# Hydrocarbon Development In The Beaufort Sea - Mackenzie Delta Region

ENVIRONMENTAL IMPACT STATEMENT

1982

VOLUME 1 SUMMARY

# ENVIRONMENTAL IMPACT STATEMENT

FOR

# HYDROCARBON DEVELOPMENT

IN THE

# BEAUFORT SEA - MACKENZIE DELTA REGION

## VOLUME 1
## SUMMARY

1982

# BEAUFORT SEA-MACKENZIE DELTA ENVIRONMENTAL IMPACT STATEMENT

**The Beaufort Sea Production Environmental Impact Statement was prepared by Dome Petroleum Limited, Esso Resources Canada Limited and Gulf Canada Resources Inc. on behalf of all land-holders in the Beaufort Sea-Mackenzie Delta region.**

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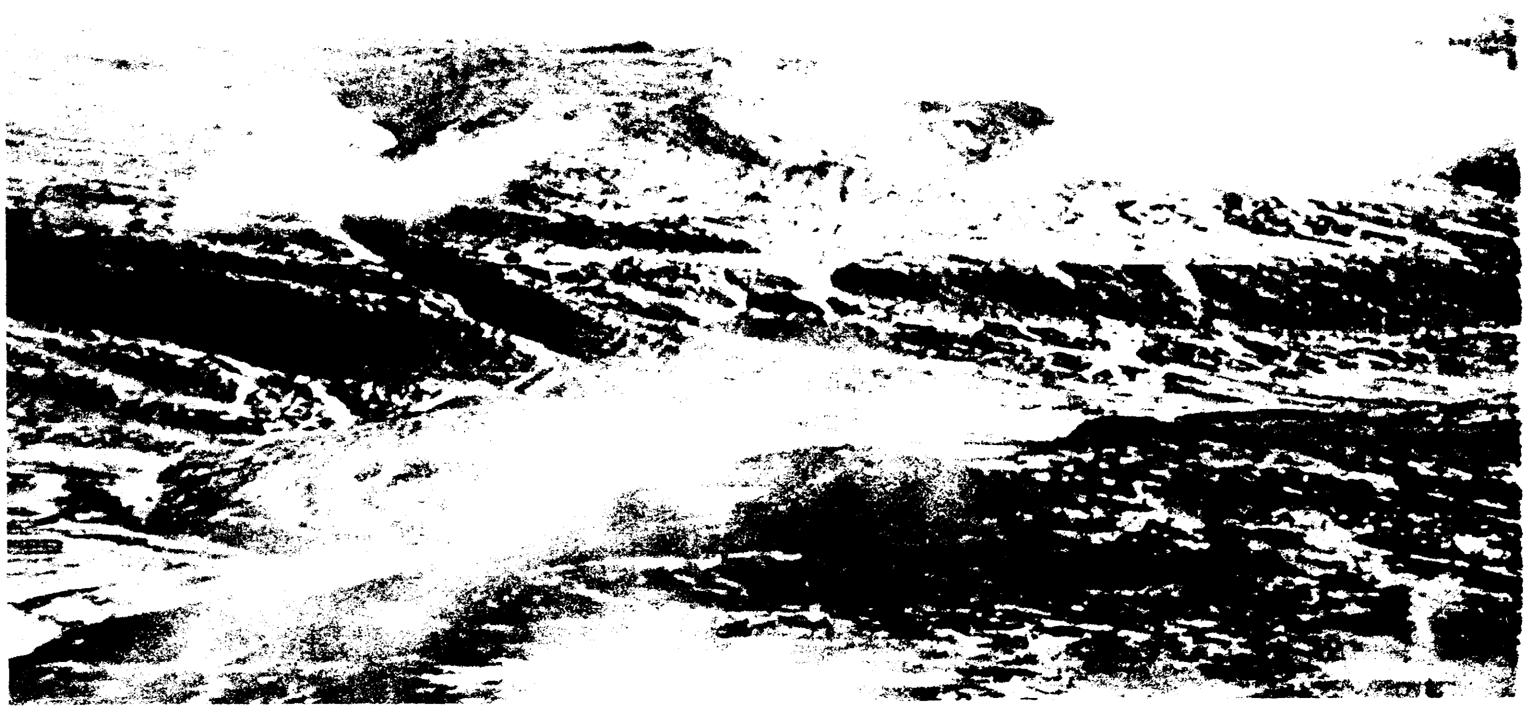

# ENVIRONMENTAL IMPACT STATEMENT

## MASTER INDEX

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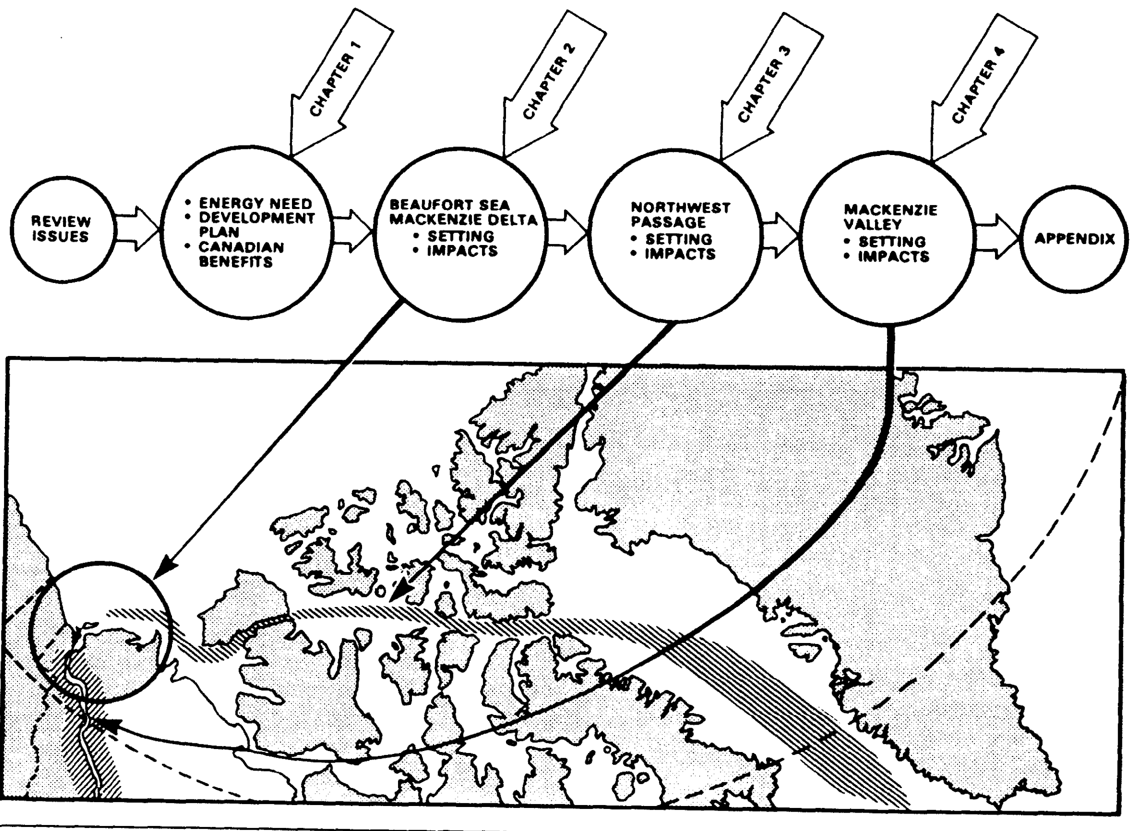
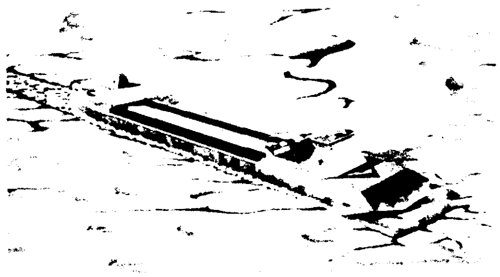
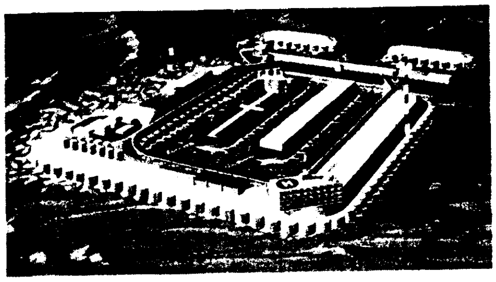
## CHAPTER 2 THE BEAUFORT SEA-MACKENZIE DELTA REGION

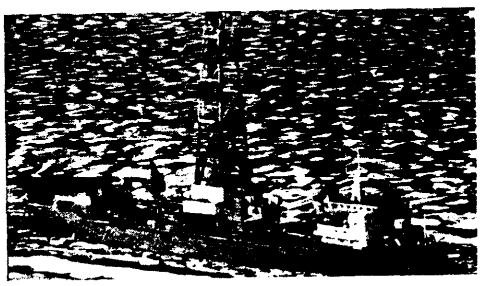
# WHAT THIS VOLUME CONSIDERS

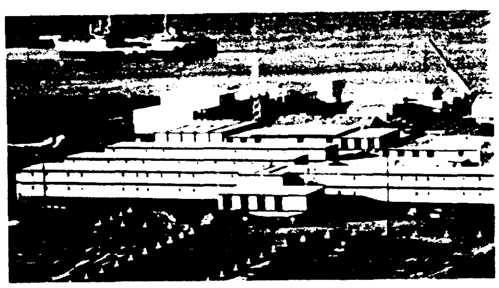
This volume provides an overview of the main body of the Environmental Impact Statement contained in Volumes 2, 3A, 3B, 3C, 4, 5, 6 and 7. It begins with a BRIEF REVIEW, intended to capture the essence of this volume and some of the major issues related to Beaufort development. CHAPTER 1 describes the need for oil, the development plan proposed to extract the oil and the possible Canadian benefits which would result. The next three chapters of the volume deal separately with the three main geographic regions north of 60°N which could be affected by development - the Beaufort Sea-Mackenzie Delta, the Northwest Passage, and the Mackenzie Valley regions. CHAPTER 2 examines the Beaufort Sea-Mackenzie Delta region, the principal area where the ongoing exploration and production related activities would take place. This chapter provides a brief description of its regional features, followed by a summary of possible environmental and socio-economic impacts in the region. CHAPTER 3 considers the Northwest Passage region, the area through which Arctic tankers would travel to deliver Beaufort Sea oil to eastern Canadian markets. CHAPTER 4 focuses on the Mackenzie Valley region, the area which would be most affected by an overland pipeline, another transportation option to deliver oil. At the end of this volume, an APPENDIX outlines the companies involved in the preparation of the Environmental Impact Statement and describes how it was produced.

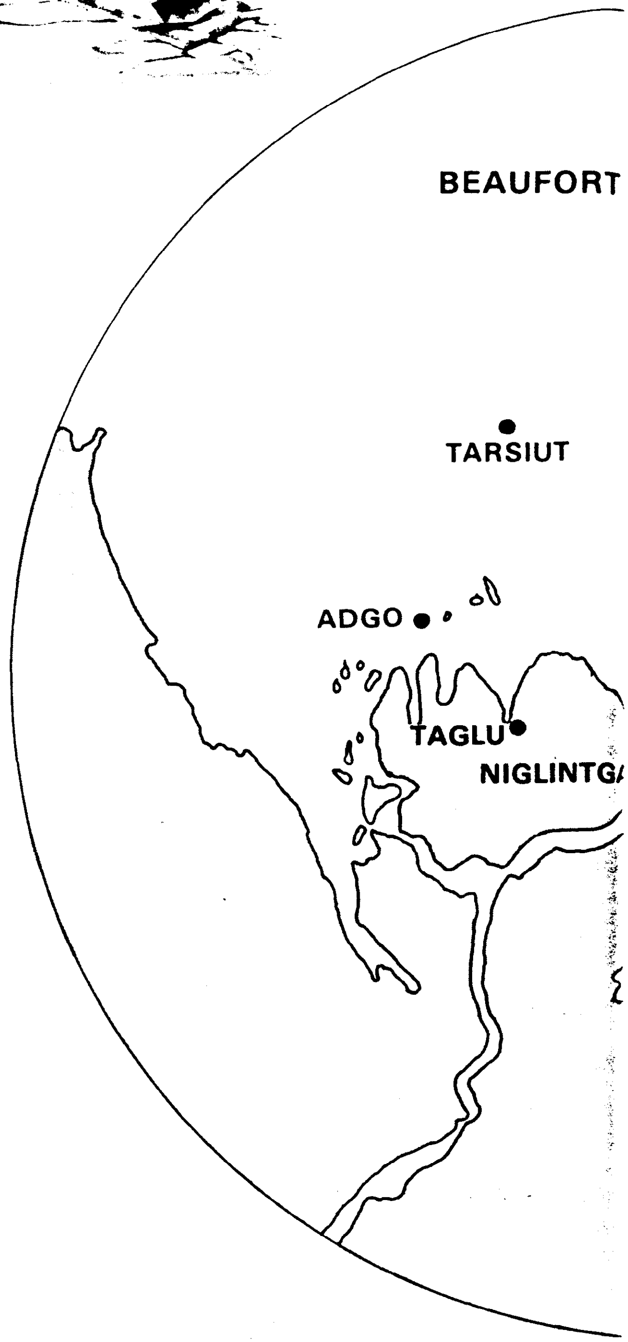








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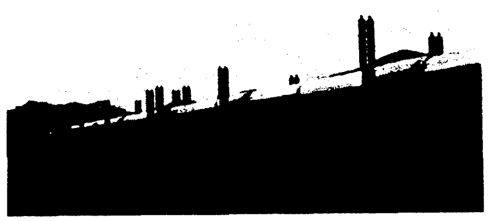


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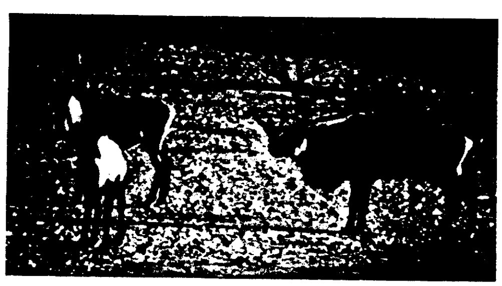


# A BRIEF REVIEW

## THE NEED FOR OIL

Is Canada and the North ready for Beaufort Sea-Mackenzie Delta Oil Production? Many of the issues arising from the prospect of moving from the exploration stage to the production stage of oil field development revolve around this question. After serious consideration of all the factors the answer can only be yes. Beaufort region oil is needed now in Canada. The technology to safely operate in the region exists. The benefits to Canada could not come at a better time, and no insurmountable or unmanageable environmental, social, or cultural problems appear to exist.

There is a risk in not undertaking Beaufort Sea-Mackenzie Delta oil production. This is the risk of losing the opportunity. Canada is not now energy-self-sufficient but is one of the very few countries in the world that could be. Today, Canada imports 80,000 cubic metres of oil per day and the National Energy Board (NEB) forecasts that this shortfall may increase to 280,000 cubic metres of oil per day by the year 2000.

