in subsequent reports of the studies program.

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Introduction

Petroleum development scenarios provide a project description of the possible course of petroleum exploration, development and production for subsequent impact analysis. They are structured on a range of resource, technological, environmental, economic and manpower assumptions and parameters derived from a review of existing petroleum development in comparable settings.

This study area is the "developable"[1] portion of the Beaufort Sea basin located between Barter Island (144°W) and Point Barrow (156°W) from the shoreline to about the 20-meter (66-foot) isobath. Within this area, scenarios are formulated for the planned joint State-Federal lease sale located between the Canning River in the east and the Colville River in the west, seaward to the three mile limit but encompassing a tier of adjacent federal tracts. A subsequent sale in the remaining Federal OCS waters to about the 20-meter (66-foot) isobath is also considered. The scenario analysis also encompasses future petroleum developments on the North Slope such as additional commercial discoveries and production from state leases between the Canning and Colville Rivers, National Petroleum Reserve - Alaska (NPR-A) and Native Corporation lands; additional reserves from these areas are fixed by assumption.

The formulation of petroleum development scenarios first involves the construction of a set of 24 skeletal scenarios based upon a combination of resource levels, obtained from U.S.G.S. estimates, and locational data on possible discovery sites derived from an independent geologic assessment of Beaufort Sea oil and gas potential. Each of the skeletal scenarios was subjected to a parametric economic analysis to establish approximate capital recovery after consideration of several combinations of parametric values for investment costs, tax status,

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") The "developable" OCS is considered to lie within the 20-meter (66-foot) isobath, the water depth believed to be the limit of present or imminent technology for exploration drilling and oil and gas production. This is because the 20-meter isobath marks the approximate landward boundary of significant ice movement and encroachment of the seasonal and polar pack ice.

transportation, and market levels. Procedures are developed to estimate minimum field sizes for development and transport system support.

In the second part of the scenario analysis, five scenarios were selected as representative of the range of geographic locations and resource levels. These were then evaluated in-depth in order to detail the facility requirements and employment of each scenario.

Environment

The physical environment, especially oceanography, places engineering constraints on offshore petroleum development. Foremost of these is sea ice, which places considerable loads on fixed structures. Initial petroleum development will be confined to the landfast ice zone of relatively stable ice which, at its maximum development in late winter, extends seaward to between the 10- and 20-meter (33- and 66-foot) isobaths. Beyond the landfast ice zone in areas affected by polar pack ice, specially-designed platforms capable of resisting significant ice forces will have to be used.

The continental shelf of the Beaufort Sea, unlike other frontier petroleum regions such as the Gulf of Alaska and North Sea, is generally shallow; the shelf 'break lies in a water depth of 70 to 75 meters (231 to 278 feet). The shelf remains shallow for considerable distances offshore; at Harrison Bay, for example, the 20-meter (66-foot) isobath lies as much as 72 kilometers (45 miles) offshore. Within the State-Federal and Federal lease sale areas, therefore, waters are generally too shallow for the operation of such drilling platforms as semi-submersibles or drillships.

The shallow waters of the Alaskan Beaufort can also be an advantage to development since artificial soil islands, ballasted barges, and artificial ice islands are specially suited to such bathymetric conditions. These options rely on proven construction techniques.

Ice scour caused by the grounding of pressure shear ridges in the stamukhi zone is concentrated in water depths of 15 to 45 meters (50 to 150 feet). In shallower waters ice scours are common but are generally less than 2 meters (6 feet) deep. Offshore pipelines will have to be buried with sufficient cover to provide protection from ice scour.

Ice-rich subsea permafrost is believed to exist close to the sea floor in water depths of less than 2.1 meters (7 feet). Potential engineering problems related to ice-rich subsea permafrost include differential thaw subsidence with related problems for foundations and buried hot oil pipelines, difficult dredging operations, and frost heaving.

During the exploration and development of OCS petroleum leases, areas of special sensitivity for fish and wildlife may be encountered. In general, the summer period is most sensitive because of the striking increase in numbers of animal species, particularly migratory birds, caribou, and endangered whales that make relatively brief use of nearshore and coastal areas for reproduction of young. The most conspicuous of the critical areas are: the Plover Islands and the beach between Pitt Point and Cape Halkett for shorebirds; Jones Island, the Colville, Sagavanirktok and Canning River deltas, and the coastal plain between the Hulahula and Aichillik Rivers for waterfowl; nearshore areas between Barrow and Smith Bay for whales; and coastal meadows near Teshekpuk Lake, Prudhoe Bay, and Barter Island for caribou calving. Areas of particular sensitivity in water are fish overwintering areas near the mouths of the Canning, Sagavanirktok, Kuparuk, Colville and Meade Rivers plus Teshekpuk Lake.

The development of permanent or semi-permanent facilities such as camps, villages, staging areas, airports, production plants, and drilling platforms require the greatest attention in planning and operation to avoid critical fish, bird, and mammal habitat. Associated developments such as regional human in-migration would cause direct impacts from increased sport hunting and fishing, increased commercial fishing and guiding, and increased subsistence activity. However, the more subtle influences including disturbance of wildlife, modification of wildlife habitat, improper garbage disposal, and winter collection of potable water from streams and rivers may be the most insidious long-term impacts. Such problems have been identified in the Prudhoe Bay area as a direct result of petroleum development, but quantitative impact analysis in that area is just beginning.

Technology

The technology framework of the scenarios evolves from a review of petroleum development in other offshore Arctic frontiers, including the southern Canadian Beaufort Sea, the Canadian Arctic Islands, and the Labrador Sea and Davis Strait off eastern Canada.

The Canadian experience in the southern Beaufort Sea, which has primarily involved exploration from artificial soil islands, is the most relevant to the Alaskan Beaufort. The applicability of the various offshore platform types to the Alaskan Beaufort for exploration and production is given in Table 1. For both the State-Federal and Federal OCS lease sales, the drilling technology will be predominantly an extension of dryland technology. Land-based Arctic drill rigs, for example, will be used on artificial islands and probably only minimal use will be made of gravity structures such as monopods or cones.

The assumptions made on the types and numbers of platforms that will be used for exploration and production for the five detailed scenarios are given in Table 2.

Other technology/technical parameters assumed for the scenario analysis were developed for:

APPLICABILITY OF PLATFORM TYPES TO ALASKAN BEAUFORT SEA PETROLEUM DEVELOPMENT

Platform Type	State of the Art: Exploration	State of the Art: Production	Applicability to Alaskan Beaufort	Water Depths	Ice Conditions	Construction Techniques	Logistical and Drilling Considerations	Environmental* concerns	Comments
Artificial Soil Island (Conventional Exploratory)	Proven	Not Suitable	Suitable; application may be locally limited by lack of nearby (within 20 miles) fill or environmental regulation.	1.5-15 meters (5-50 feet) (summer construction] 0.3-3.3 meters (1-10 feet) (winter construction)	Landfast ice Zone Only	Floating construction spread with dredge, barges, etc. in summer or winter construction over ice by backfilling excavation in ice.	Dryland drilling rigs used; provides extended drilling season vs. ice island; support problems during freeze-up and break-up	Dredging and construction activities; effects of Increased marine traffic on marine mammals	Most suitable of platform options of currently proven techniques in land fast zone, provided suitable fill is available and no insurmountable environmental problems
Caisson/Sheet Pile Artificial Soil Island	Conceptual	Conceptual	Suitable	1.5-18 meters (5-60 feet)	Landfast Ice Zone and Pack Ice Zone	Floating construction spread with dredge, barges, cranes, etc. in summer; caissons or cellular piling prefabricated on shore.	Caisson/Sheet piles provide significant saving of fill and added protection	Dredging and construction activities; effects of increased marine traffic on marine mammals	Most suitable of platform options of currently proven techniques in landfast zone, provided suitable fill is available and no insurmountable environmental problems
Artificial Ice Island	Proven	Not Suitable	Suitable	0.3.9 meters (1-30 feet)	Landfast Ice Zone Only	Minimal construction spread; flooding of ice surface by pumps to thicken ice.	Dryland drilling rig used; time limitation on drilling; resupply over Ice	Minimal; drilling has to terminate about 45 days before break-up as precaution in case relief well has to be drilled	Most environmentally compatible option but water depth and drilling time limitations; key to extension of range rests on ice thickening technology and ice preservation technology
Reinforced Ice Platform	Proven	Not Suitable	Not suitable due to limitation posed by shallow water, ice movement, riser angle	Variable with ice movement, 100-400 meters (330-1300 feet)	Landfast Ice Zone Only	Minimal construction spread; flooding of ice surface by pumps to thicken Ice.	Dryland drilling rig used; resupply over ice; subsea SOP stack	Minimal; drilling has to terminate about 45 days before break-up as precaution in case relief well has to be drilled	Shallow water depths combined with ice movement would impose unacceptable riser angles.
Ballasted Barge	Proven	Conceptual	Suitable	1 .5.4.5 meters (5-15 feet) for conventional barge	Landfast Ice Zone Only	Floating construction spread with dredge, barges, cranes, etc. in summer; barge(s) ballasted to sea floor and berm constructed around periphery.	Dryland drilling rig used; provides extended drilling season vs. ice island; support problems during freeze-up and break-up	Dredging and construction activities; disturbance to marine mammals from increased marine traffic	Provides the mobility that soil islands lack but conventional barges restricted to narrow depth range. Specially designed drilling barges (self-contained drilling/production systems) could have greater application
Ice-Strengthened Drillship	Proven	Not Suitable	Limited; cannot operate in depths present in areas considered for leasing	11-300 meters (35-980 feet)	Open water summer operations only unless ice breaking protection provided by support vessels"	Fabricated outside Arctic; production variant may require on-site modular(?) installation in summer.	Requires support fleet; short drilling season; subsea BOP stack	See footnote	Due to short drilling season, deep targets may take more than one season to drill and evaluate
Monopod	Proven (for limited ice loads)	Conceptual	Suitable	10-100 meters + (33-320 feet)	Landfast Ice Zone and Polar Pack Ice Zone (7)	fabricated outside Arctic; production variant may require on-site modular(7) installation in summer.	Self-contained drilling system	See Footnote	Best suited to deeper waters of the State-Federal and Federal OCS lease sale areas. Can either be a mobile exploration platform or fixed Production platform.
Cone	Conceptual	Conceptual	Suitable	10-100 meters + (33-320 feet)	Landfast Ice Zone and Polar Pack Ice Zone	Fabricated outside Arctic; production variant may require on-site modular(?) installation in summer.	Self-contained drilling system	See Footnote	Best suited to deeper waters of the State-Federal and Federal OCS lease sale areas. Can either be a mobile exploration platform or fixed production platform.
MonoCone	Conceptual	Conceptual	Suitable	10-100 meters + (33-320 feet)	Landfast Ice Zone and Polar Pack Ice Zone	Fabricated outside Arctic; production variant may require on-site modular(7) installation in summer.	Self-contained drilling system	See Footnote	Best suited to deeper waters of the State-Federal and Federal OCS lease sale areas. Can either be a mobile exploration platform or fixed production platform.
Conventional Semi-submersible	Proven (Summer Only)	Conceptual	Unsuitable; summer only operation; high standby costs; water too shallow in lease areas for operation.	30-610 meters (98-2000 feet)	Open water only	Fabricated outside Arctic; production variant may require on-site modular(?) installation in sumner.	Self-contained drilling system; short drilling season; high standby costs	See Footnote	Has not been used in Beaufort Sea or Arctic islands and would require ice protection to operate in these areas.
Conventional Jack-up	Proven (Summer Only)	Not Suitable	Unsuitable; summer operation only with high standby costs.	15-45 meters (50-150 feet)	Open water only	Fabricated outside Arctic; production variant may require on-site modular (?) installation in summer.	Self-contained drilling system; short drilling season; high standby costs	See Footnote	Has not been used in Beau fort Sea or Arctic islands and would require ice protection to operate in these areas.

● A general environmental concern for oil spills and offshore drilling is assumed. Each platform type presents different spill and for clean up problems. Floating systems such as drill ships with subsea BOP stacks are a particular concern. Artificial soil islands present fewer problems in case of a blowout although access to the island during freeze-up and break-up may be difficult. Drilling from ice islands or drillships has to terminate in sufficient time before break-up or freeze-up to permit sufficient time for drilling of relief wells if a blowout occurs.

Source: Dames & Moore

TABLE 2

TEChnOlOgy ANO FACILITIES FRAMEWO RK OF FIVE SELECTED (DETAILED) SCENARIOS(T)

SCENARIO	NUMBER OF WELLS				EXPLORATION PLATFORMS				PRODUCTION PLATFORMS				TRUNK PIPELINES[2]				OTHER FACILITIES		PEAK EMPLOYMENT
	xplora-tion	Oil Produc-tion	Gas Produc-tion	Other	Soil [slands	Barges	Ice Islands	Gravity Struc-tures	Soil slands	8arges	Ice Islands	Gravit; Struc-tures	Offshore Kilometers (Mi.) Oil	Offshore Kilometers (Mi.) Gas	Onshore Kilometers (Mi.) Oil	Onshore Kilometers (Mi.) Gas	OFFSHORE		
Camden-Canning (3 (1.3 Bbbl)	18	433	12	75	9	6	3	0	9	5	0	1	10(6)	10(6)	87[54)	87(54)		1 base camp (incl. airstrip, harbor, storage area); 2 construction camps; 2 flow stations; 1 gas treatment! compressor station plant; 1 pump station; 87 km. (54 mi.) of haul road 9.7 km. (6 mi.) of service roads	2048
Prudhoe-Large (1.9 Bbbl)	14	253	15	22	7	4	3	0	4	1	0	T	6(4)	6(4)	15(9.5)	15(9.5)		2 flow stations; 1 gas treatment/compressor station plant; some expansion of existing Prudhoe facilities	2750
Prudhoe-Sma 11 (O. 8 Bbbl)	12	270	13	47	6	4	2	0	5	2	0	1	6(4)	6(4)	15(9.5)	15(9.5]		T flow station; 1 gas treatment/compressor station plant; some expansion of existing Prudhoe facilities	1505
Cape Hal kett (0.8 Bbbl)	8	143	3 (injection)	14	0	6	2	0	2	0	0	2	82(51)	- -	66(41)	--	1 flow station 1 compressor station 1 pump station	1 base camp (incl. airstrip, harbor, storage area)	1326
Smith-Dease(4) (0.4 Bbbl)	12				0	'f	8	0										Existing base camp at Lonely used	131

(1) Refer to Table 4 for additional scenario characteristics.
(2) All production scenarios assume trunk pipelines to Prudhoe 8ay interconnection with Alyeska and Alcan pipelines,
(3) Scenario assumes two adjacent fields.
(4) Exploration-only scenario; field deemed uneconomic.

Source: Dames & Moore

- numbers of wells and depth ranges
- diameters and miles of offshore and onshore pipelines
- processing facilities
- staging areas/ports

These are summarized for the five detailed scenarios in Table 2.

Resource Estimates

The basis of the resource estimates used for development of the scenarios is the U.S.G.S. estimates of undiscovered recoverable oil and gas resources of the Beaufort Sea between the O- and 200-meter (656-foot) isobaths, as described in Circular 725 (Miller et al., 1975). The estimates prepared in 1975 for the Beaufort Sea are:

	Probability 95%	Probability 5%	Statistical Mean
Oil (Bbbl)	0	7.6	3.28
Gas (tcf)	0	19.3	8.2

In a subsequent working paper (Open-File Report 76-830, July, 1976), the U.S.G.S. provided an allocation of the resource estimate as follows: .