Oil exists in the Beaufort Sea-Mackenzie Delta region. The oil industry has spent more than one billion dollars to date to find this oil and to determine whether it exists in commercial quantities. What is not known is how large the quantities of oil are. Industry estimates range from 0.9 to 5.1 billion cubic metres (6 to 32 billion barrels) of recoverable oil from the Beaufort region. This is comparable to proven reserves in North Sea oil fields.

The opportunity for Canada to achieve oil self-sufficiency requires that Beaufort oil field development begin now concurrently with the development of other frontier oil and oil sands reserves.

## THE TECHNOLOGY

Most of the equipment and systems used, and to be used in the Beaufort, are conventional and already have a history of safe world-wide operation. The production facilities to be used in the Beaufort region are not unique and have been used for over ten years in Cook Inlet and at Prudhoe Bay, only 500 kilometres (300 miles) to the west.

The oil industry has a respectable history of operating safely and efficiently in the Arctic. Indeed, the cost of operating in this remote area with short seasons and a cold climate is an added incentive to ensure that all operations work and work well, and that personnel are and will continue to be well trained.

Artificial islands, adapted to the Beaufort Sea, have been developed to the point where they can safely be used as production platforms. Twenty exploration islands have now been built and the designs required for producing oil are extensions of existing knowledge.

Artificial island platforms will continue to be built in the Beaufort Sea. Some of these will be used as platforms to supplement drillships during exploration drilling. Others will be built as production islands on proven oil reservoirs through which clusters of production wells will be drilled. Islands will be constructed by dredging sand from the ocean floor. Subsea pipelines will be layed to collect and transport oil from individual islands to central terminals.

To deliver produced oil to southern markets, Arctic tankers, an overland pipeline, or a combination of both could be used. Arctic tankers may take on oil from specially designed storage and loading terminals. By world standards, these vessels will be modest in size — 390 metres long, with a cargo capacity of 200,000 tonnes (1.5 million barrels) of oil — but unique in their ability to traverse through the ice fields of the Northwest Passage. By the year 2000, as many as 16 could make the 30 day round trip to eastern Canada.

Alternatively, it is just as feasible that one or more pipelines could be built from the Mackenzie Delta to Edmonton, Alberta, a distance of 2,200 km, to deliver oil into existing distribution pipelines.

## CONCERNS

As with any major development there are environmental and socio-economic concerns. However, to do nothing would be to forego regional and national socio-economic benefits. Components to be used in the proposed development are environmentally acceptable elsewhere in Canada. Nevertheless, overall systems will incorporate into their design and operation means to mitigate specific environmental and socio-economic impacts in the region.

Employment, training and business opportunties for northerners will ensure that they have a future in the development. Important animal habitats will be avoided whenever possible. The unique Arctic heritage can and will be protected. The rate of development would be such that possible adverse environmental and socio-economic effects will be identified and changes made as development proceeds, such as altering routes, sites, operations and incorporating different mitigative measures.

## THE PACE OF DEVELOPMENT

Oil development in Canada, and elsewhere in the world, involves ongoing exploration drilling to confirm the presence of hydrocarbons in prospective reservoirs. After confirming the existence of a reservoir, delineation drilling determines the reservoir size. To bring the oil to market requires the drilling of production wells to produce the oil, the installation of production equipment to make it suitable for transport, and a transportation system to get it to market. The past 15 years have been spent confirming the presence of Beaufort Sea-Mackenzie Delta oil. The next steps — producing it and transporting it to market — can now be taken.

Early production, or "first oil", may be achieved from the Beaufort region as early as 1986. To accomplish this, a production and transportation system would have to be set in place over the next four years. Over the long term there will be a need to continue exploring, confirming and developing other commercial reservoirs in order to fulfill the projected Canadian demand.

The build-up of development activity can be gradual, with careful consideration for the physical, biological, and human environment. The related issues and concerns have now and will continue to be addressed as this development unfolds. By managing the pace of development and monitoring its impact, development can be environmentally and socially acceptable.

Canada and the north require Beaufort Sea-Mackenzie Delta oil now. A goal of energy self-sufficiency by 1990 is possible, but only if steps leading to development of Canadian oil fields, including those in the Beaufort Sea, begin in 1983.

There would be benefits to Canada as a whole for all sectors of the its economy. By the year 2000, total development expenditures could reach 100 billion dollars. Jobs, income and significant growth could occur in all regions of the country including the north. These expenditures would be spread over the next 20 or more years, thereby adding a measure of economic stability.

While this Environmental Impact Statement is essentially dedicated to oil development, substantial reserves of gas already exist in the Mackenzie Delta area. The need, timing and markets for gas are more uncertain than the need for oil. We expect the earliest timing for gas development and transmission to market will be in the early to mid 1990's. There are a number of gas transmission alternatives. These include the Foothills Dempster line, the Polar Gas Y-line and a possible Mackenzie Valley line. Foothills submitted an EIS for the Dempster line in June of 1979 to fulfill an agreement with the Federal Government. Polar Gas have been preparing an application on the Y-line for submission to the National Energy Board. These alternatives are reviewed briefly in the EIS as other projects that could impact Beaufort development in the interval between 1990 and the year 2000.

## MAJOR ISSUES

The prospect of hydrocarbon development in the Beaufort Sea-Mackenzie Delta region stimulates discussion on important issues. These range from such development issues as the need for Beaufort oil and the adequacy of existing technology, to environmental and socio-economic issues. The following development, environmental and socio-economic issues are those which have been identified through the guideline hearings, community meetings and associated processes as being the "higher profile" issues. Responses to the concerns stemming from these issues are briefly stated. Details on the responses to these and other issues and concerns are covered in Volumes 2, 4, 5, and 6, while proposed research or monitoring programs to address unknowns or concerns are reviewed in Volume 7.

# DEVELOPMENT ISSUES

**ISSUE**

**NEED FOR BEAUFORT OIL NOW**

**CONCERNS**

- Canadian need for oil
- Best development location
- Canadian benefits
- Regional benefits

**RESPONSES**

- Canadian shortfall of oil supply of 86,000 cubic metres per day is forecast for 1990.
- All Canadian sources will need to be developed including the Beaufort, east coast offshore and oil sands to offset shortfalls forecast to the year 2000.
- Beaufort oil will reduce dependence on imports and will benefit the Canadian economy. There could be from 65 to 100 billion dollars of new investment, of which 75 to 90% would be spent in Canada. There are opportunities to develop Canadian expertise and technology. The Canada-wide economic multiplier effect will increase employment opportunities and benefits.
- In the north, there would be economic expansion, less dependence on southern Canada, more employment and enhanced business opportunities.

**ISSUE**

**WORKABLE PRODUCTION SYSTEMS**

**CONCERNS**

- Special problems in the Arctic
- Adequacy of design
- Risks of failure

**RESPONSES**

- The Beaufort environment is harsh but industry has operated successfully for 10 years offshore and considerably longer onshore. Although the components of production systems are well-proved, there are special conditions of operation and installation in the Beaufort Sea which are recognized and require adaptation.
- Design criteria focus on requirements to handle cold weather, ice, offshore and onshore permafrost, seismicity, waves and bottom scouring by ice. Improvements have resulted from experience with 20 artificial islands, approximately 100 onshore wells, about 35 offshore wells, and the operation of various ice-class vessels, including the icebreaker KIGORIAK.
- Possible failures will be minimized by using well-proven production systems, adapted by industry based on the 10 years of experience in the Beaufort region.

**ISSUE**

**THE SCALE OF PROPOSED DEVELOPMENT**

**CONCERNS**

- The initial development may be unnecessarily large
- The pace of development may be too rapid

**RESPONSES**

- There is a minimum size of proven oil reserve below which it would be uneconomical to produce, depending on initial production and transportation system costs. The major components required for Beaufort development are identical to those used in world-wide oil field developments. All require production platforms, support systems and an oil transportation system.
- Development will occur over a number of years and the pace will depend on further oil discoveries, energy needs, technical feasibility, economics, and environmental and social concerns.

**ISSUE**

**OIL TRANSPORTATION OPTIONS:**

- Arctic tankers, or
- Overland pipelines, or
- Both Arctic tankers and overland pipelines.

**CONCERNS**

- Environmental considerations
- Viability of systems
- Regional benefits

**RESPONSES**

- Each system has its own types of possible environmental impacts. Direct comparisons are not valid. Effects related to pipeline systems across Arctic lands are becoming well known but those associated with icebreaking tankers are less familiar. Use of either an overland pipeline and/or tankers is considered environmentally compatible by the industry.
- The preference for one system over another, apart from environmental and social factors, will depend on overall costs, proved oil reserves, logistics, system flexibility and expandability. Eventually, perhaps both Arctic tankers and pipelines may be used. Other transportation options, such as the use of submarine tankers, are not presently considered viable.
- Overall, regional benefits would not differ significantly in the provinces with the use of tanker or pipeline only options. In the north, greater business and employment opportunities will be generated in the Mackenzie Valley for the oil pipeline option.

# ENVIRONMENTAL ISSUES

ISSUE

**MAJOR OIL SPILLS, from:**
- Oilwell blowouts,
- Tanker accidents,
- Ruptured pipelines, and
- Ruptured oil storage tanks.

CONCERNS

- Adequacy of prevention
- Adequacy of cleanup capability
- Impacts on wildlife

RESPONSES

- All development systems and operational procedures are designed to minimize spill possibilities and accident risks. Studies have been done on tanker accident causes and on accident causes in offshore operations. Recommendations from these studies will be incorporated into development systems.
- Adequacy of cleanup capability depends on spill size, season, location, available equipment and what is at risk. Extensive studies have been conducted to determine how these factors may affect clean-up capability in the Beaufort Sea. About $35 million has been invested to date in Arctic spill research and countermeasure development. Research is continuing through the Canadian Offshore Oil Spill Research Association (COOSRA), government and other means.
- Most serious regional impacts would be on marine and marine associated birds. However, knowledge of where and when they are vulnerable, and the use of appropriate countermeasures have the potential to reduce possible impacts.

ISSUE

**MARINE STRUCTURES, such as:**
- Artificial islands and
- Coastal bases

CONCERNS

- Extension of landfast ice
- Effluent discharges
- Attraction of wildlife
- Effects on whales
- Coastal fisheries effects

RESPONSES

- Possible extensions to the landfast ice boundary caused by presence of artificial islands are being monitored. The research shows that such extensions fall well within natural year-to-year variations in the ice-edge boundary. Effects of islands on break-up of the shorefast ice are expected to be localized and short-term in nature, and monitoring will continue.
- All effluent will be treated to acceptable standards.
- Attraction of polar bears and foxes will be minimized by incineration of garbage and other mitigative measures.
- Whale monitoring programs will be continued to ensure that operations' effects on whales will be minimized.
- Design of shorebase docks and causeways will account for coastal fish migrations, and important fisheries habitats will be protected.

ISSUE

**STRUCTURES ON LAND, such as:**
- Overland pipelines,
- Support bases, and
- Roads

CONCERNS

- Terrain disturbance
- Fish habitat disturbance
- Mammal habitat disturbance
- Bird habitat disturbance

RESPONSES

- Arctic construction techniques, designed to preserve permafrost, and prevent hydraulic erosion and slumping, will produce minimal terrain disturbance. These involve winter construction, the use of insulating pads and pilings, careful grading and revegetation. Such techniques have been time-tested.
- Sedimentation of streams and waterbodies will be minimized during construction. Stream flows and access to waterbodies will be maintained to protect fish habitat.
- All permanent facilities on land will be sited, where possible, to avoid important mammal habitat. Also, pipelines and roads will be designed to be crossed by migratory species such as caribou. Vehicle use of permanent roads can be controlled to avoid disturbance to migrating mammals.
- Facilities will be sited, where possible, to avoid disturbance to endangered and rare raptor species.

ISSUE

**DREDGING, required for:**
- Artificial island construction,
- Developing and maintaining harbours, and
- Excavating pipeline trenches and shipping channels.

CONCERNS

- Effects on fish
- Removal and burial of sea-bottom life
- Creation of turbid waters and oxygen demand
- Disturbance to migratory whales

RESPONSES

- Monitoring of current dredging has shown that few fish are captured by dredges and that they are usually bottom species. Dredging occurs in productive river deltas worldwide. Provided critical fish habitat is not removed, effects on the fisheries have been minimal. The same would be expected in the Beaufort Sea where most dredging will be conducted well offshore.
- The fraction of the seabottom which would be disturbed is very small compared to available habitat, and rapid re-colonization is expected. The seabed, particularly for water depths less than 40 metres, is naturally scoured by moving ice.
- The suspended sediment lost from dredging operations is insignificant compared with the sediments distributed naturally by the turbid plume of the Mackenzie River. Increased oxygen demand may only be of consequence in confined areas with little circulation. Where measurements have been made in the Beaufort Sea, such demands have been insignificant.
- Migrating whales have so far exhibited little sensitivity to offshore marine activity. Nevertheless, monitoring will continue.

ISSUE

**ICEBREAKING, due to:**
- Icebreaking tankers,
- Icebreaking of corridors to harbours, and
- Icebreaking around platforms.

CONCERNS

- Alteration of ice patterns
- Prevention of travel on ice in winter and spring
- Killing of seal pups
- Trapping of whales in artificial leads

RESPONSES

- Minor alteration of ice patterns may occur in the Northwest Passage and in the Beaufort Sea in the spring and fall but, in general, such alterations should not exceed those associated with the natural seasonal and year-to-year variations in the sea ice.
- Ongoing experiments using the icebreaker KIGORIAK show that icebreaking in 10/10th ice creates rubble filled tracks which can be crossed by komatiks and snowmobiles within a few hours. Experiments are continuing.
- Some seal pups will be killed, constituting a small proportion of the regional population. Actual effects will be carefully monitored and measures will be employed to reduce impacts.
- Whales are unlikely to be trapped in icebreakers' tracks because the tracks will fill with rubble and are unlike natural leads in the ice.

ISSUE

**NOISE, from:**
- Aircraft,
- Marine traffic,
- Dredges,
- Artificial islands, and
- Structures on land.

CONCERNS

- Aircraft noise disturbance to wildlife
- Underwater noise disturbance to marine mammals

RESPONSES

- Effects of aircraft noise will be minimized by altitude and route restrictions based on knowledge of wildlife habitats and their seasonal sensitivities.
- Underwater noise will be generated in the Beaufort Sea by exploration and production development activities and along Arctic tanker routes. Possible adverse effects on mammals depend on their seasonal locations and migratory habits, their hearing sensitivities, their communication needs and sensitivities to noise disturbance, and other factors including; natural noise levels, how noise travels in water, and how loud the industrial noise would be. Assessments of possible effects have taken into account these variables. However, ongoing monitoring programs will continue to determine actual effects. No serious effects have been identified to date and none are anticipated.

ISSUE

**WASTES, such as:**
- Solid wastes,
- Gaseous emissions, and
- Liquid effluents.

CONCERNS

- Proliferation of solid wastes
- Effects of air emissions
- Effects of the discharge of drill muds, sewage, and produced water

RESPONSES

- Combustible solid wastes will be incinerated; incombustibles will be recycled or disposed of in approved landfill sites.
- Air emissions will conform to government standards and will occur at widely dispersed locations. In winter local ice fog will sometimes be produced. Kitchen odours may attract foxes and bears. However, the careful handling of garbage and the employment of safety measures such as bear monitoring will minimize interactions and the need to destroy problem animals.
- Liquid effluents will consist mainly of drill muds, produced water (produced with oil from wells) and sewage. All liquids will be treated to government specified standards before disposal.
- Offshore, treated sewage will be discharged to the sea; on land the sewage will be discharged into sewage lagoons or excavated sumps, or in some cases treated sewage will be discharged to rivers, depending on camp size.
- Offshore, treated produced water may be discharged to the sea, particularly during early production. On land, and later offshore, produced water may be re-injected into subterranean strata.
- On land, waste drill muds will generally be collected in excavated sumps while offshore they will be disposed of into the sea. Government specifications determine toxicity limits; expected impacts are negligible.

# SOCIO-ECONOMIC ISSUES

## ISSUE

**EMPLOYMENT OF REGIONAL RESIDENTS:**
- In drilling, construction, and production operations
- In indirect and induced labour requirements,
- In the community,
- In the business sector, and
- In the government sector.

## CONCERNS

- Low education and skill levels
- Northerners limited to unskilled and semi-skilled jobs
- Awareness of job openings
- Migration to growth centres
- Interference with traditional harvesting
- Seasonality of construction employment
- Short duration of major projects
- Effect of cash earnings on family and community life

## RESPONSES

- There will be encouragement of job progression by on-the-job and institutional training.
- First consideration will be given to northerners for training and employment.
- Employment opportunities will be communicated throughout the territories insofar as possible.
- Employees will be transported from their home communities. Local development will be encouraged to forestall migration.
- Rotational schedules will be made to permit continued renewable resource harvesting.
- Beaufort employment will become increasingly year-round. Beaufort development will offer long term employment prospects.
- There will be counselling services for employees.

## ISSUE

**DEVELOPMENT OF THE BUSINESS SECTOR; required to accommodate:**
- Drilling, construction, production supply and service needs,
- Community population growth,
- Rising levels of income,
- Rising expectations, and
- Changing lifestyles.

## CONCERNS

- Limited and undiversified local business sectors
- Limited availability of capital
- Increasing competition from non-resident firms
- Lack of business support services
- Insufficient managerial expertise

## RESPONSES

- Continuation of policy of first consideration to competive regional suppliers.
- Encouragement of joint ventures with non-resident firms to raise expertise and make venture capital available.
- Encouragement to firms offering new services to locate in the region.
- Encouragement to develop managerial and business expertise and talent via training programs.
- Encouragement to business support services, including government services, to locate in the region.

## ISSUE

**NATIVE TRADITIONAL HARVESTING, could be disrupted by:**
- Construction of shorebases, pipelines, roads, etc.,
- Population and community growth induced by development,
- Hunting and fishing by non-native people,
- Changes in behavior of economically important animals,
- Native wage employment, and
- Increased vessel and vehicle movements.

## CONCERNS

- Decline in traditional resource base
- Competition by non-native harvesters
- Increased access to harvesting areas
- Interference by recreational land-users
- Declining nutritional standards in native communities
- Decline of native culture
- Overharvesting of lands near some communities

## RESPONSES

- There will be consultation with interest groups on location of facilities. Wildlife disturbance and mitigation studies will be supported. There will be continued monitoring of economically important fauna such as whales and caribou.
- Hunting and fishing by industry on-site personnel will be controlled.
- Encouragement of government to regulate harvesting activities of an expanding regional population (native and non-native).
- Encouragement of government to control recreational land-use.
- Encouragement of local commercial renewable resource industries.
- Rotational work schedules will enable native people to carry out traditional resource harvesting.
- Encouragement of land-use planning.

**ISSUE**

**SOCIAL AND CULTURAL CHANGE, could result from:**

- Community growth,
- Growth of non-native population,
- Rising income and changing expectations,
- Increasing wage employment,
- Changes in the animal resource base, and
- Changes in harvesting patterns.

**CONCERNS**

- Erosion of native values and culture
- Decline in viability of small communities
- Increase in social problems
- Increase in welfare dependence
- Decline in nutritional standards

**RESPONSES**

- Industry encouragement of government and the native peoples to resolve political status of native people at an early date.
- Encouraging government to make funds available to native economic organizations to develop native business establishments, skills and expertise. Encouragement of local renewable resource based industries to expand the employment base of small communities.
- Involvement of regional residents in industrial and community planning.
- Rotational employment out of home communities to enable native employees to continue to harvest the land.

**ISSUE**

**COMMUNITY GROWTH, due to:**

- Drilling, construction, production personnel requirements,
- Indirect and induced labour demand,
- Growth of the business sector,
- Growth of the government sector,
- Transients

**CONCERNS**

- Need for housing, education and health facilities, social services, recreation, infrastructures, etc.
- Shortages, local inflation, social problems.
- Strain on municipal and territorial revenues and resources.
- Competition and interference with native traditional harvesting.

**RESPONSES**

- Municipal planning has occurred and will continue with industry participation. Encouragement of government to establish facilities such as crisis centres, impact information centres, and transient facilities.
- Advanced industry and government planning will ensure the necessary transportation and supply of goods and services.
- Encouragement of government to provide funds to meet local growth. North-south rotation of the majority of the work force will moderate community growth.
- Encouragement of government to continue initiatives in land-use planning. Enforcement of hunting, fishing and trapping regulations by industry personnel on duty. Encouragement of government to control the harvesting and recreational activities of a growing regional population.

# CHAPTER 1

# ENERGY NEED, DEVELOPMENT PLAN, AND CANADIAN BENEFITS

It is forecast that Canada will have to continue to import crude oil unless new sources of supply such as frontier oil are developed. This chapter begins by assessing Canadian oil supply shortfall to the year 2000 against a backdrop of potential oil reserves in the Beaufort region. A development plan to produce and deliver Beaufort oil and gas to market is then described, followed by a brief summary of the benefits to Canada of such development proceeding.

## 1.1 CRUDE OIL SUPPLY AND DEMAND

The question of whether or not Canada needs frontier oil can be answered only by looking at the forecast supply and demand for crude oil. Canada's future energy supply and demand outlook was examined in a 1981 National Energy Board (NEB) report and in a 1981 Canadian Energy Research Institute (CERI) study. The NEB report forecasts Canadian energy supply and demand for the period 1980 to 2000, while the CERI study examines Canada's outlook for crude oil supply and demand, and addresses the major issues inherent in various oil supply and demand scenarios.

Focusing on the NEB study, the energy demand forecasts were based on a population growth averaging 1% per annum, economic growth averaging 3.2% per annum and certain energy price assumptions for the next twenty years. Based on these assumptions, the total Canadian demand for energy from all sources was forecast to be equivalent to 1.2 million cubic metres of oil per day in the year 2000, compared to 730 thousand cubic metres per day in 1980. The NEB forecast also indicates that less of the energy demand in the year 2000 would be made up by crude oil, only 26% compared with 39% in 1980. The NEB used several supply and demand case studies to handle the uncertainties in forecasting oil supply and demand and summarized these case studies in the crude oil demand forecasts shown in Figure 1-1.

On the supply side, the NEB high supply forecast (Figure 1-2 case 1) includes optimistic amounts from oil sands, more oil recovered from existing wells and oil from new wells in frontier regions. This high forecast predicts that 380 thousand cubic metres per day of oil would be domestically produced in the year 2000. This case seems highly optimistic since the forecast projects oil supplies from oil sands plants equivalent to the production from six new plants, requiring an investment of 90 to 120 billion dollars. Such an investment is unlikely in the proposed time frame.

The more realistic middle demand and base supply forecasts in Figures 1-1 and 1-2, indicate a shortfall of 86 thousand cubic metres of oil supply per day by 1990, which increases to 177 thousand cubic metres per day by the year 2000. This shortfall may be met by east coast production, tar sands development and Beaufort Sea-Mackenzie Delta production, or by further imports (Figure 1-3).

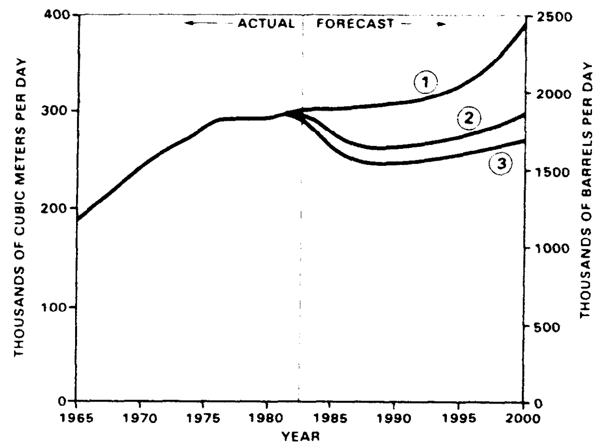



**FIGURE 1-1** *The National Energy Board (1981) has made three projections of demand for crude oil in Canada up to the year 2000: high demand (1), middle demand (2), and low demand (3). The middle demand shows a small annual decrease to 1990 followed by a gradual increase to the year 2000. Demand is difficult to forecast as evidenced by the wide range between the high and low curves.*

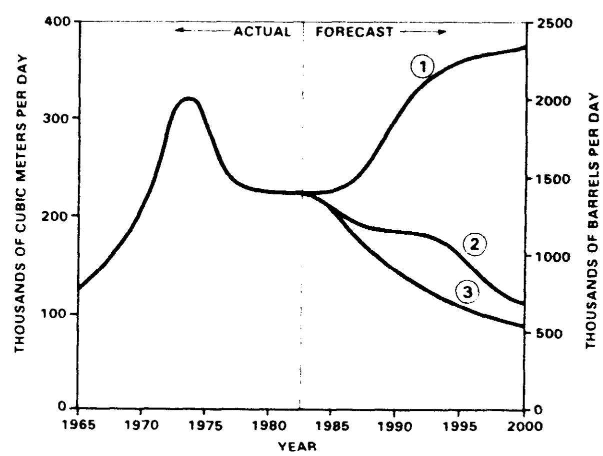



**FIGURE 1-2** *A range of crude oil supply forecasts has been provided by the National Energy Board (1981): high supply (1), base supply (2) and low supply (3). Both the low and base supplies show a significant decline from 1981 reserves while the high supply, based on optimistic projections, shows a significant increase. The high forecast assumes contributions to supply by oil sands and frontier discoveries.*

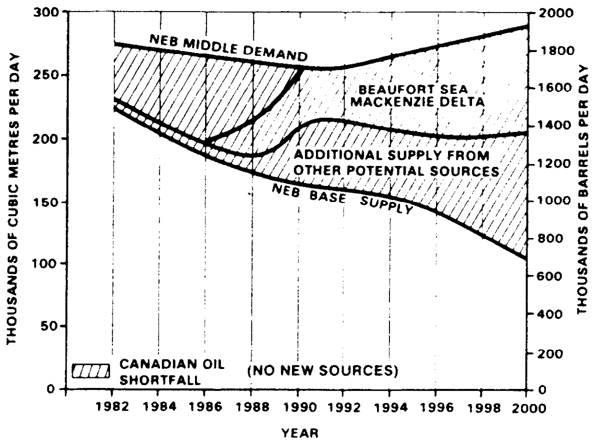



**FIGURE 1-3** *Using the middle demand and base supply forecasts of the National Energy Board (1981), it is projected that there will be a supply shortfall of 86,000 cubic metres of crude oil per day in 1990. This will increase to 177,000 cubic metres per day by 2000. The crude oil supply shortfall could be reduced by development of other potential supplies such as oil sands, and east coast offshore and Beaufort Sea-Mackenzie Delta reserves.*

Which Canadian sources will be developed and in what order will depend on the outcome of the search for oil, the cost of producing commercial discoveries and government policies. However, as indicated in Figure 1-3, it is likely that all available new sources of oil will need to be developed.

Conclusions from the Canadian Energy Research Institute (CERI) study are similar to those in the NEB report. Therefore, the need for Beaufort oil clearly exists but long lead times are required to bring the oil into production. Government and industry estimates of the potential oil reserves in the Beaufort Sea region range from 0.9 to 5.1 billion cubic metres. This resource potential indicates the significance of this region in contributing to oil self-sufficiency.

## 1.2 THE DEVELOPMENT OBJECTIVE

The objective of producing oil from the Beaufort Sea region (Figure 1-4) is consistent with the national

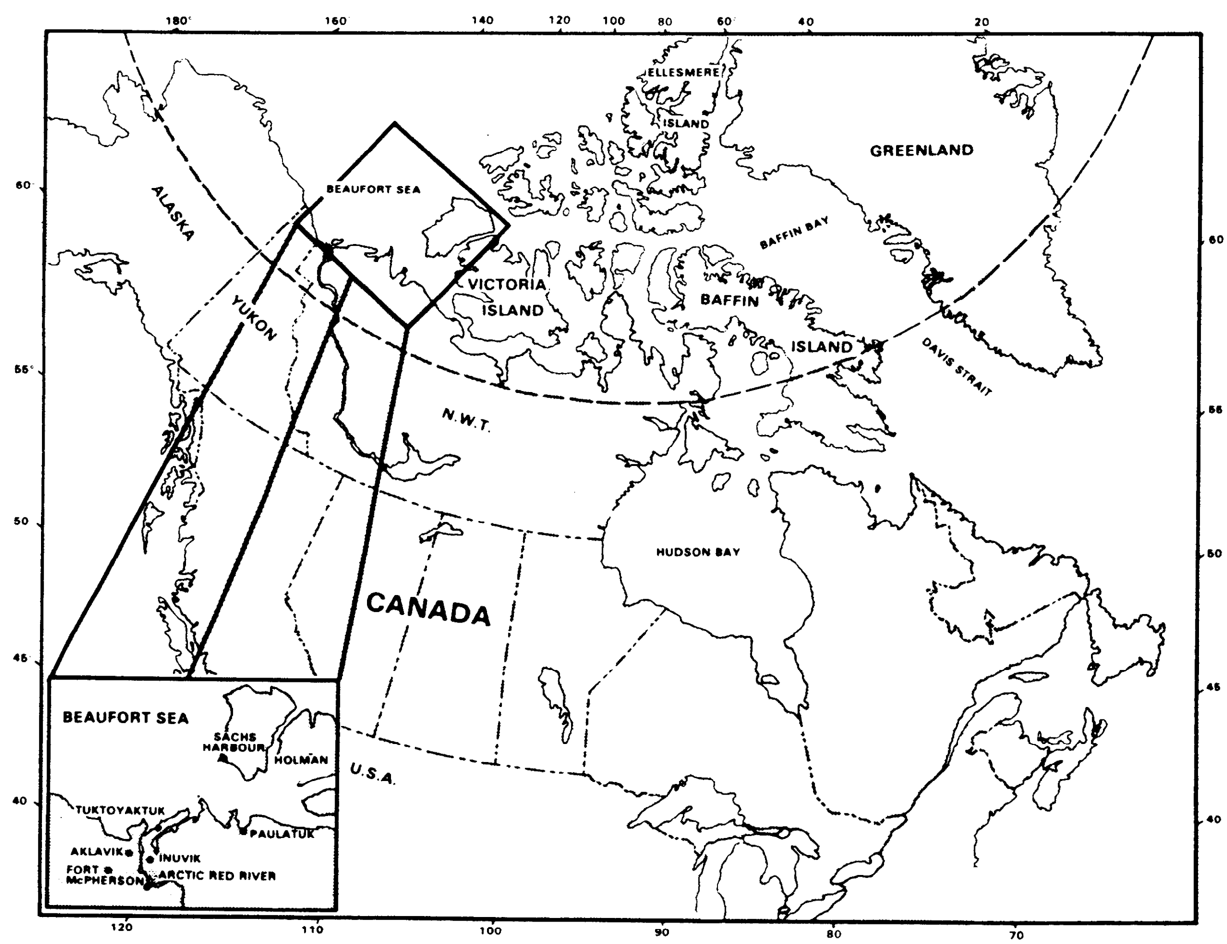



**FIGURE 1-4** *It is proposed to develop the oil and gas reserves of the Mackenzie River Delta and southeastern Beaufort Sea in the western Canadian Arctic. The area is about 500 km east of the giant Prudhoe Bay field which has been producing for several years. Because of its proximity to the North Pole the area is approximately equal distance from Japan, northern Europe and the east and west coasts of North America.*

interests. These goals include attaining oil self-sufficiency by 1990, creating new employment opportunities and encouraging regional development. The first (pre-production) phase of oil field development involves a long lead time during which time transportation and production facilities are constructed to put the initial commercial discoveries on production.