40 percent - Federal waters between the 20- and 200-meter (66- and 656-foot) isobaths

51 percent - Federal waters between the 5-kilometers (3-mile) limit and 20-meter isobath

9 percent - State waters

A revision to the above estimates was contained in a U.S.G.S. memorandum (Memo EGS-214936, dated 11 October 1977; see Radlinski, 1977), which gave estimates for a sub-area of the Beaufort Sea -- out of the 20-meter (66-foot) isobath between longitudes 146°W and 150°W only. These estimates are:

	Low	High	Statistical Mean
Oil (Bbbl)	1.0	2.5	1.5
Gas (tcf)	1.75	6.25	3.25

Thus, the area between 146°W and 150°W longitude is assigned 1.5 Bbbl of the 2.2 Bbbl mean estimate of the entire Beaufort region out to the 20-meter (66-foot) isobath. Estimates generated in an independent geologic assessment provide a basis for allocating the statistical mean value of 2.2 Bbbl to four areas within the 20-meter isobath:

0.70 Bbbl - Camden Bay-Canning River
0.93 Bbbl - Offshore Prudhoe Bay
0.38 Bbbl - Cape Halkett
0.19 Bbbl - Smith Bay-Dease Inlet

Resource estimates for each hypothetical discovery area are summarized in Table 3.

Skeletal Scenarios

Twenty-four skeletal scenarios were constructed on the basis of the U.S.G.S. resource estimate probabilities which were allocated to four possible discovery locations. The major characteristics of these scenarios are presented in Table 4.

TABLE 3

RESOURCE ESTIMATES EXTRAPOLATE FROM U.S.G.S. ESTIMATES[1]

(Bbbl Oil)

Probability	Total Beaufort	Beaufort Sub-Area to 20 Meters	Sub-Area to 20 Meters Between 146° - 150°	Allocation of Sub-Area Resource Estimates			
				Camden-Canning	Offshore Prudhoe	Cape Halkett	Smith-Dease
Low (95%)	1.0	1.0	1.0	0.4	0.6	Nil	Nil
Modal	2.2	1.85	1.4	0.6	0.8	0.3	0.15
Mean (50%)	2.8	2.2	1.63	0.7	0.93	0.38	0.19
High (5%)	7.6	3.76	2.5	1.1	1.4	0.80	0.40
(1.0 %)	11.7	4.98	3.2	1.3	1.9	1.18	0.60

Note: Gas averages 2,000 cubic feet per barrel of oil, in a range from 1,700 to 2,500 cubic feet.

[1]) The quantities in the total Beaufort, Beaufort sub-area to 20 meters and the sub-area to 20 meters between 146° - 150°W longitude are estimated from a probabilistic distribution. The quantities in the four regions are allocated somewhat arbitrarily on a geological basis. Given a 5% chance of finding at least 2.5 Bbbl of oil in the sub-area to 20 meters, between 146° and 150°W longitude, it would be reasonable to assume that 1".4 Bbbl of oil may be in the offshore Prudhoe area.

Source: Dames & Moore

TABLE 4

SKELETAL SCENARIO CHARACTERISTICS

		Oil (Bbbl)	Gas Ratio	Gas Location	Fill Factor (bbl/acre)	Well Spacing (acres)	Acreage	Producing Wells	Well Allowances	Total Wells	Platforms	Tracts
Camden-Canning	1	0.6	1.2	Assoc	40,000	140	15,000	107	13	120	3	12
	2	0.6	1.2	Assoc	30,000	100	20,000	200	30	230	6	16
	3	1.1	2.2	Assoc	40,000	140	27,500	196	24	220	6	22
	4	1.1	2.2	Sep	30,000	100	37,000	367	73	440	11	29
	5	1.3	3.25	Assoc	50,000	140	26,000	186	24	210	5	21
	6*	1.3	3.25	Sep	30,000	100	43,000	433	87	520	13	34
Prudhoe - Central	7	0.6	1.2	Assoc	40,000	150	15,000	100	15	115	3	12
	8*	0.8	1.6	Sep	30,000	100	27,000	270	60	330	8	21
	9	1.4	2.8	Assoc	50,000	150	28,000	187	23	210	6	22
	10	1.4	2.8	Sep	40,000	120	35,000	292	68	360	9	28
	11*	1.9	4.75	Assoc	50,000	150	38,000	253	37	290	6	30
	12	1.9	4.75	Sep	40,000	120	47,500	396	84	480	13	37

TABLE 4 (Cont.)

		Oil (Bbl)	Gas Ratio	Gas Location	Fill Factor (bbl/acre)	Well Spacing (acres)	Acreage	Producing Wells	Well Allowances	Total Wells	Platforms	Tracts
Cap : lkett	13	0.3	0.2	Assoc	40,000	140	7,500	54	6	60	2	3-4
	14	0.3	0.2	Assoc	30,000	120	10,000	83	17	100	3	4
	15*	0.8	0,6	Assoc	40,000	140	20,000	143	17	160	4	7
	16	0.8	0.6	Sep	30,000	120	27,000	222	48	270	7	10
	17	1.2	1.2	Assoc	50,000	140	24,000	171	19	190	4	8-9
	18	1.2	1.2	Sep	30,000	120	40,000	333	67	400	10	14
Smith-Dease	19	0.15	0.1	Sep	40,000	120	4,000	32	8	40	1	2
	20	0.15	0.1	Sep	20,000	80	7,500	94	21	115	3	3-4
	21	0.4	0.4	Sep	40,000	120	10,000	84	21	105	3	4
	22*	0.4	0.4	Sep	20,000	80	20,000	250	50	300	8	7-8
	23	0.6	0.9	Sep	40,000	120	15,000	125	25	150	3	6
	24	0.6	0.9	Sep	20,000	80	30,000	375	85	470	11	11-12

*Scenarios selected for detailed analysis

Source: Dames & Moore

Selected (Detailed) Scenarios

Of the 24 skeletal scenarios, five were selected for detailed analysis. These provided a range of location and developmental magnitudes that allowed the most realistic prediction of baseline conditions (project description) for subsequent socioeconomic impact assessment. With the exception of the Prudhoe Bay scenarios, only one of which may occur, the selected scenarios, although individually analyzed, represent the cumulative petroleum development as anticipated in the Beaufort Sea within the confines of the U.S.G.S. estimates and lease sale areas.

Scenario	Reserves Oil Bbbl	Resource Estimate	Lease Sale
Camden-Canning	1.3	High	Joint State-Federal
Prudhoe-Small (1)	0.8	Modal	Joint State-Federal
Prudhoe-Large (1)	1.9	High	Joint State-Federal
Cape Halkett	0.8	High	Federal OCS
Smith-Dease (2)	0.4	High	Federal OCS

Notes:

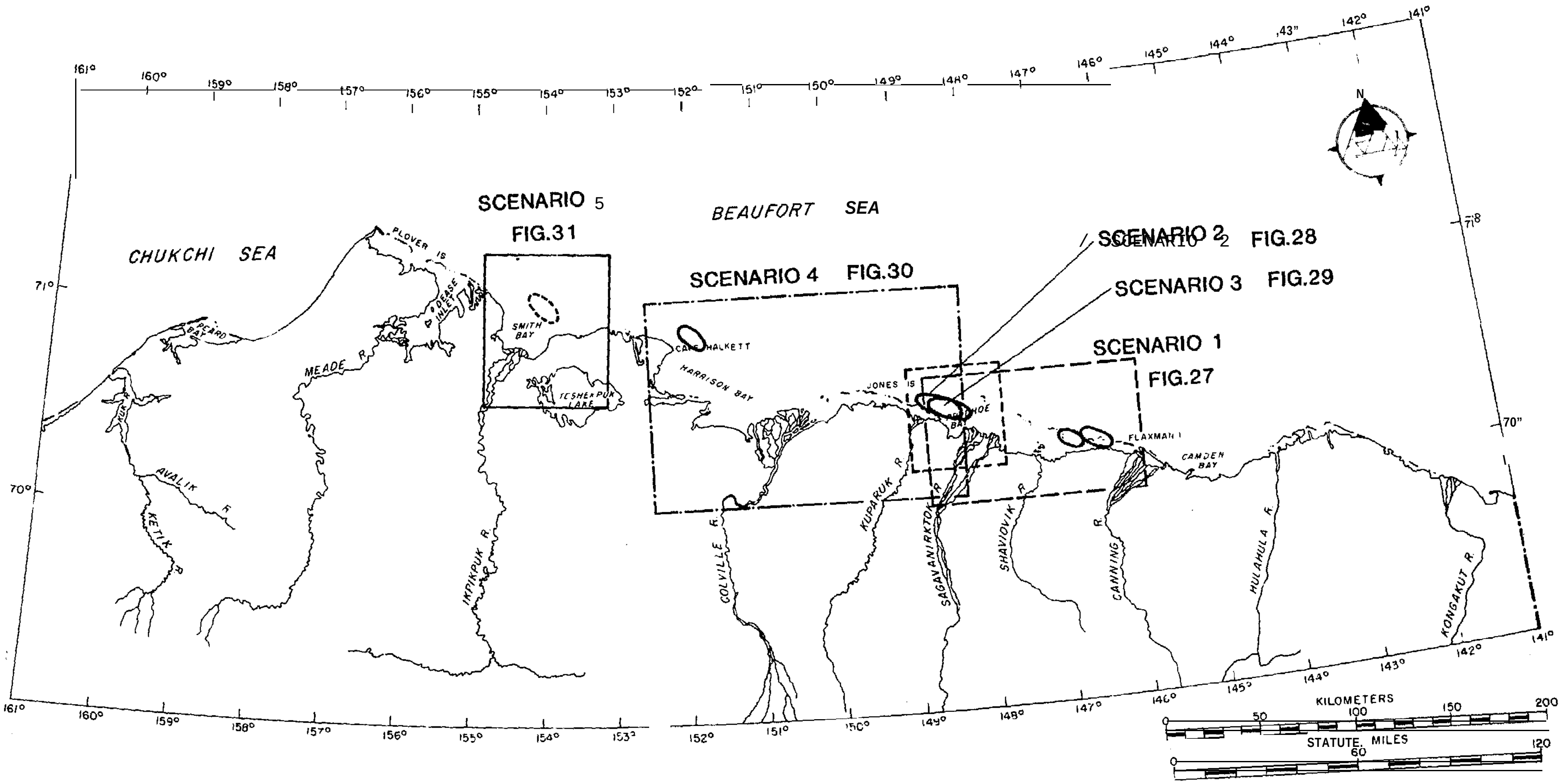
(1) For cumulative impact analysis, only one scenario can be taken.

(2) Oil discoveries are deemed uneconomic - only exploration occurs.

The location of the selected scenarios and their postulated infrastructure (platforms, pipelines, etc.) is shown in Figures 1 through 6. The technology and facilities framework of the selected scenarios is given in Table 2.

Economics

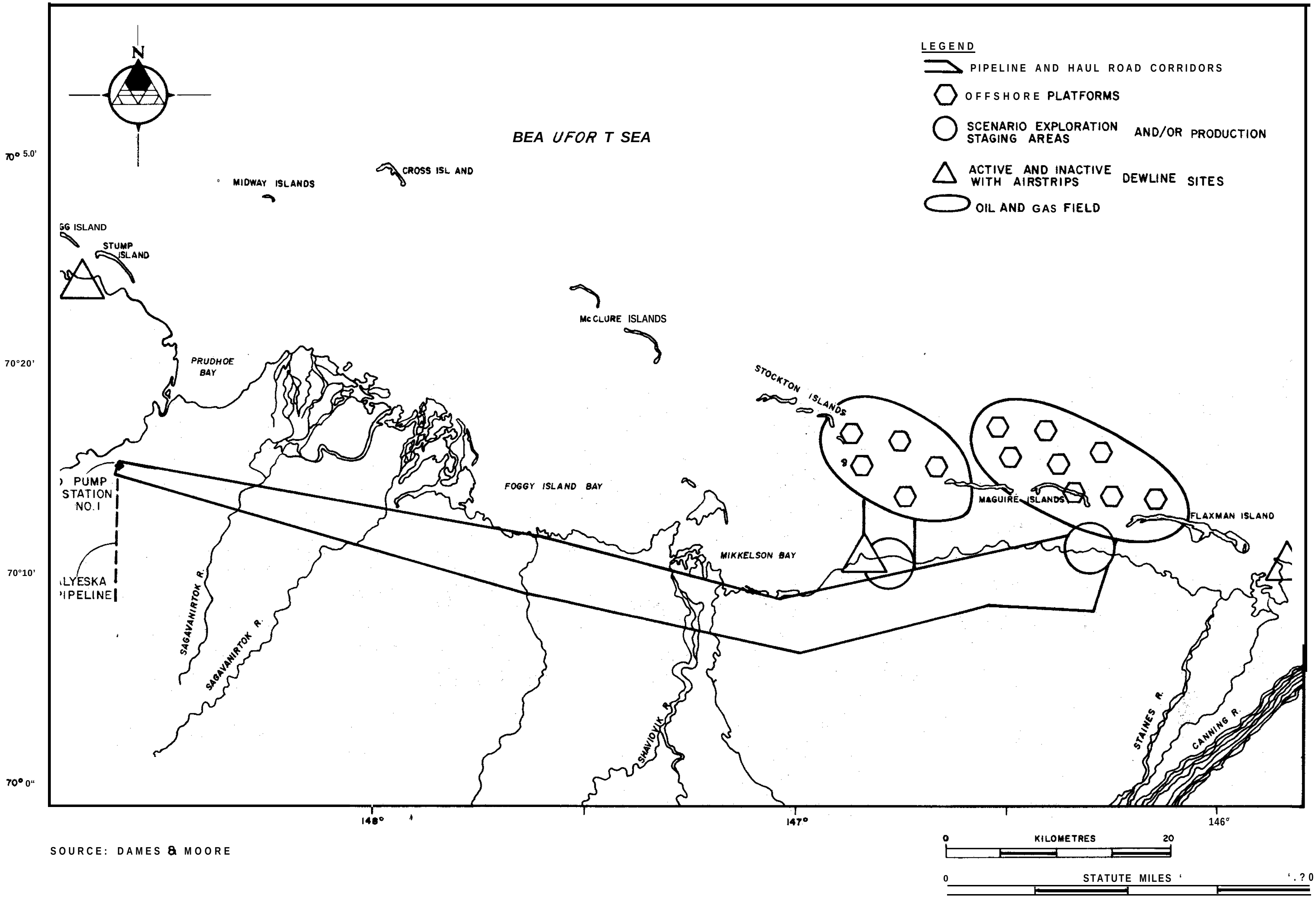
Economic analysis of the 24 skeletal scenarios and the five selected (detailed) scenarios resulted in the following principle conclusions on the economic viability of Beaufort Sea oil and gas resources predicted by U.S.G.S. estimates.