Assuming that the first oil reservoir of commercial size is confirmed by 1983, oil might be produced from the Beaufort as early as 1986. The industry is confident that its operational experience in the Beaufort region during the past ten years has provided it with both the knowledge and technology to make Arctic oil production feasible.

It is expected that most of the oil produced in the Beaufort region will come from offshore reservoirs located under the continental shelf of the Beaufort Sea. Shelf waters are relatively shallow, thus artificial islands can be used as permanent production platforms. The number of production platforms required to drain a reservoir efficiently will depend on the geometry, depth and area of each reservoir.

Figure 1-5 illustrates how the production rate increases in a step-wise fashion as each well is drilled from an island platform and placed on production. The peak production rate from an island is reached after all its wells have been drilled. This rate is typically maintained for several years and then it begins to decline as the reserves are depleted. If the reservoir is larger than the area accessible from one island, one or more additional islands will be built. The total volume of oil produced from a reservoir at any time (the production profile) is the sum of the oil produced from several islands, as also shown in Figure 1-5. The shape of the production profile is determined by many factors including the reservoir characteristics, productivity of each well, and reservoir management considerations.

Because there are a large number of variables that have an impact on the rate of development (including technical, environmental, social, economic and regulatory factors), the most practical way to discuss Beaufort Sea-Mackenzie Delta production is to display a range of production rates as shown in Figure 1-6. The high rate of production shown is considered technically feasible based on current knowledge of

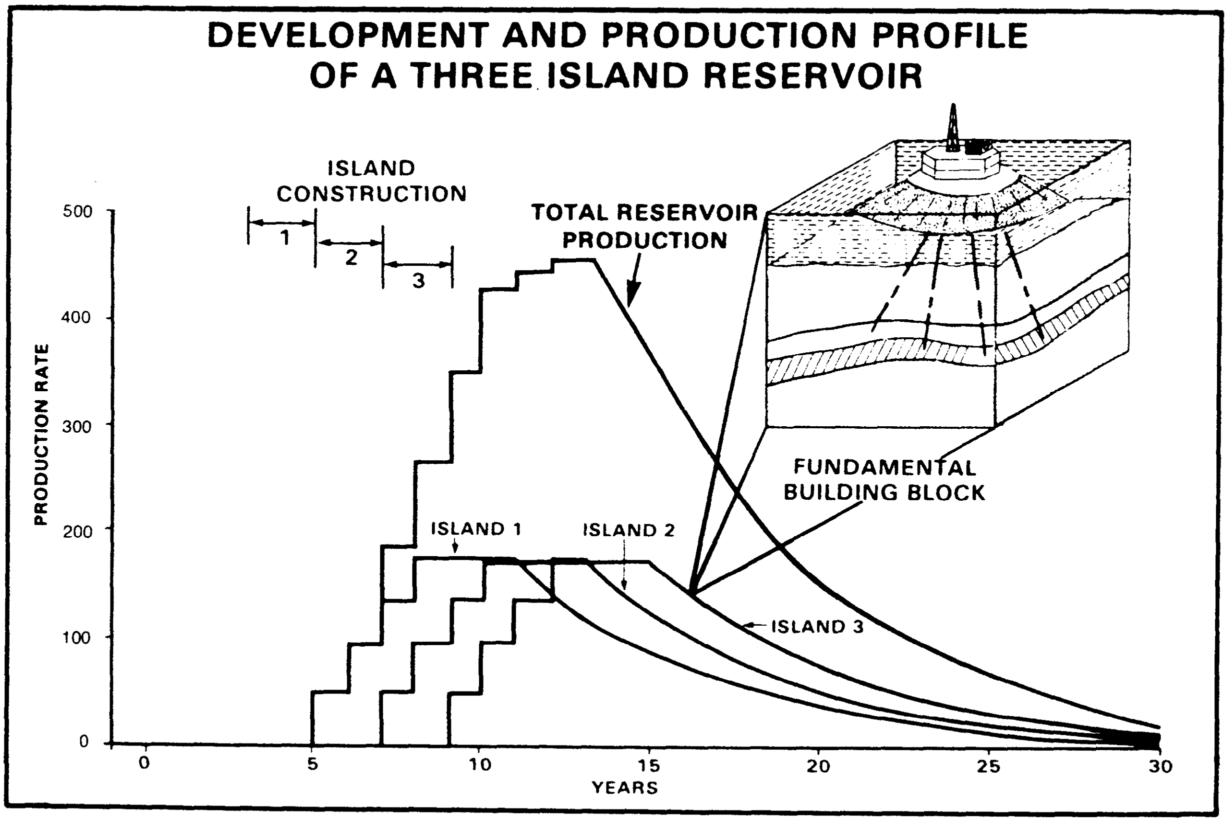



**FIGURE 1-5** *Offshore production will take place from artificial islands built with sand, capped with concrete or steel caissons. The number of islands will depend on the size and depth of the reservoir. Typically production increases in a step-wise fashion as wells are drilled and brought on production. The maximum production rate is determined principally by the production capacity of the individual wells. An island, along with the wells drilled from it, and the production facilities to process the oil may be regarded as a building block. Each building block is more or less an economic unit.*

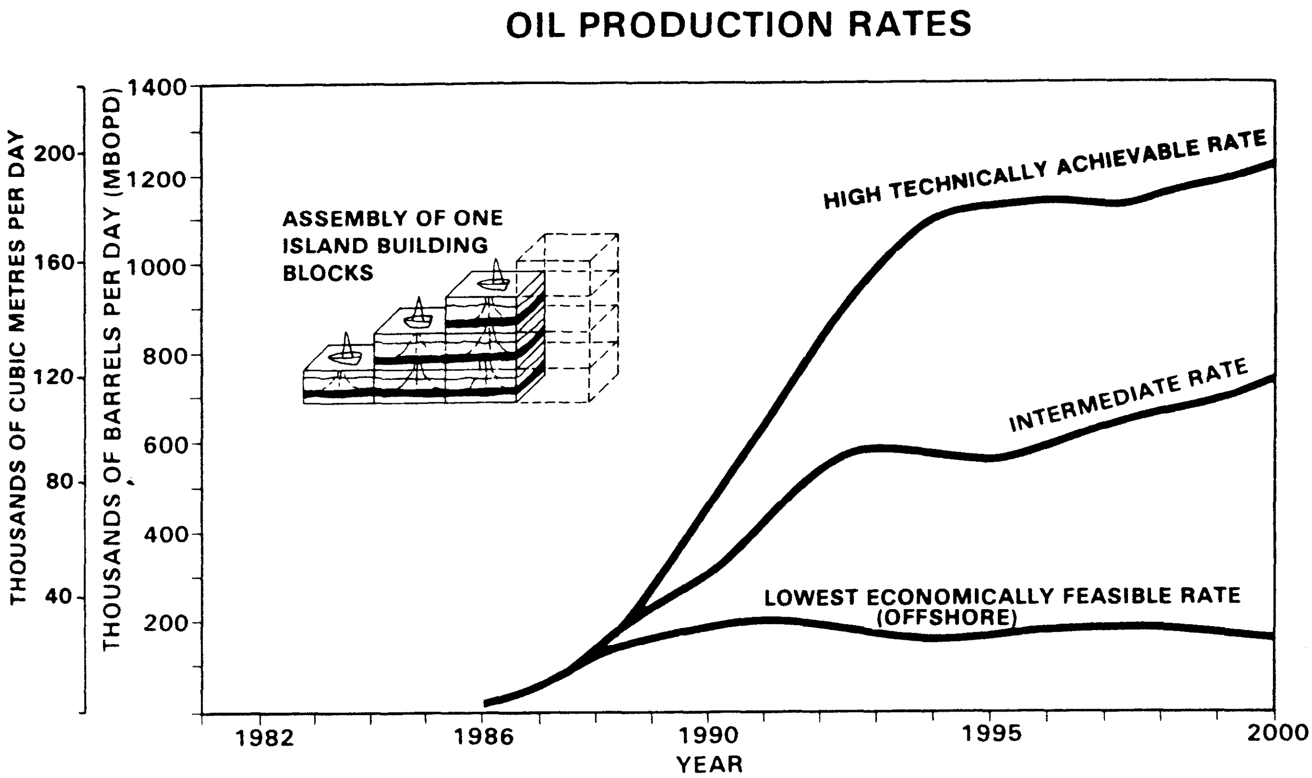



**FIGURE 1-6** *A range of production rates can be achieved in the Beaufort Sea-Mackenzie Delta area, depending mainly on the pace of development. The 'building blocks' described in Figure 1-5 may be stacked end to end, or spaced out to achieve a slower growth of production, or placed closer together or one on top of the other to achieve a higher rate. There is also a high rate which is determined by such things as the availability of resources required to develop the various fields. It can be demonstrated that the high rate is an environmentally acceptable scheme. The intermediate production rate for the Beaufort Sea-Mackenzie Delta area lies between the two. This curve illustrates the production rate in 1990 of approximately 300,000 barrels per day, increasing to about 700,000 barrels per day by the year 2000.*

the region. However, constraints such as logistics, government approvals, economics, the availability of markets and capital make it unlikely that this high rate of production will be achieved. The lowest production case presented is based on the discovery of smaller reservoirs or lower discovery rates. This low case may represent the lowest economically feasible production rate for offshore development.

A broad array of oil production or development profiles exists between the low case and the high case. A more likely rate of development is the intermediate production rate shown in Figure 1-6.

### 1.2.1 BEAUFORT PLANNING MODEL

A computer model has been used to determine the level of development activities that would be associated with a particular discovery rate and production profile. Development of this model was based on experience gained from other offshore areas such as the North Sea and the Gulf of Mexico.

The model allows planners to test various development assumptions. These can then be assessed with respect to their environmental and socio-economic impact. For the purpose of impact assessment, a development level associated with the intermediate production rate has generally been used. This production rate represents a compromise of industry opinions regarding the hydrocarbon potential of the Beaufort Sea-Mackenzie Delta region.

The actual planning process for development of the region is iterative and is based on discovery rates, technical and economic feasibility, government policies and social and environmental concerns. The development plan proposed in this document is the result of current information and projections calculated by the Beaufort Planning Model.

## 1.3 THE DEVELOPMENT PLAN

The proposed development plan consists of two main phases (Figure 1-7). The first phase requires confirmation of a commercial reservoir and the construction of production and transportation facilities. It is assumed that first production might be as early as 1986. The second phase provides for further discoveries and long term oil production.

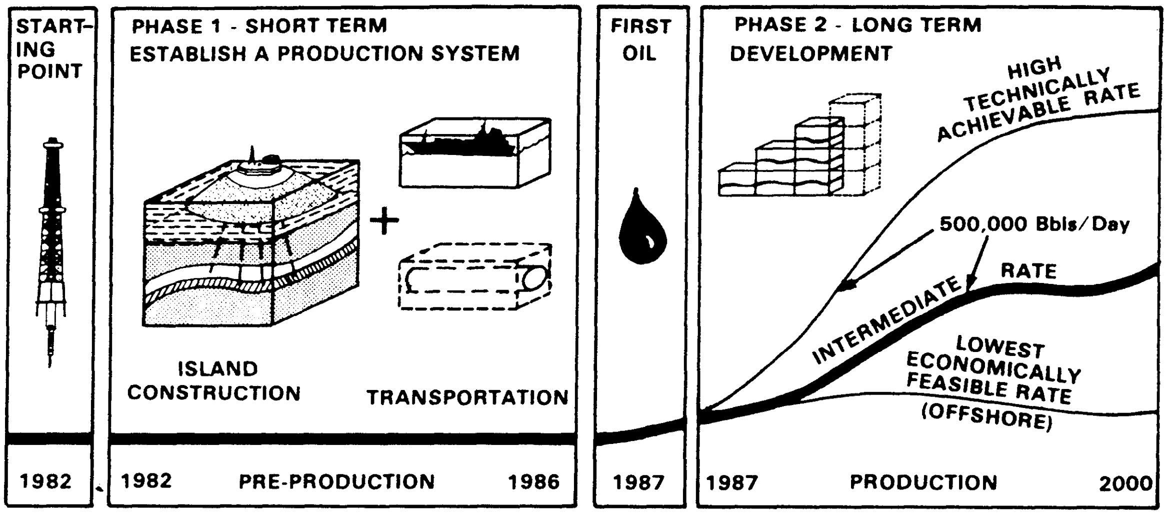



**FIGURE 1-7** *After a discovery has been made there are two main phases of activity. The first is development where the production facilities are built and installed and the transportation system is put in place. The second phase is production. It requires about four years to develop a typical offshore oil reservoir. The number of reservoirs being developed at any one time in a given area is the pace of development. Production might start from the Beaufort as early as 1986.*

### 1.3.1 PHASE 1 - ESTABLISH OIL PRODUCTION, 1982-1987

A number of activities are required to establish first production. These include:

- Exploration activities and drilling to identify and delineate oil reserves;

- Construction of development platforms, drilling of wells and assembly of oil production facilities;

- Installation of subsea pipelines and onshore gathering systems to connect production and transportation facilities;

- Development of a means of transporting oil to markets either by marine vessels, or through an overland pipeline, or some combination of both.

All these systems must be in place before oil can be recovered and transported to market.

**The Starting Point - 1982**

Delineation drilling to define the offshore discovery at Tarsiut (Figure 1-8) is underway in 1982. Whether or not this reservoir is commercial should be known next year. Onshore, further exploration or delineation drilling will occur in 1983.

Elsewhere in the region in 1982, three offshore exploration wells are scheduled to be completed that were suspended at the end of the 1981 drilling season. Up to six additional exploration wells could be started during the season if time and conditions permit.

Programs are being prepared to drill additional offshore exploration wells in 1983 and beyond. To drill these wells, two mobile Arctic caissons will join the Beaufort offshore fleet in 1982 and another in 1984. A floating conical drilling unit will be operational in 1983. These will be in addition to the existing conventional drillships and artificial islands. Some of the new drilling systems are illustrated in Figure 1-9.

In 1982, existing support bases will be expanded and marine equipment will be brought into the region to support future offshore drilling. Gulf is building a base on the existing Arctic Transportation Limited property at Tuktoyaktuk to accommodate up to 250 people. The existing marine base at McKinley Bay may have its mooring basin expanded by dredging. The dredged material from the basin would be used to build an ice protection island next to the existing artificial island. Plans for the existing island in McKinley Bay have yet to be finalized, but a landing strip for STOL aircraft is presently being built.

Table 1-1 summarizes the major industry activities planned and the support equipment required for 1982. The level of activity planned for 1982 is not appreciably greater than that of previous years, but will reflect the start of planning and preliminary design to progress from the exploration phase to the production phase.

### 1.3.2 DEVELOPMENT PLAN - 1982 to 1987

The forecast development schedule for 1982 to 1987 is shown in Figure 1-10. The following is a description of the activities, which, based on current knowledge, the industry feels could occur.

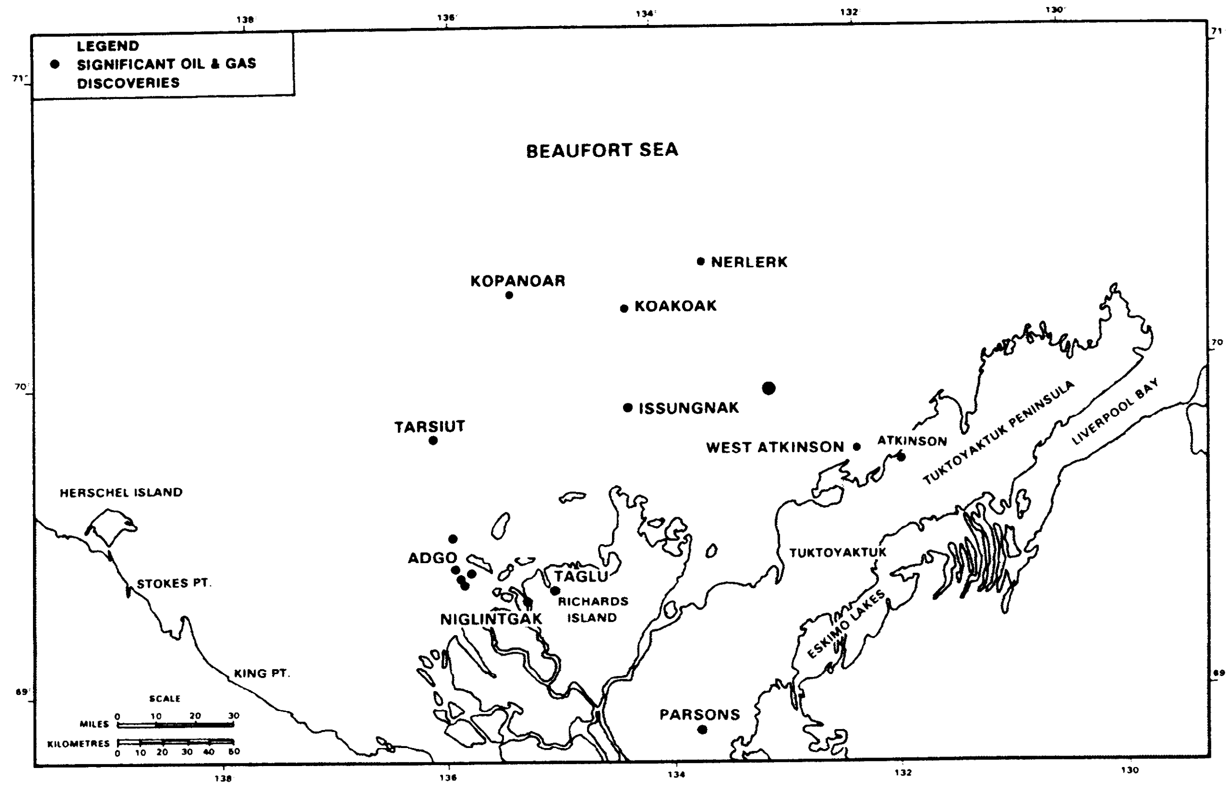



**FIGURE 1-8** *Several significant oil and gas discoveries have been made in the Mackenzie Delta and offshore in the Beaufort Sea. The commercial viability of the offshore oil discoveries is presently being evaluated.*

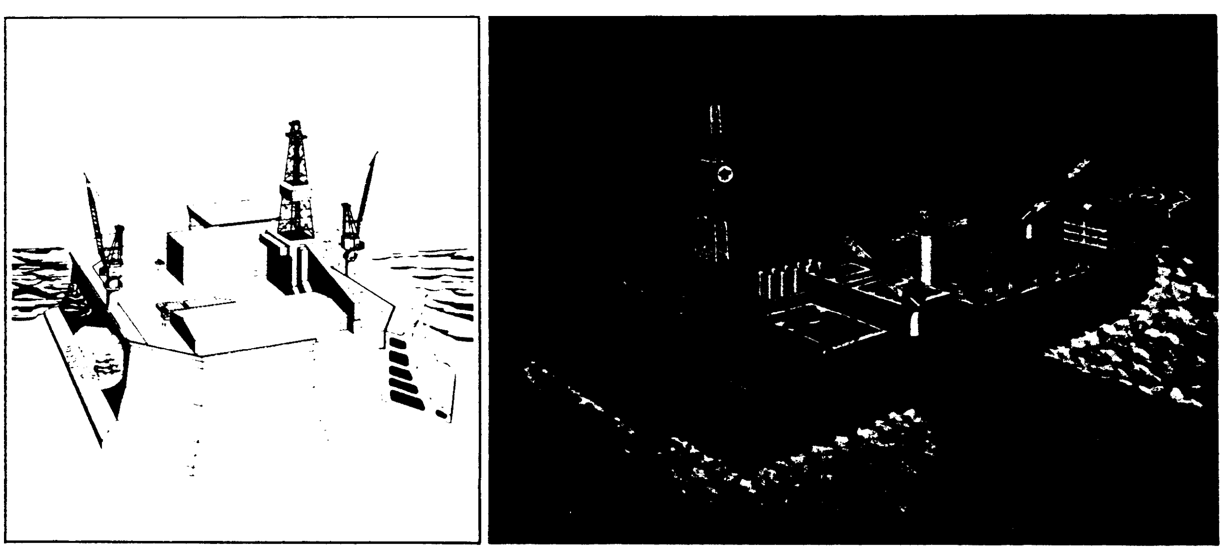


**FIGURE 1-9** *Drillships and artificial islands have been used as foundations for exploration drilling rigs in the Beaufort for the past several years. Variations of these concepts include artificial islands, which are capped with different types of caissons, and conical drilling systems, which have the capability to drill in more ice than a conventional drillship. Exploration drilling systems are temporary in nature, generally drilling only one well and then moving to a different location.*

**TABLE 1-1**
**PLANNED ACTIVITIES AND EQUIPMENT FOR 1982**

| Component | Existing (approx.) | Estimated New in 1982 | Estimated Total to the End of 1982 |
|---|---|---|---|
| Wells Drilled | 133 | 9 | 142 |
| Islands Constructed | 20 | 2 | 22 |
| Personnel on site | 1,170 | 260 | 1,430 |
| Marine Vessels | 29 | 7 | 36 |
| Aircraft | 11 | 4 | 15 |
| Supplies Required (Tonnes/Annum) | 149,000 | 200,000 | |
| Support Bases | 2 | 1 | 3 |

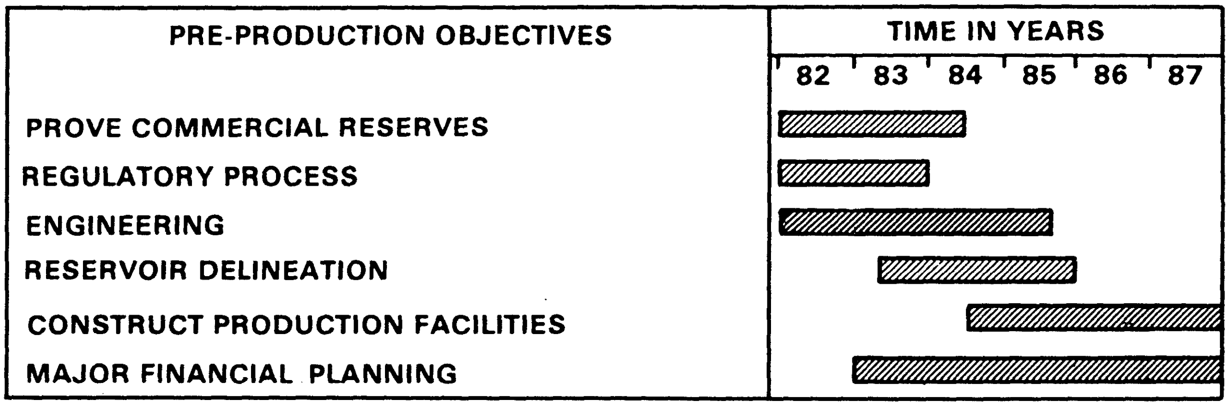



**FIGURE 1-10** *The development schedule indicates that the major financial commitments must be made in early 1983 in order to achieve production by 1986.*

### 1.3.2.1 Offshore

The exploration and drilling program is expected to concentrate on delineating reservoirs such as those at Tarsiut and Issungnak (shown in Figure 1-8). These reservoirs are located in relatively shallow water areas - less than 25 metres - at depths of about 1,500 metres below the sea floor. Exploratory and delineation drilling will continue at other locations, including Kopanoar and Koakoak, to further assess the potential of these reservoirs.

Assuming commercial reserves are confirmed, detailed engineering for at least one oil production system will begin. Early efforts will concentrate on the design of production structures and facilities and a transportation system. When all of this work has been finalized, a complete production system, as shown in Figure 1-11, will then be in place.

Earth-filled artificial islands are the main drilling platforms used in the shallow waters of the Beaufort Sea. Tarsiut, the first caisson-retained island, was built in 1981 and placed in the moving ice zone of the Beaufort Sea. Figure 1-12 shows an artist's cut-away drawing of this island and a photograph of the island in operation during the winter of 1981-82.

Experience with artificial island building during the last ten years is being applied to the design of production islands. Figure 1-13 illustrates a possible sequence for upgrading an exploration island to a production island. Other production structures such as concrete gravity structures are also being studied.

Currently, the Tarsiut reservoir is projected to be the first offshore commercial reservoir. From recent results, it is anticipated that only a few delineation wells may be required to justify proceeding with development. The reservoir illustrated in Figure 1-14 measures about 25 kilometres by 4 kilometres. The entire reservoir could be produced using five artificial islands. The first main production unit will probably be constructed in southern Canada, barge-mounted

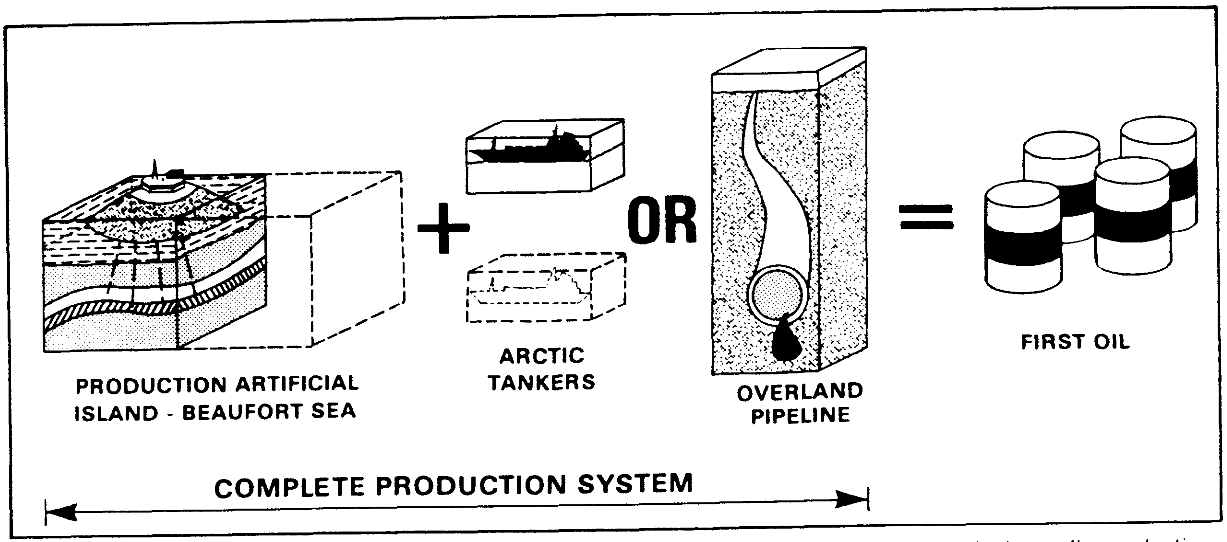
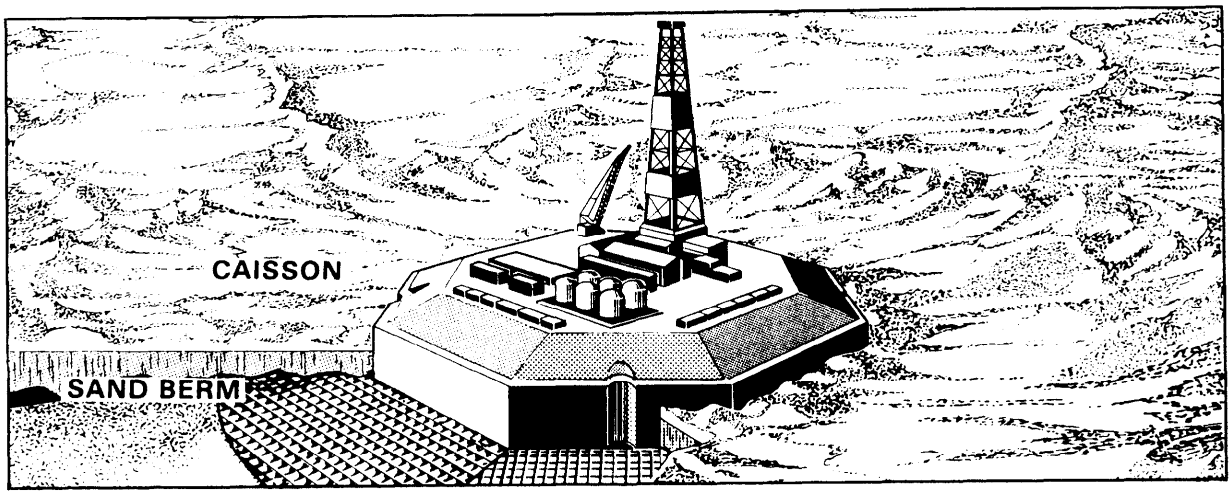