SOURCE DAMES & MOORE

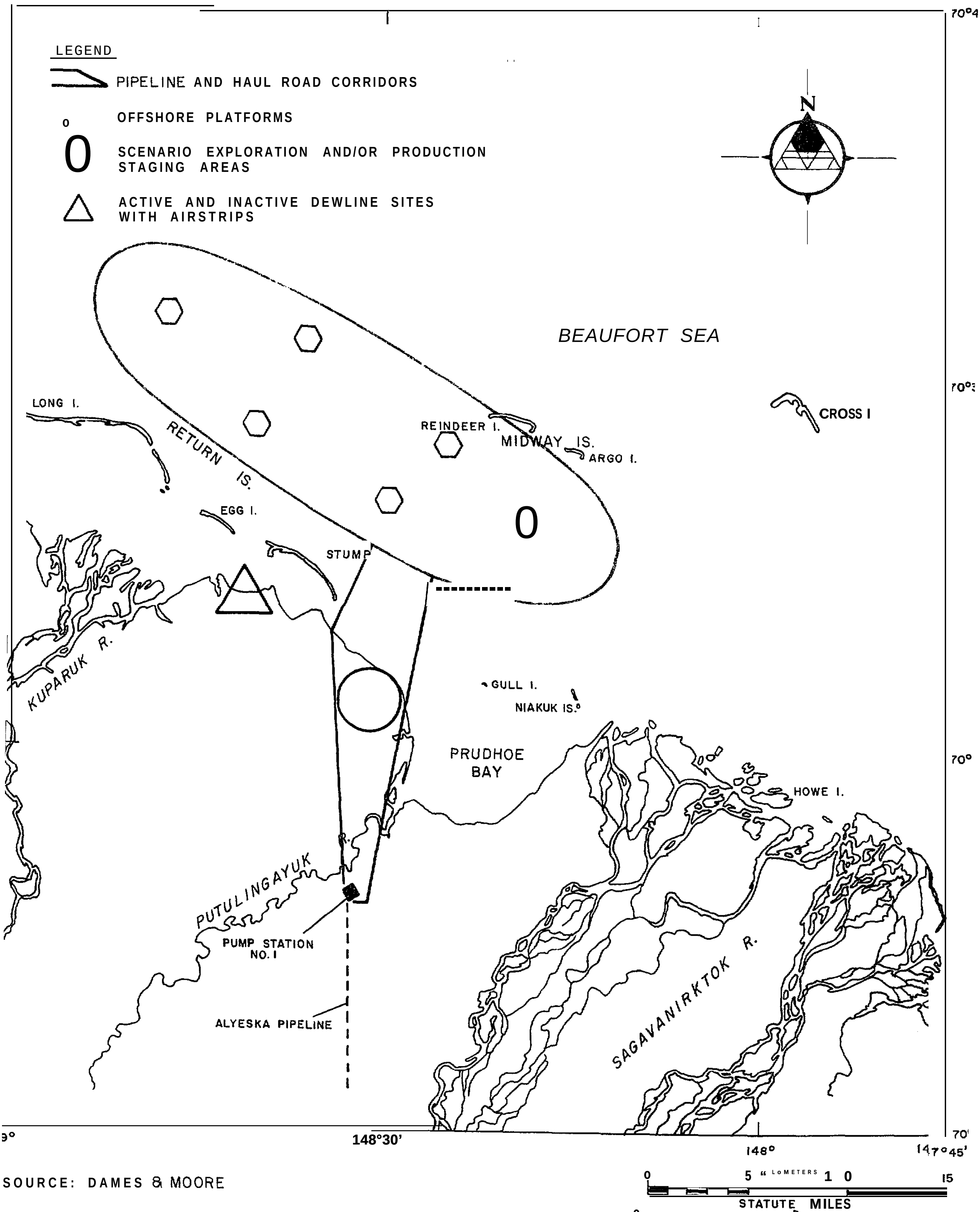
FIGURE 1

SELECTED PETROLEUM DEVELOPMENT SCENARIO LOCATIONS



SOURCE: DAMES & MOORE

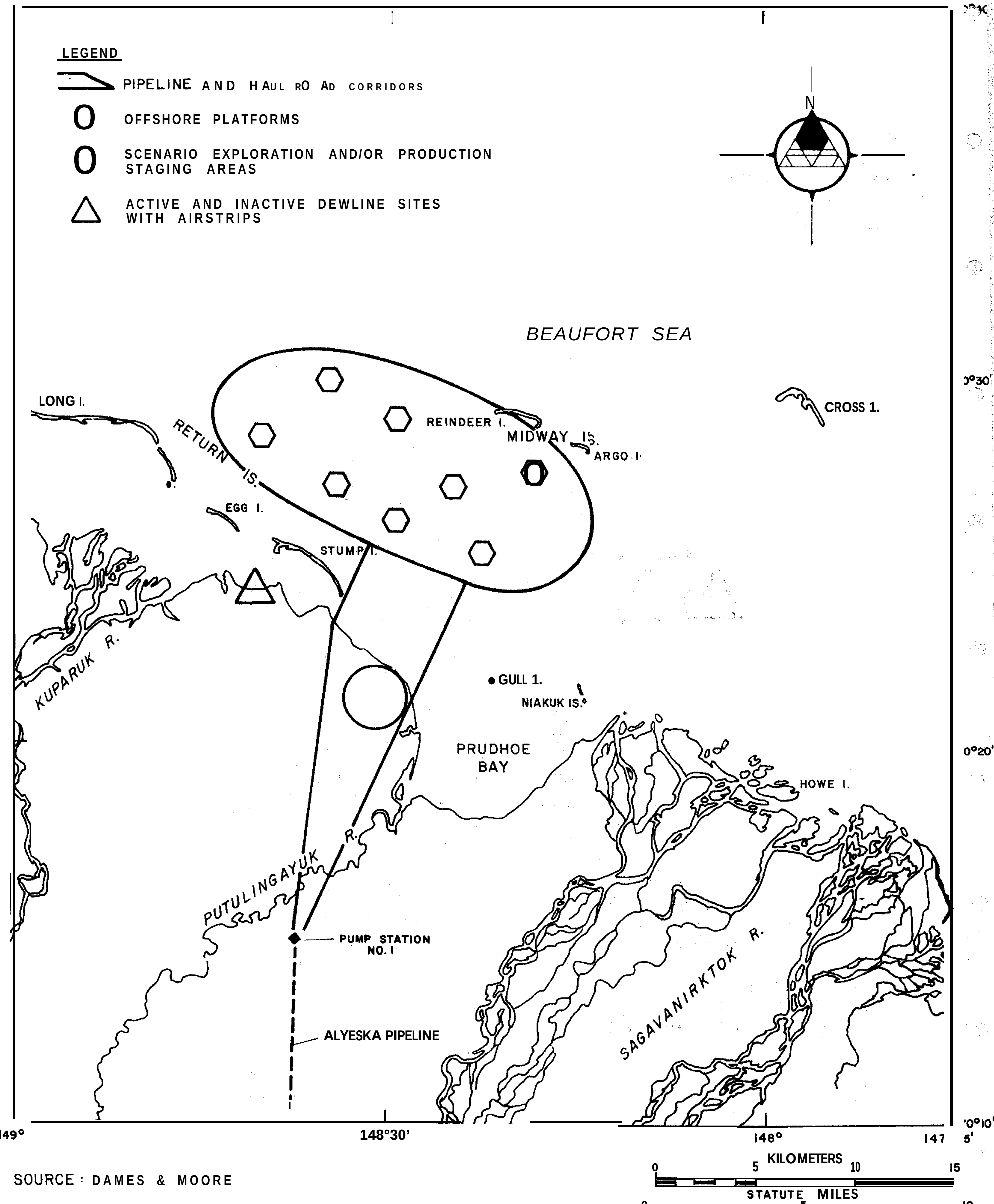
FIGURE 2 - SCENARIO 1: CAMDEN-CANNING, 1.3 BBL RESERVES



SOURCE: DAMES & MOORE

FIGURE 3

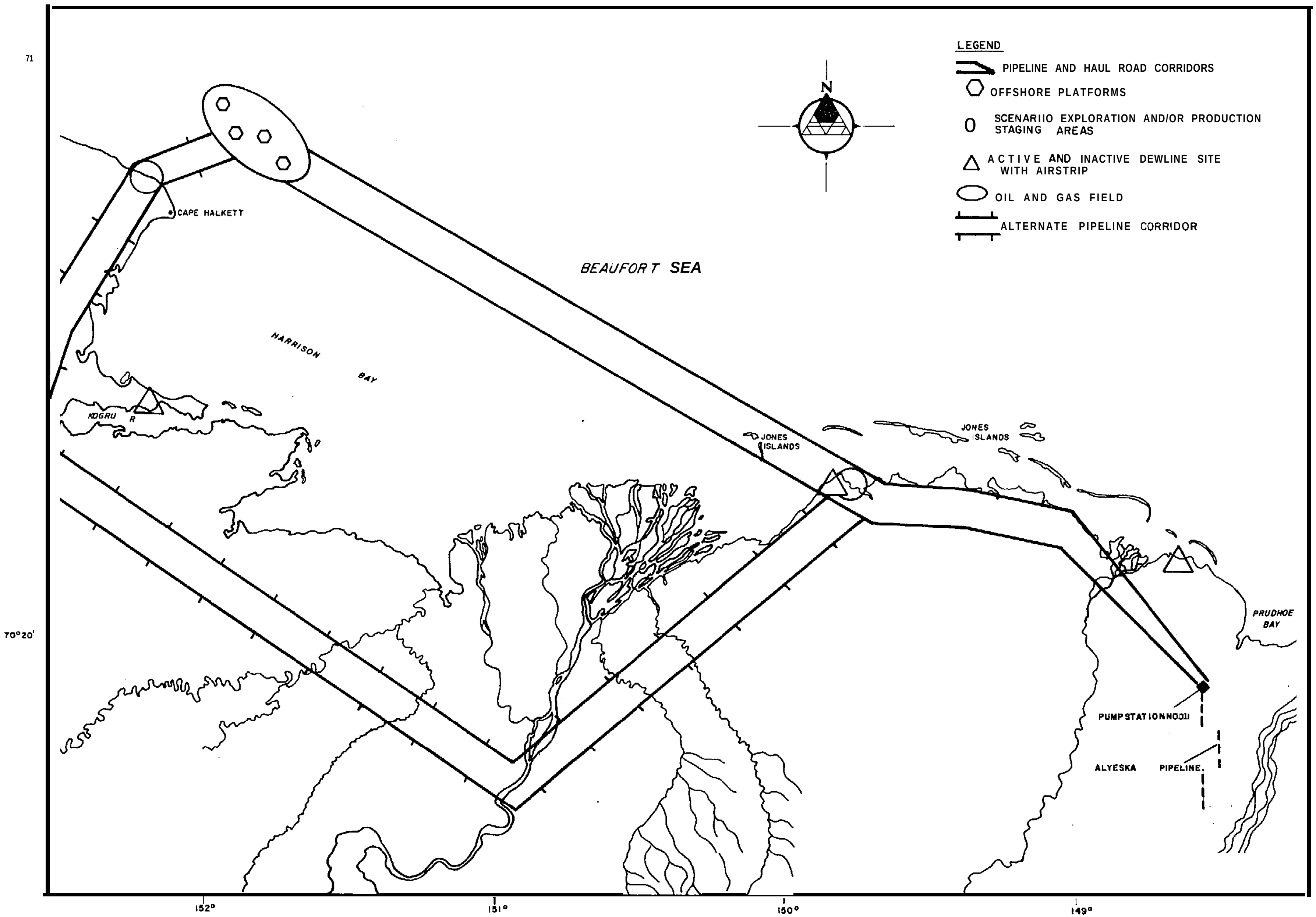
SCENARIO 2: PRUDHOE BAY OFFSHORE, 1.9 BbI. RESERVES



SOURCE: DAMES & MOORE

FIGURE 4

SCENARIO 3: PRUDHOE BAY OFFSHORE, 0.8 BbI. RESERVES