**FIGURE 1-11** *The major components of a production system include systems for drilling and producing wells, production processing facilities, various support systems, foundations on which to place this equipment, and an oil transportation system. Artificial islands will be used as foundations for the drilling and production systems, while either tankers or pipelines are suitable for hydrocarbon transportation.*



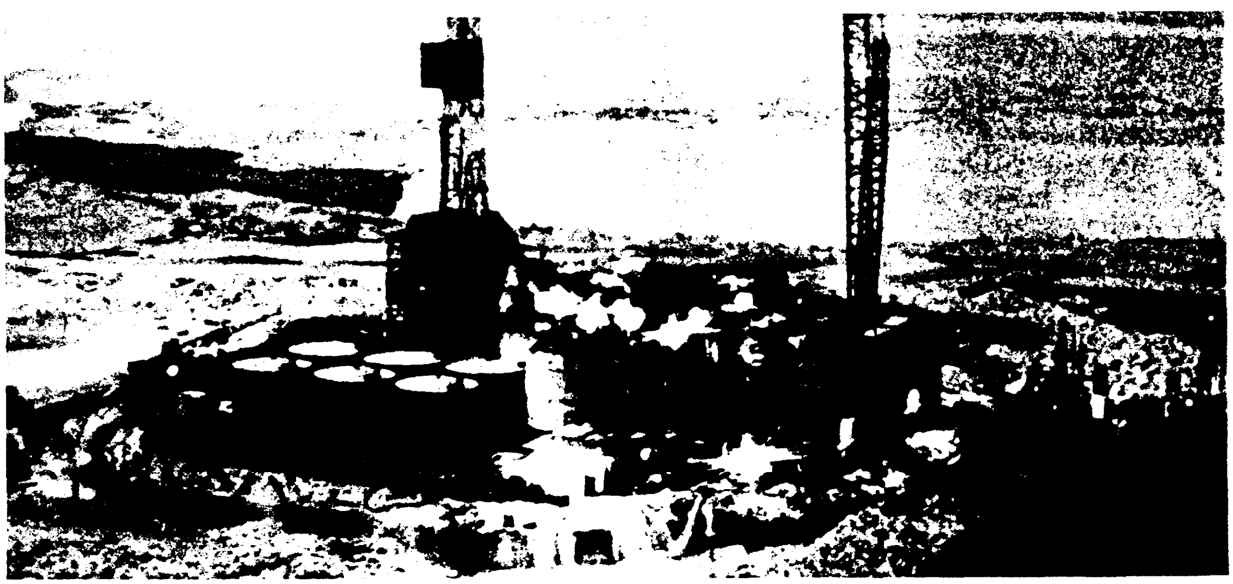



**FIGURE 1-12** *Progressive experience with exploration islands has demonstrated the feasibility of using artificial islands as a foundation for permanent production and drilling facilities. Islands such as Tarsiut, built in 1981, provide the technical data required for designing larger permanent production islands.*

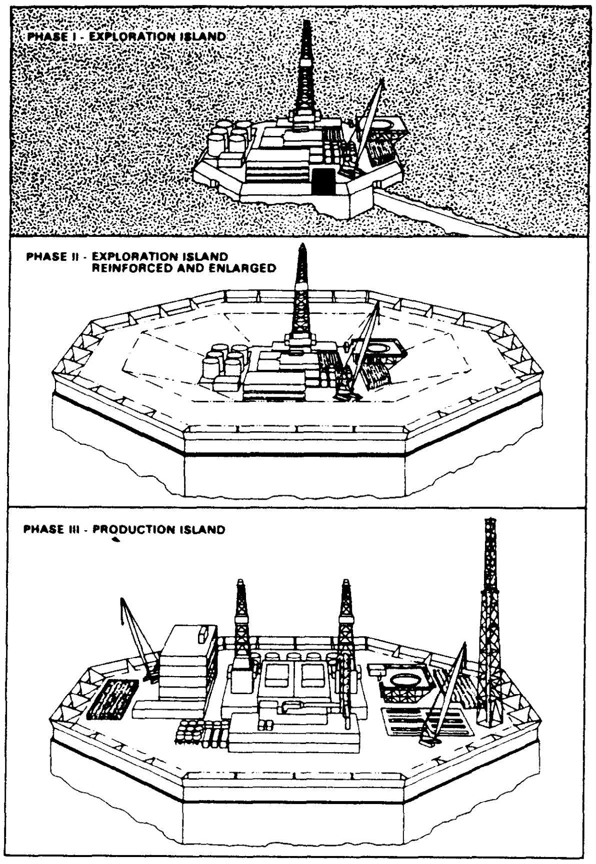



**FIGURE 1-13** *An exploration island like Tarsiut could be converted to a production island by enlarging and strengthening the existing island as illustrated in this schematic sequence.*

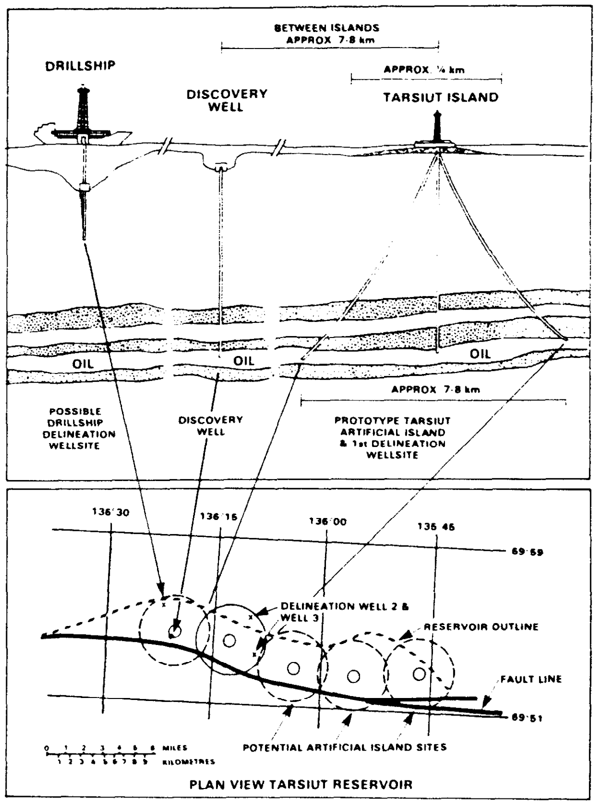



**FIGURE 1-14** *The Tarsiut discovery well was drilled from a drillship. The delineation well, drilled from an experimental island, was 7.8 kilometres east. The reservoir is relatively long and narrow. Four to six islands will be required to develop the reservoir because of the limited reach of the directionally drilled wells. One of the islands could be a combination production, processing and loading facility.*

and then towed to the first production island. This installation could take place as early as 1986. Further production systems would be installed as other islands are completed.

The Tarsiut field, as well as future reservoirs, would be tied into the production and transportation facilities using a gathering system. Such a system is described in Section 1.4.1.4 of this chapter.

Other reservoirs will be developed and tied into the transportation system when they are proven to be commercial. Currently, the most likely reservoirs are Koakoak, Issungnak and Kopanoar.

### 1.3.2.2 Onshore-Nearshore

For the major existing onshore and nearshore discoveries, delineation drilling could be completed by 1984 with expected production as early as 1987, assuming a transportation system is in place.

Onshore and nearshore reserves will be developed in a manner similar to those offshore. Once reservoir delineation is completed, design, fabrication and installation of production facilities could begin. These production facilities will be located on gravel pads or pilings to minimize permafrost degradation and will be similar to but smaller than offshore production facilities because of the smaller projected reservoir sizes. Development at Adgo for example could include 3 gravel production islands with a total of 15 producing wells to produce 2,500 to 3,000 cubic metres of oil per day.

### 1.3.2.3 Oil Transportation

In 1983, planning and engineering will also focus on the options for an oil transportation system. For the tanker option, engineering studies will focus on the design of Arctic tankers (Figure 1-15) and the offshore loading facilities they will require in the Beaufort Sea. The proposed year-round tanker route through the Northwest Passage is shown in Figure 1-16.

Another transportation option is an overland pipeline as shown in Figure 1-17. The present develop-

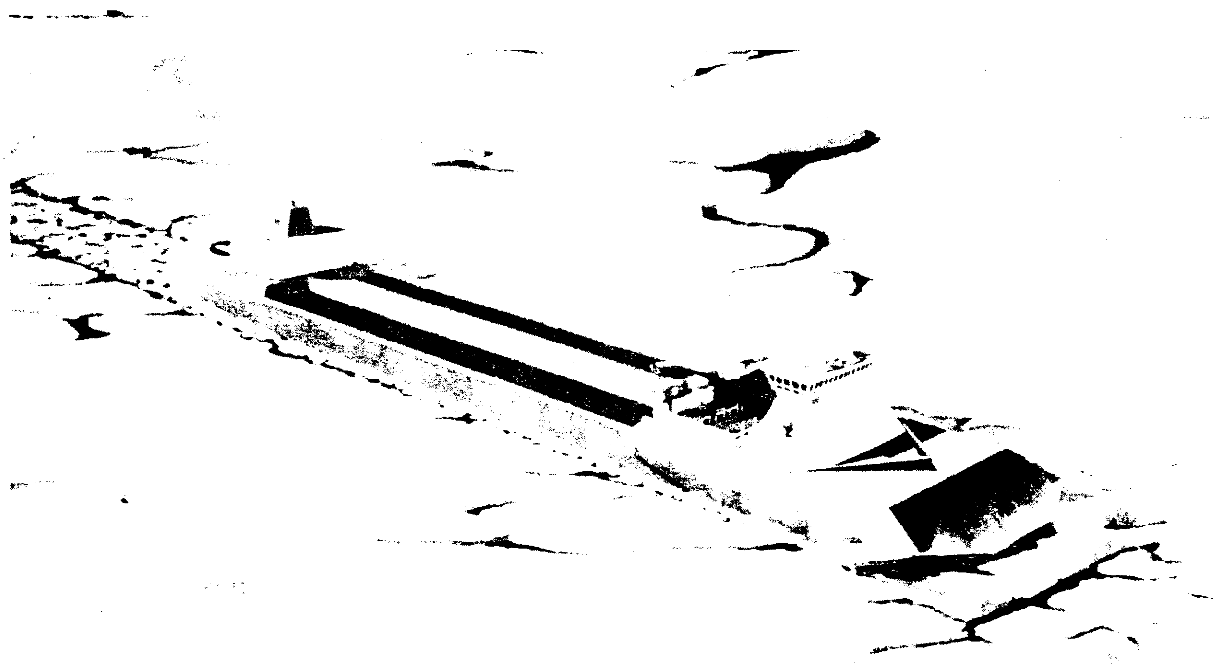


**FIGURE 1-15** *Conceptual design of an Arctic oil tanker. A vessel of this type is specifically designed to operate in the Arctic marine environment.*

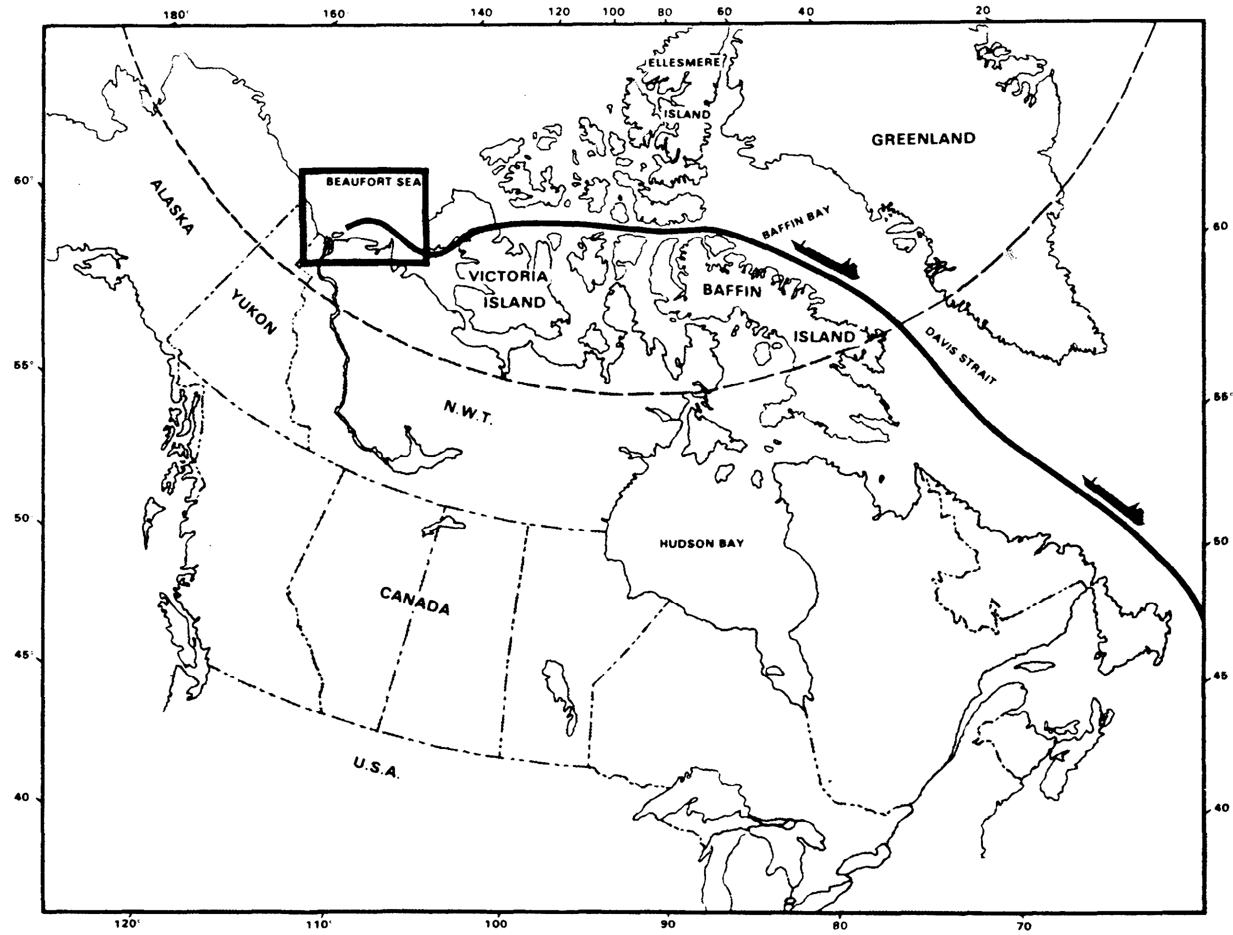



**FIGURE 1-16** *If Arctic tankers transport oil from the Beaufort Sea they would most likely be routed through the Northwest Passage, Baffin Bay and Davis Strait to eastern seaports.*

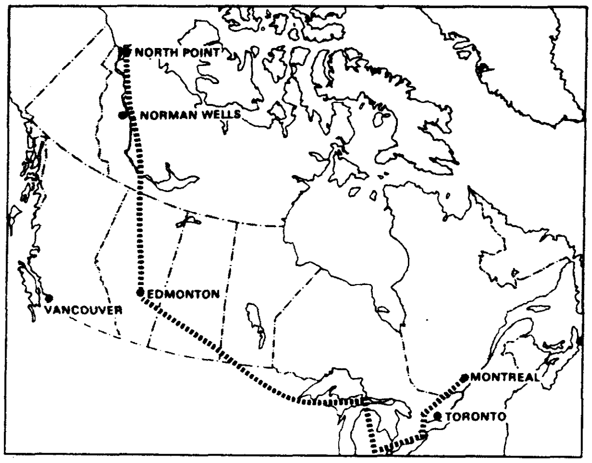



**FIGURE 1-17** *If a pipeline were used to carry oil from the Beaufort it would be routed down the Mackenzie Valley and tie in with an existing pipeline system north of Edmonton which would carry the oil east to Toronto and Montreal.*

ment plan considers two pipeline proposals, both using the Mackenzie Valley for transporting oil from the Beaufort Sea. First, a small diameter, 300 to 400 millimetre, buried crude oil pipeline could be built to carry low viscosity, low pour point oil. This line could connect to the Norman Wells pipeline and deliver up to 3,500 cubic metres of oil per day from onshore and nearshore Beaufort Sea oil discoveries such as at Adgo and Atkinson. Second, as larger offshore reserves are proven, the smaller line could be looped with either a number of small diameter diameter buried lines or a large diameter partially elevated line, extending from a site such as North Point on Richards Island to Edmonton. Other pipeline routes may also be considered. As well, engineering studies of a combined tanker and pipeline transportation system will be conducted.