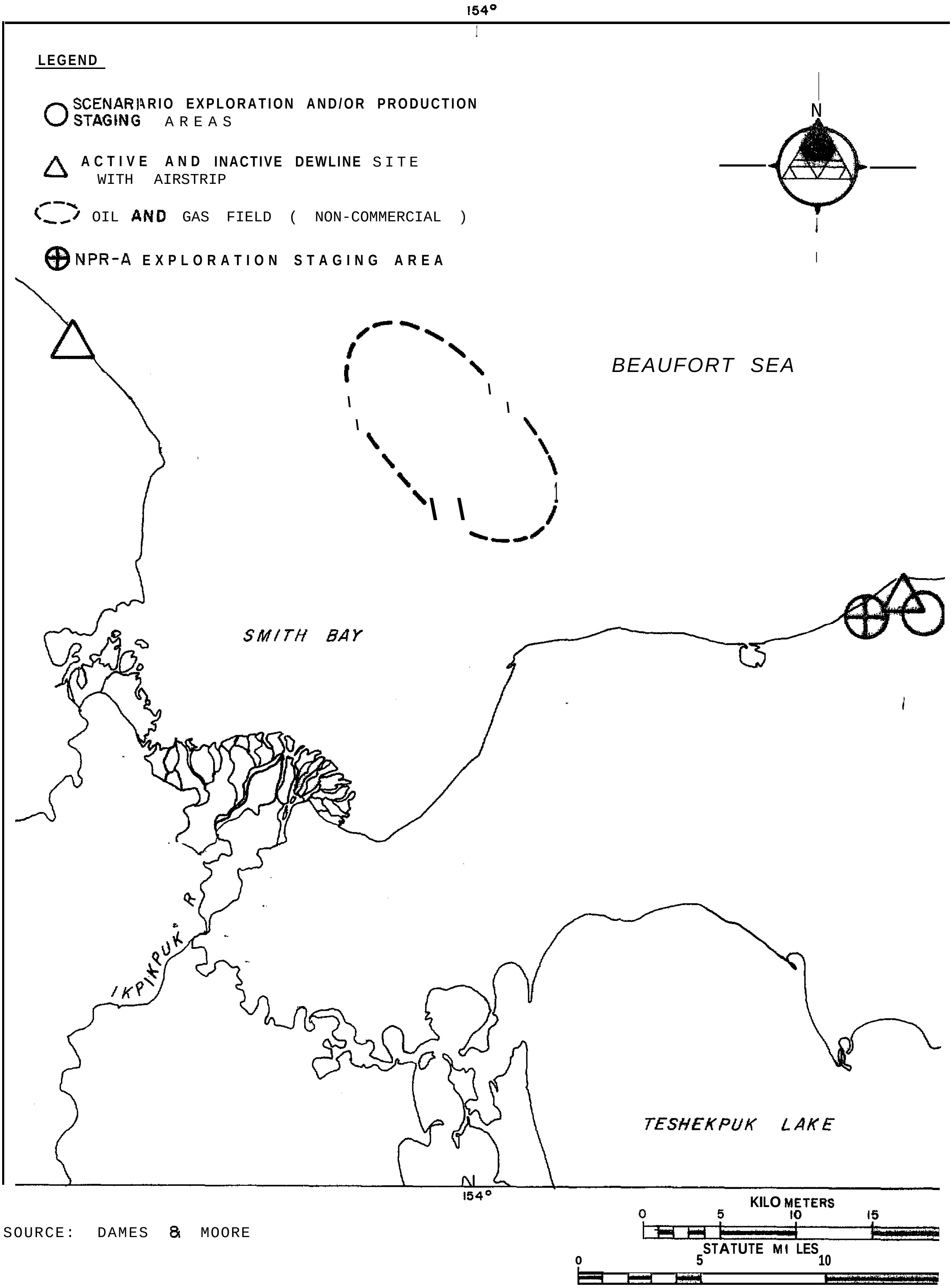


SOURCE DAMES & MOORE

KILOMETERS 0 20

STATUTE MILES 0 20

FIGURE 5
SCENARIO 4: CAPE HALKETT, 0.8 BBbl. RESERVES



SOURCE: DAMES & MOORE

FIGURE 6

SCENARIO 5: SMITH BAY-DEAS INLET, 0.4 Bbl. RESERVES

New discoveries in the central and eastern Beaufort Sea within the range of present estimates will rely upon existing transport systems of the North Slope (i.e. Alyeska and Alcan pipelines).