#### 1.3.2.4 Support Services

Support services are those systems that are external to the operating sites, such as support bases, tug and supply boats, icebreakers, fixed wing aircraft, helicopters and communication systems. A growth of these services will be required to support the operations from 1982 to 1987. Support base expansion in this time period may be focused at McKinley Bay and at a site on the Yukon coast.

#### 1.3.2.5 Levels of Activity

The following tabulation of activities projected for the period 1982 to 1987, is based on the intermediate production rate. Figure 1-18 illustrates the number of islands constructed, wells drilled, freight transported, marine vessel and on-site personnel requirements. The levels shown are largely independent of whether tankers or an overland pipeline are used to transport the oil. Numbers of personnel needed to construct the pipeline are shown separately.

### 1.3.3 THE PACE OF DEVELOPMENT IN 1987

By 1987, it is assumed that production will have commenced and additional commercial reserves will have been discovered. By that time, further knowledge will have been gained on the environmental and socio-economic impacts and Canada's oil supply-demand balance.

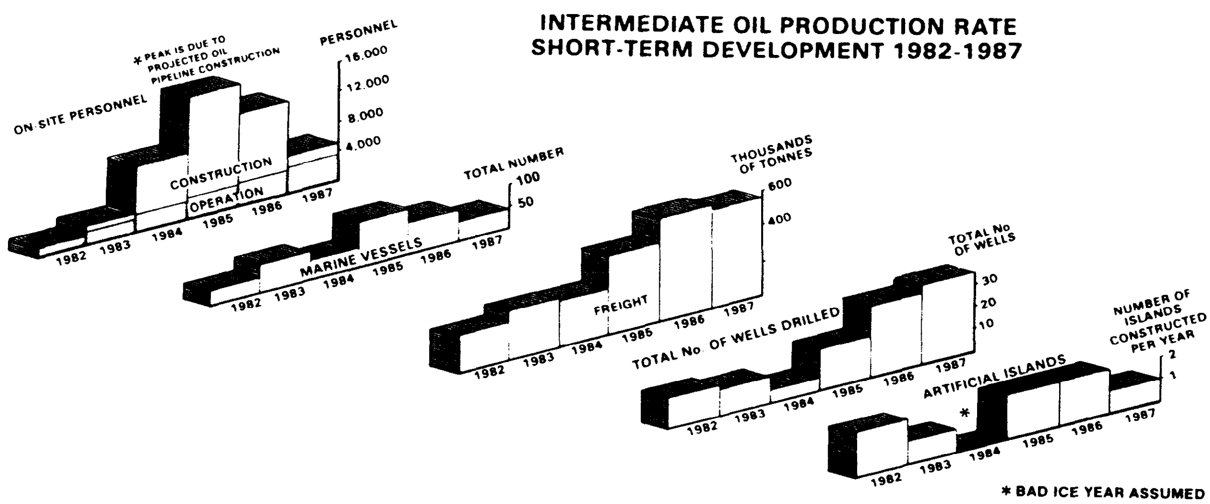



**FIGURE 1-18** *Short term levels of activity projected during the years 1982 through 1987 assuming the intermediate oil production rate and bad ice years.*

Assuming the intermediate production rate, oil by this time is projected to be produced at a rate of 5,720 cubic metres (38,000 barrels) per day, and the exploration, production and support systems listed in Table 1-2 will be in place.

**TABLE 1-2**
**STATUS OF DEVELOPMENT 1987**
**INTERMEDIATE DEVELOPMENT RATE**

| | |
|---|---|
| **EXPLORATION** | |
| Drillships | 4 |
| Extended Season Drillships | 4 |
| Caisson Drill Systems | 3 |
| Exploration Wells Drilled during 1987 | 8 |
| **CONSTRUCTION** | |
| Conventional Dredges | 7 |
| Arctic Dredges | 1 |
| Crane Barges | 3 |
| Pipe-Laying | 1 |
| Accommodation Barges | 3 |
| **PRODUCTION** | |
| Production Islands | 4 |
| Arctic Production and Loading Atoll | 1 |
| **TRANSPORTATION** | |
| Arctic Tankers | 1 |
| Small Pipeline | 1 |
| **SUPPORT SERVICES** | |
| Icebreakers | 16 |
| Supply Vessels | 16 |
| Other Vessels | 36 |
| Helicopters | 14 |
| Long Range Aircraft | 4 |
| STOL Aircraft | 9 |
| **PERSONNEL** | |
| Onsite Employment | 3800 |

### 1.3.4 PHASE 2 - HYDROCARBON PRODUCTION 1987 TO 2000

The long term development plan for the years 1987 to 2000 is presented here. The pace of development in this phase will depend on further discoveries, but assumes the intermediate production rate. This development schedule is shown in Figure 1-19. It is predicted that seven reservoirs could be developed in the Beaufort Sea-Mackenzie Delta region by the end of this period - 4 offshore and 3 onshore.

With the start of oil production, gas associated with the oil will also be produced. Figure 1-20 illustrates the expected gas production rate during the period from 1987 to 2000. Initially, only associated gas will be produced. The associated gas will be used as fuel wherever possible. Gas produced in excess of fuel usage will be flared for about 2 years at each island in the initial stages of production. After that early period, gas could be reinjected for gas conservation and to maintain oil reservoir pressures. When gas handling facilities are in place, both associated and non-associated gas will be transported to markets.

The projected levels of activity for certain key operations in the period 1987 to 2000 are illustrated in Figure 1-21. During this interval, about 655 oil and gas wells could be drilled including production, exploration, delineation and injection wells. There will be continuing construction of production islands offshore and pads onshore to support the drilling and production activities.

Many factors will determine the actual development rate in the time interval 1987 to 2000, one of which is the rate of commercial oil discoveries. The Beaufort Planning Model was used to predict the activity requirements associated with various rates of production ranging from the high technically achievable rate of oil production down to the lowest economically viable rate of offshore oil production. As stated earlier, it is likely that the actual activity levels (intermediate rate) will fall within this range of numbers. Figure 1-21 illustrates the estimated activity levels for this intermediate rate of oil production.

The timing and rate of development will be affected by the choice of transportation system. The alternatives, pipelines and tankers, are described in EIS Volume 2. The ultimate decision to use either pipelines, Arctic tankers or a combination of systems will be based upon a number of considerations, including environmental and socio-economic impacts, project economics and crude oil supply and demand.

## 1.4 PRODUCTION & TRANSPORTATION SYSTEMS

The components of a complete production system must be designed, built, installed and operating in order to produce the first barrel of oil. The complete system includes production systems in the Beaufort Sea region and a system for transporting oil out of the region.

### 1.4.1 BEAUFORT SEA PRODUCTION SYSTEMS

The major components for producing Beaufort Sea oil are summarized in Figure 1-22 and include:

- Production drilling structures;

- Production processing facilities to safely handle and treat the well fluids so that they are transportable;

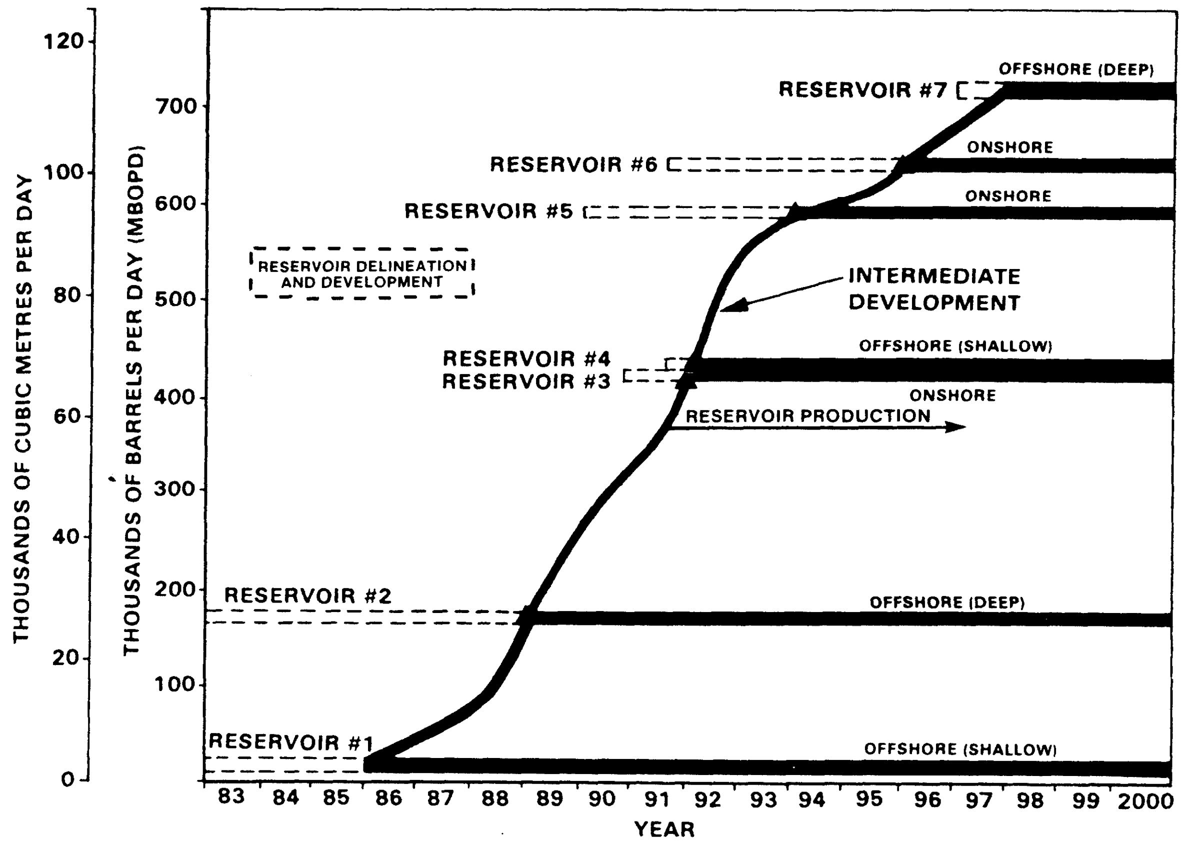



**FIGURE 1-19** *The level of activity in the years 1987-2000 is much more difficult to forecast. It will depend on future discoveries and the pace at which these discoveries are developed.*

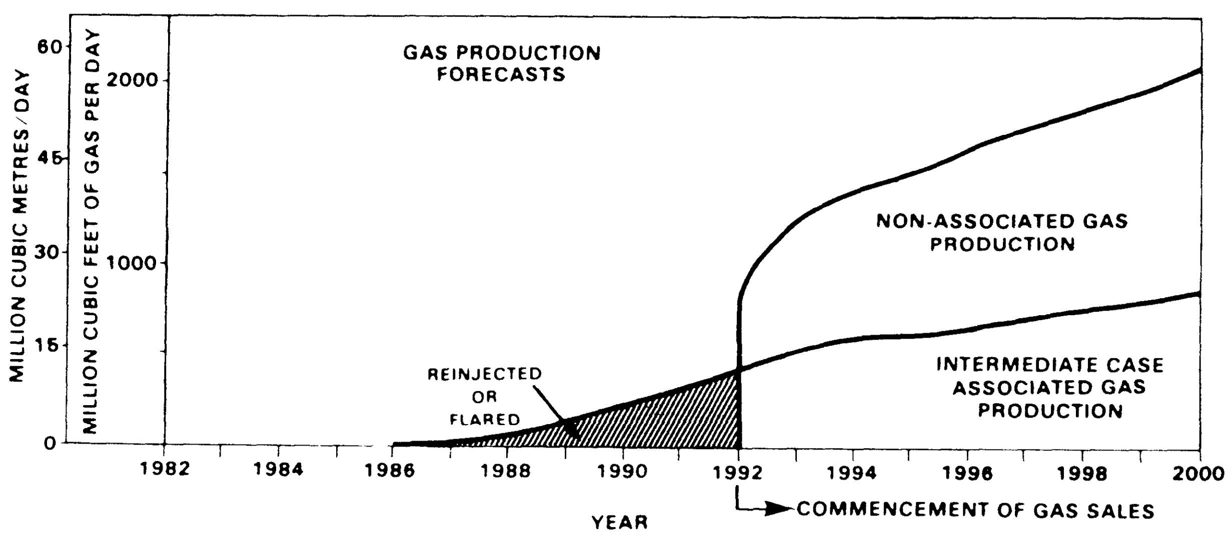



**FIGURE 1-20** *Gas produced with the oil will be flared for the first year or so of production and then re-injected until such time as a transportation system is in place to carry the gas out of the Beaufort region. When the transportation system is in place gas discoveries in the Beaufort (non-associated gas) will also be developed.*