The higher the cost of transporting Beaufort Sea resource production to transport centers for oil and gas assumed available to the North Slope, the larger the resource must be for an economically feasible scenario. In the case of offshore Prudhoe Bay, the practical minimum field size required is 400 MMbbl. In the eastern Beaufort, which is up to 90 kilometers (54 miles) from Prudhoe Bay, 700 to 1,000 MMbbl are reasonable minimum producible deposits, depending on the productivity of an average well. In the Cape Halkett area, which is about 150 kilometers (90 miles) from Prudhoe Bay, 700 to 1,000 MMbbl may be necessary to justify production, provided that the Beaufort Sea pipelines can be constructed within projected costs. In the western Beaufort, which is 200 kilometers (120 miles) or more from Prudhoe Bay, at least 1 Bbbl of reserves may be necessary to justify production.

Economically producible resource discoveries to support a new trans-Alaska oil pipeline system, in addition to the 3.64 billion barrels surplus which can be accommodated in the present system would have to total about 3 Bbbl. Gas reserves, in addition to the 34 tcf which can be accommodated in the proposed Alcan system, would have to total at least 10 tcf. These minimum levels are predicated upon small tariff premiums over those currently envisioned for the transport systems.

Western Beaufort production could support a Nome oil pipeline route from NPR-A. However, the estimated 3 Bbbl of oil which would have to be found in NPR-A are not considered likely. Current estimates of one billion barrels in NPR-A could be supported by fortunate levels of discovery in the western Beaufort for a pipeline route to the Alyeska line.

The most likely discovery levels for the eastern Beaufort are marginally producible under the projected economic costs. Factors which favor development projections are the cost effectiveness demonstrated by the industry in North Slope production well drilling and the potential for reducing offshore pipeline costs relative to those incurred onshore.

Beaufort Sea discoveries cannot be projected as stimulating Alaskan petrochemical development because they would not alter but rather would follow any pattern set by present Prudhoe Bay production.

Manpower

The actual manpower requirements of production of offshore petroleum reserves in the Arctic will hinge on the technology employed, especially the type of platforms used, the development schedule, and the number and size of fields, which determine the number of platforms and scale of production equipment that must be installed.

In the development scenarios described in this study, manpower requirements are modest, certainly in comparison to the manpower requirements of developing the Prudhoe Bay field; the highest peak employment is some 2,750 men for the Prudhoe-Large scenario, and the smallest peak is some 1,326 for the Cape Halkett scenario. Manpower summaries and annual employment and peak employment for each scenario are given in Tables 5 through 14.

Since the economic analysis in this study indicates that new offshore production would be shipped via the existing Alyeska pipeline as capacity becomes available (construction of a second Alyeska pipeline would require substantial employment, estimated at 50 to 60 percent of that required to build the first line), pipeline construction in the scenarios is limited to connecting lines to Alyeska Pump Station No. 1.

Development of new offshore fields in the Prudhoe Bay area will benefit from existing infrastructure at the Prudhoe Bay field, such as airfields, and construction camps and roads; however, the other fields will benefit only marginally from Prudhoe Bay facilities and duplication of much of this infrastructure will be required.

TABLE 5

MANPOWER SUMMARY SHEET

CAMDEN-CANNING SCENARIO

Phase	Year	PETROLEUM Man-Months	PETROLEUM Annual Monthly Average	CONSTRUCTION Man-Months	CONSTRUCTION Annual Monthly Average	TOTAL Man-Months	TOTAL Annual Monthly Average
Exploration Begins	1	911	76	106	9	1,017	85
	2	1,106	92	619	52	1,725	144
	3	1,301	108	362	30	1,663	138
	4	585	49	725	61	1,310	110
Decision to Develop Camden	5	585	49	2,666	224	3,251	273
	6	585	49	7,794	649	8,379	698
Decision to Develop Canning	7	1,974	165	14,387	I ,200	16,361	1,365
	8	3,363	280	9,047	754	12,410	1,034
Camden Production Begins	9	8,280	690	6,968	581	15,248	1,271
	10	9,864	822	3,632	303	13,496	1,125
	11	12,048	1,004	990	83	13,038	1,087
Canning Production Begins	12	12,120	1,010	0	0	12,120	1,010
	13	12,120	1,010	990	83	13,110	1 , 0 9 3
	14	11,712	976	1,346	113	13,058	1,089
	15	10,416	868	0	0	10,416	868
	16	10,416	868	990	83	11,406	951
	17	9,768	814	60	5	9,820	819
	18	9,048	754	60	5	9,108	759
	19	8,328	694	60	5	8,388	699
	20	8,328	694	60	5	8,388	699
	21	7,608	634	60	5	7,668	639
	22	7,608	634	60	5	7,668	639
	23	? ,608	634	60	5	7,668	639
	24	7,608	634	60	5	7,668	639
	25	7,032	586	60	5	7,092	591
	26	7,032	586	60	5	7,092	591
	27	6,072	506	60	5	7,092	511
	28	6,072	506	60	5	7,092	511

Source: Dames & Moore

TABLE 6

ESTIMATED ANNUAL EMPLOYMENT AND EMPLOYMENT PEAKS

CAMDEN-CANNING SCENARIO

Years from Start of Exploration

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Annual Monthly Average	88	144	138	110	273	698	1365	1034	1271	1125	1087	1010	1093	1089	868	951	819	759	699	699	639	639	639	639	591	591	511	511
Employment On Jan 1	0	132	216	207	165	349	1047	1551	1551	1688	*																	
Employment On June 1	44	72	69	55	273	698	1638	1034	1525	1725	*																	
Peak Employment	132	216	207	165	410	1047	2048	1551	1907	1688	*																	
Months of Peak	Sept Dec	Sept Dec	Sept Dec	Sept Dec	Sept	Dec	Sept	Jan	Sept	Jan																		

* As soon as production begins, employment is expected to stabilize at the annual monthly average, year around.

NOTE: See Manpower Summary Sheet (Table 41) for petroleum/construction breakdown and development schedule.

Source: Dames & Moore

TABLE 7

MANPOWER SUNNARY SHEET

PRUDHOE BAY OFFSHORE (1.9 Bbbl) SCENARIO

Phase	Year	PETROLEUM Man-Months	PETROLEUM Annual Monthly Average	CONSTRUCTION Man-Months	CONSTRUCTION Annual Monthly Average	TOTAL Man-Months	TOTAL Annual Monthly Average
	1	716	60	0	0	716	60
	2	1,301	108	725	60	2,026	168
	3	1,106	92	212	18	1,318	110
	4	390	33	1,026	86	1,416	119
	5	390	33	1,026	86	1,416	119
Decision to Develop	6	390	33	1,143	99	1,533	132
	7	195	16	2,880	240	3,075	256
	8	1,974	165	20,018	1,668	21,992	1,833
	9	3,168	264	17,069	1,422	20,237	1,686
Production Begins	10	13,152	1,096	60	5	13,212	1,101
	11	13,152	1,096	60	5	13,212	1,101
	12	13,152	1,096	60	5	13,212	1,101
	13	13,152	1,096	60	5	13,212	1,101
	14	11,712	976	60	5	11,772	981
	15	11",232	936	60	5	11,292	941
	16	9,972	831	60	5	10,032	836
	17	9,792	816	60	5	9,852	821
	18	9,792	816	60	5	9,852	821
	19	9,792	816	60	5	9,852	821
	20	9,792	816	60	"5	9,852	821
	21	9,792	816	60	5	9,852	821
	22	9,792	816	60	5	9,852	821
	23	9,792	816	60	5	9,852	821
	24	9,792	816	60	5	9,852	821
	25	9,792	816	60	5	9,852	821
	26	9,792	816	60	5	9,852	821
	27	9,792	816	60	5	9,852	821
	28	8,832	736	60	5	8,892	741
	29	8,832	?36	60	5	8,892	741

Source: Dames & Moore

TABLE 8

ESTIMATED ANNUAL EMPLOYMENT AND EMPLOYMENT PEAKS

PRUDHOE BAY OFFSHORE (1.9 Bbbl) SCENARIO

Years from Start of Exploration

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Annual Monthly Average	60	168	110	119	119	132	256	1853	1696	1101	1101	1101	1101	981	941	836	821	821	821	821	821	821	821	821	821	821	821	741	746
Employment On Jan 1	0	90	252	165	179	179	128	384	2529	*																			
Employment On June 1	30	84	55	60	60	132	256	2200	1686	*																			
Peak Employment	90	252	165	179	179	198	384	2750	2529	*																			
Months of Peak	Sept Dec	Sept Dec	Sept Dec	Sept Dec	Sept Dec	Sept	Dec	Sept	Jan																				

* As soon as production begins, employment is expected to stabilize at the annual monthly average, year around.

NOTE: See Manpower Summary Sheet (Table $5) for petroleum/construction breakdown and development schedule.

Source: Dames & Moore

TABLE 9

MANPOWER SUNMARY SHEET

PRUDHOE BAY OFFSHORE (0.8 Bbbl) SCENARIO

Phase	Year	PETROLEUM Man-Months	PETROLEUM Annual Monthly Average	CONSTRUCTION Man-Months	CONSTRUCTION Annual Monthly Average	TOTAL Man-Months	TOTAL Annual Monthly Average
Exploration Begins	1	716	60	0	0	716	60
	2	1,355	113	725	61	2,080	173
	3	1,142	95	212	18	1,354	113
	4	426	36	1,026	86	1,452	121
	5	426	36	1,026	86	1,452	121
Decision to Develop	6	213	18	800	67	1,013	85
	7	213	18	2,960	247	3,173	265
	8	1,797	150	10,250	855	12,047	1,005
	9	3,168	264	7,102	592	10,270	856
Production Starts	10	6,696	558	3,168	264	9,864	822
	11	6,696	558	990	83"	7,686	641
	12	6,768	564	990	83	7,758	647
	13	6,840	570	356	30	7,196	600
	14	6,912	526	990	83	7,902	659
	15	7,944	662	60	5	8,004	667
	16	7,944	662	60	5	8,004	667
	17	7,224	602	60	5	7,284	607
	18	6,504	542	60	5	6,564	547
	19	6,504	542	60	5	6,564	547
	20	5,064	422	60	5	5,124	427
	21	5,064	422	60	5	5,124	427
	22	5,064	422	60	5	5,124	427
	23	5,064	422	60	5	5,124	427
	24	5,064	422	60	5	5,124	427
	25	5,064	422	60	5	5,124	427
	26	5,064	422	60	5	5,124	427
	27	5,064	422	60	5	5,124	427
	29	5,064	422	60	5	5,124	427
	30	4,104	342	60	5	4,164	347
	31	4,104	342	60	5	4,164	347

Source: Dames & Moore

TABLE 10

ESTIMATED ANNUAL EMPLOYMENT ANO EMPLOYMENT PEAKS

PRUDHOE BAY OFFSHORE (0.8 Bbbl) SCENARIO

Years from Start of Exploration

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Annual Monthly Average	60	169	110	118	118	83	263	1103	856	822	641	647	600	659	667	667	607	547	547	427	427	427	427	427	427	427	427	427	427	347	347
Employment On Jan 1	0	90	254	165	177	177	132	395	1284	*																					
Employment On June 1	30	85	55	59	59	83	263	1204	856	*																					
Peak Employment	90	254	165	177	177	125	395	1505	1284	*																					
Months of Peak	Sept Dec	Sept Oec	Sept Dee	Sept Oec	Sept Dec	Sept	Dec	Sept	Jan																						

* As soon as production begins, employment is expected to stabilize at the annual monthly average, year around.

NOTE: See Manpower Summary Sheet (Table 49) for petroleum/construction breakdown and development schedule.

Source: Dames & Moore

TABLE 11

MANPOWER SUMMARY SHEET

CAPE HALKETT SCENARIO

Phase	Year	PETROLEUM Man-Months	PETROLEUM Annual Monthly Average	CONSTRUCTION Man-Months	CONSTRUCTION Annual Monthly Average	TOTAL Man-Months	TOTAL Annual Monthly Average
Exploration Begins	1	358	30	0	0	358	30
	2	748	62	256	21	1,004	83
	3	943	39	406	34	1,349	113
Decision to Develop	4	195	16	150	13	345	29
	5	195	16	1,418	119	1,613	135
	6	195	16	4,989	416	5,184	432
	7	792	66	9,814	818	10,606	884
	8	1,584	132	5,687	474	7,271	606
Production Starts	9	5,904	492	416	35	6,320	527
	10	5,904	492	60	5	5,964	497
	11	5,976	498	60	5	6,036	503
	12	5,976	498	60	5	6,036	503
	13	5,976	498	60	5	6,036	503
	14	5,496	458	60	5	5,556	463
	15	5,496	458	60	5	5,556	463
	16	4,776	398	60	5	4,836	403
	17	4,776	398	60	5	4,836	403
	18	4,776	398	60	5	4,836	403
	19	4,776	398	60	5	4,836	403
	20	4,776	398	60	5	4,836	403
	21	4,776	398	60	5	4,836	403
	22	4,776	398	60	5	4,836	403
	23	4,776	398	60	5	4,836	403
	24	4,776	398	60	5	4,836	403
	25	4,776	398	60	5	4,836	403
	26	4,776	398	60	5	4,836	403
	27	3,816	318	60	5	3,876	323
	28	3,816	318	60	5	3,876	323

Source: Dames & Moore

TABLE 12

ESTIMATED ANNUAL EMPLOYMENT AND EMPLOYMENT PEAKS

CAPE ' HALKETT SCENARIO

Years from Start of Exploration

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	79	20	21	22	23	24	25	26	27	28
Annual Monthly Average	30	83	113	29	135	432	884	606	527,	497	503	503	503	463	463	403	403	403	403	403	403	403	403	403	403	403	323	823
Employment On Jan 1	0	45	125	170	45	216	648	909	*																			
Employment On June 1	15	42	57	15	135	432	1061	606	*																			
Peak Employment	45	125	170	45	203	648	1326	909	*																			
Months of Peak	Sept Dec	Sept Dec	Sept Dec	Sept Dec	Sept	Dec	Sept	Jan																				

* As soon as production begins, employment is expected to stabilize at the annual monthly average, year around.

NOTE: See Manpower Summary sheet for petroleum/construction breakdown and development schedule.

Source: Dames & Moore

TABLE 13

MANPOWER SUMMARY SHEET

SMITH-DEASE SCENARIO

Year	PETROLEUM Man-Months	PETROLEUM Annual Monthly Average	CONSTRUCTION Man-Months	CONSTRUCTION Annual Monthly Average	TOTAL Man-Months	TOTAL Annual Monthly Average
1	358	30	0	0	358	30
2	553	46	150	13	703	59
3	748	62	300	25	1,048	87
4	585	49	362	30	947	79
5	390	33	256	21	646	54
6	390	33	256	21	646	54
7	195	16	150	13	345	29
8	195	16	150	13	345	29

Source: Dames & Moore

*This scenario has only an exploration phase.

TABLE 14

ESTIMATED ANNUAL EMPLOYMENT AND EMPLOYMENT PEAKS

SMITH-DEASE SCENARIO

	Years from Start of Exploration							
	1	2	3	4	5	6	7	8
Annual Monthly Average	30	59	87	75	54	54	29	29
Employment On Jan 1	0	45	89	131	113	81	81	44
Employment On June 1	15	30	44	38	27	27	15	15
Peak Employment	45	89	131	113	81	81	44	44
Months of Peak	Sept Dec	Sept Dec	Sept Dec	Sept Dec	Sept Dec	Sept Dec	Sept Dec	Sept Dec

NOTE: This scenario entails exploration only. See Manpower Summary Sheet (Table 55) for petroleum/construction breakdown.

Source: Dames & Moore