## INTERMEDIATE OIL PRODUCTION RATE
## LONG-TERM DEVELOPMENT 1987-2000

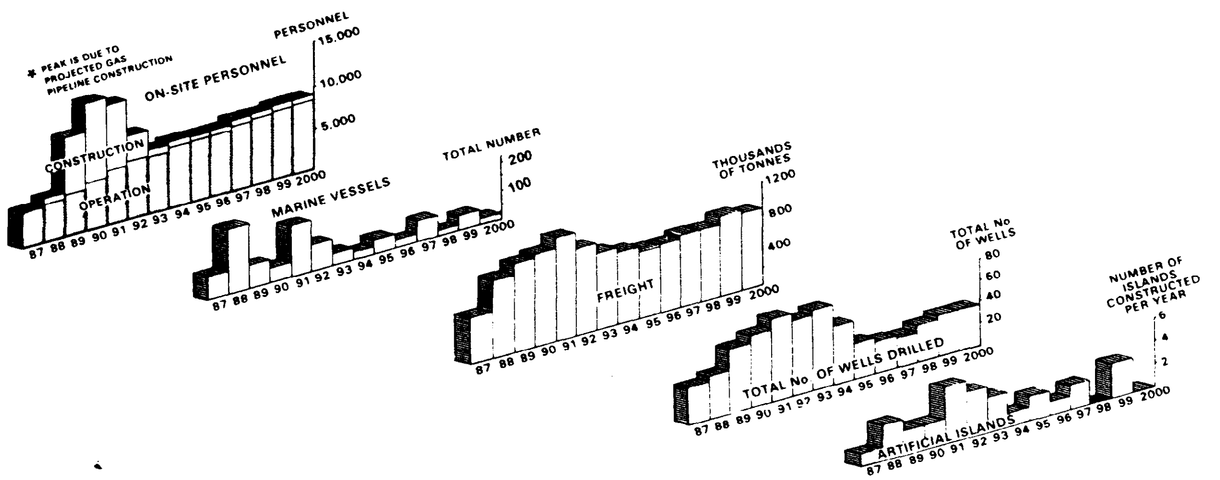



**FIGURE 1-21** *Long term levels of activity projected during the years 1987 through 2000, assuming the intermediate oil production rate.*

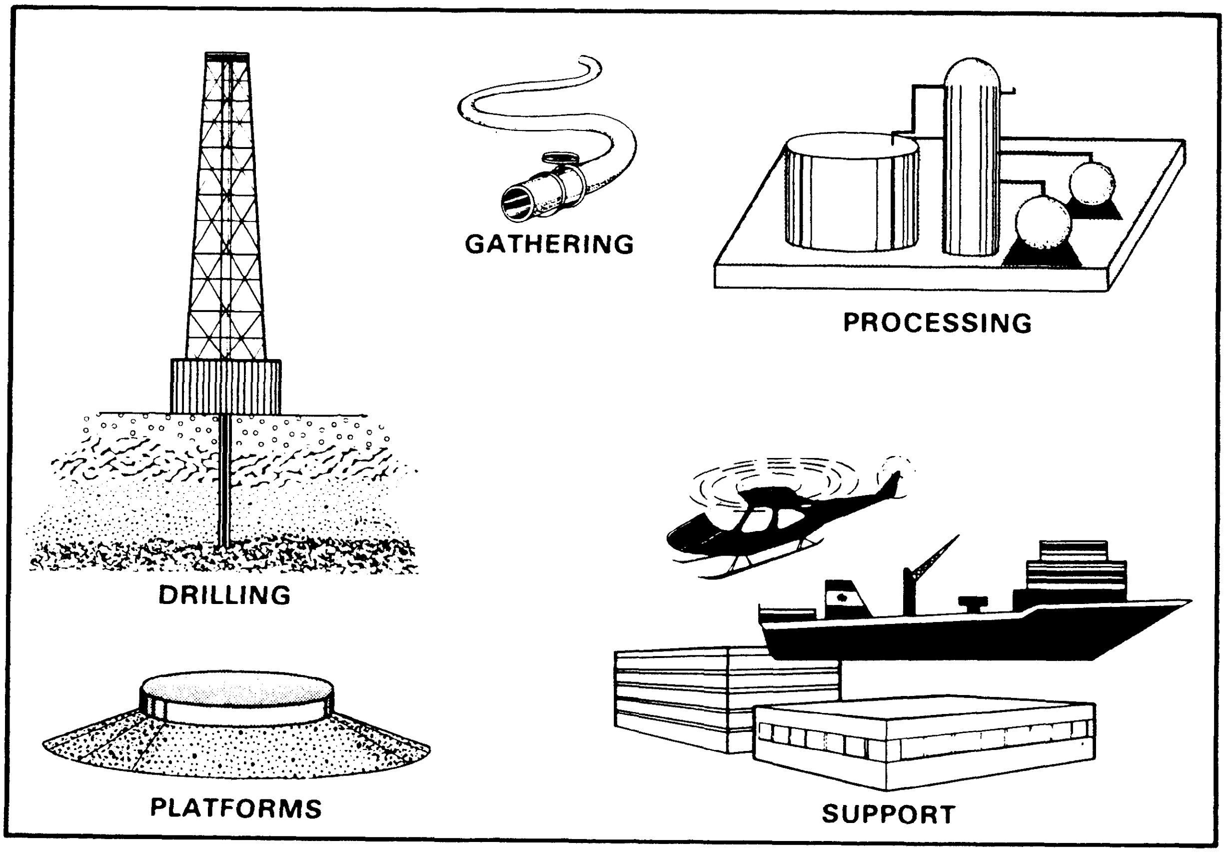



**FIGURE 1-22** *The major components required for producing hydrocarbons include drilling systems and their platforms, gathering lines, production processing facilities and support systems.*

- Gathering systems to move the oil to a transportation terminal;

- Support systems of various types including construction and supply vessels; air, land and marine services; and support bases for storage, maintenance and personnel requirements.

### 1.4.1.1 Exploration Drilling Systems and Platforms

Industry has been drilling in the Beaufort offshore for 10 years. This experience has provided the cornerstone for the development of offshore reservoirs. Reservoirs are found by drilling exploration wells. Delineation drilling then determines whether or not a reservoir contains sufficient recoverable reserves to make it economic to produce.

The equipment and techniques used for drilling in the Beaufort Sea-Mackenzie Delta region are similar to those used in southern Canada. The drilling components are compact to conserve space and are enclosed to protect personnel and equipment from the elements. As in other remote areas, the drilling systems are self-contained with their own power generators, accommodations units and waste management facilities. Special drilling equipment designs and procedures have been developed to handle unique conditions such as permafrost and shallow high pressure water zones.

Onshore, drilling is conducted from gravel pads which prevent permafrost degradation. Offshore, drilling is carried out from artificial islands built on the ocean floor or from mobile drilling platforms such as drillships. To date, twenty artificial islands have been built by industry in the Beaufort Sea. Four drillships are currently in use in the Beaufort. These vessels are specifically designed for Beaufort Sea ice conditions and operate 90 to 120 days each year.

A new generation of anchored drilling systems, specifically designed to operate in ice, will be brought into the region in 1983. One of these, a "Conical Drilling Unit" has a deep circular polygonal hull capable of deflecting ice. With icebreaker support, the drilling season for these systems will be extended substantially.

Exploration drilling in shallow water will continue using conventional drilling systems placed on artificial island platforms. Artificial islands are constructed from sand and gravel dredged from the sea floor. Caissons, fabricated from concrete or steel, are now used to contain the dredged material and protect the drilling systems from ice, wind and wave forces.

### 1.4.1.2 Development - Production Platforms

As the focus of operations moves from the exploration to the production phase, permanent island platforms will be developed. These platforms will provide the foundations for production wells, drilling systems, oil and gas processing facilities, storage, and related accommodation and support facilities.

The design of the islands will incorporate the information gained from research on ice interactions with structures, as well as the 10 years of Beaufort Sea island building technology. Factors considered in the design of artificial islands, shown in Figure 1-23, include: forces imposed by ice features such as first year ice, multi-year ice with pressure ridges, hummock fields, and ice islands; ice ride-up and ice pile-up; the mechanisms of ice failure as it impinges on an island; waves, ocean currents and water level fluctuations; seafloor foundations; seismic activity; and subsea permafrost.

Conventional dredges of both the cutter suction and hopper types will continue to be used during the summer open water season to build islands for exploration and production. Dredges will also be used for harbour construction and maintenance purposes.

The requirement for larger production islands in the deeper waters of the Beaufort Sea has resulted in the design of a new generation of large capacity, icebreaking hopper dredges. If built, such vessels will have a hopper capacity of 25,000 cubic metres and the ability to operate in water depths up to 80 metres for an extended time in winter.

On land, the design of production platforms will be based on the many years of permafrost construction experience in the Arctic. Prevention of permafrost degradation is a key design parameter and will be accomplished by using gravel pads (Figure 1-24) to insulate the frozen soil or by elevating platforms above the ground. The use of land will be kept to a minimum when production platforms and ancillary facilities, such as access roads, are constructed. Gravel hauling and delivery of construction components will be carried out over snow roads during winter.

### 1.4.1.3 Processing Systems

Fluids from production wells normally include crude oil, associated gas and some water. Conventional and proven systems will be used to separate the well fluids into oil, gas and water (Figure 1-25). Crude oil processing systems will be assembled from components constructed elsewhere and transported to the region on barges. The components of a processing system to be used on an island will likely be stacked

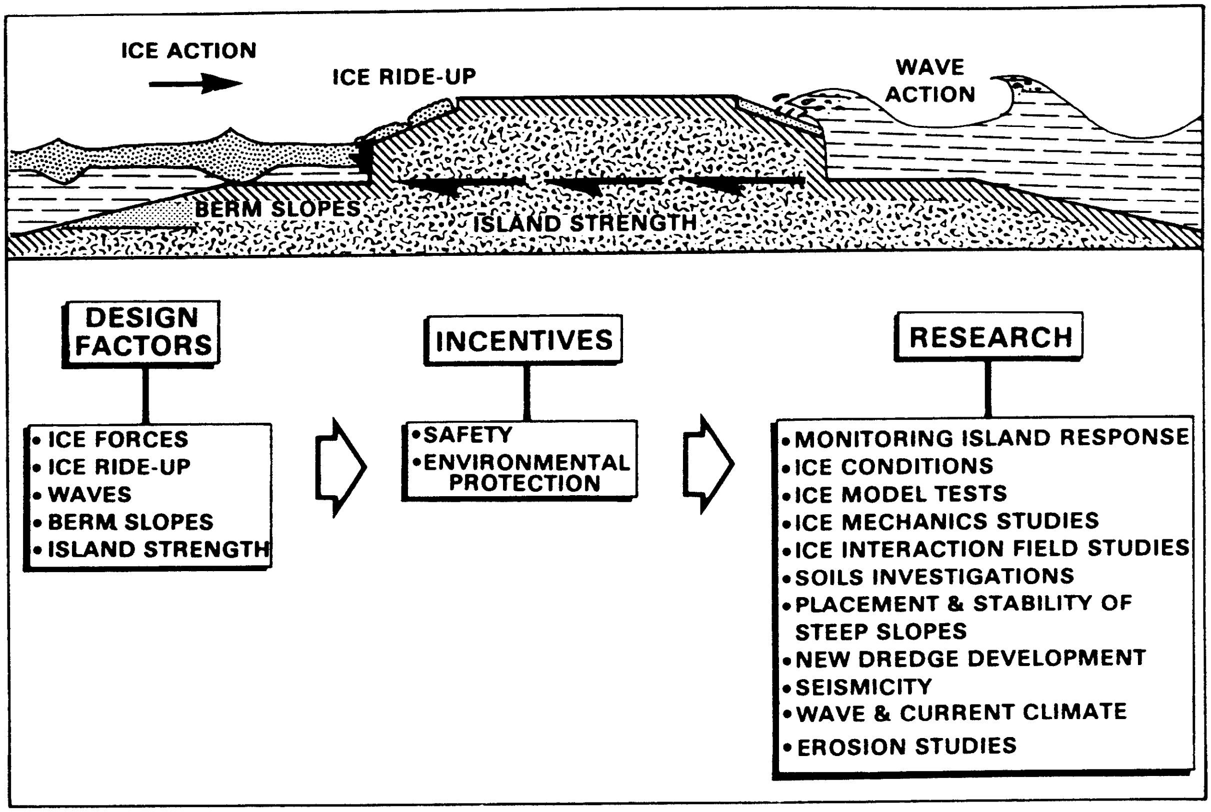



**FIGURE 1-23** *Artificial islands have been selected as the most practical foundation system for permanent drilling and production facilities in the Beaufort Sea. The factors which govern the design of artificial islands have been the subject of extensive research on island building technology and ice interactions for over a decade. The ice forces are accurately known, as is the ability of man-made islands to resist these forces.*

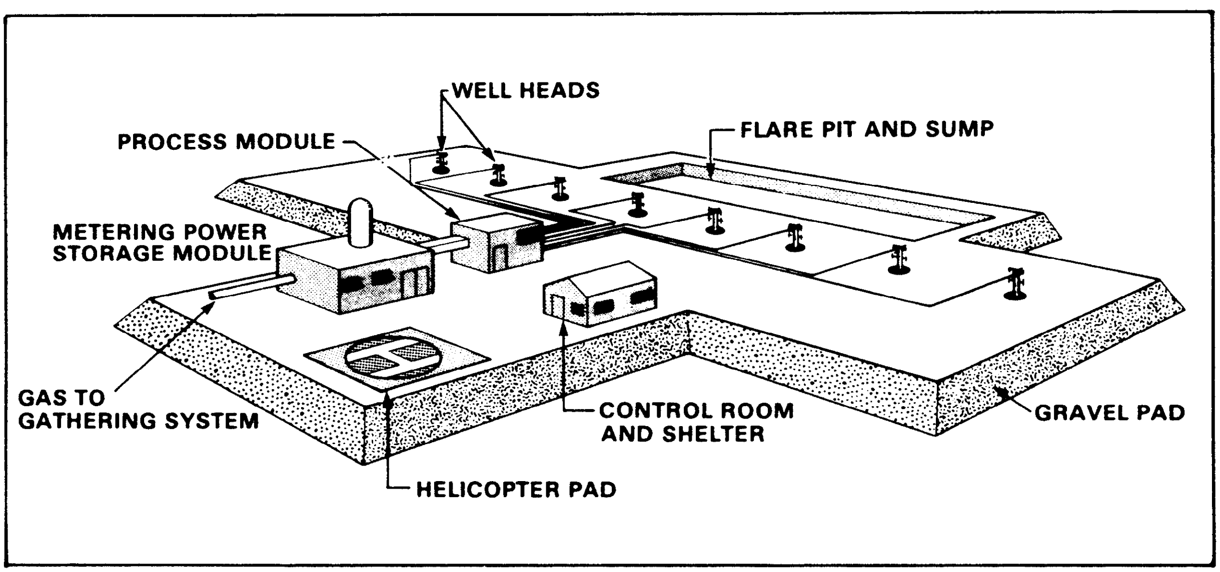



**FIGURE 1-24** *A typical land-based gas well cluster site situated on a gravel pad.*

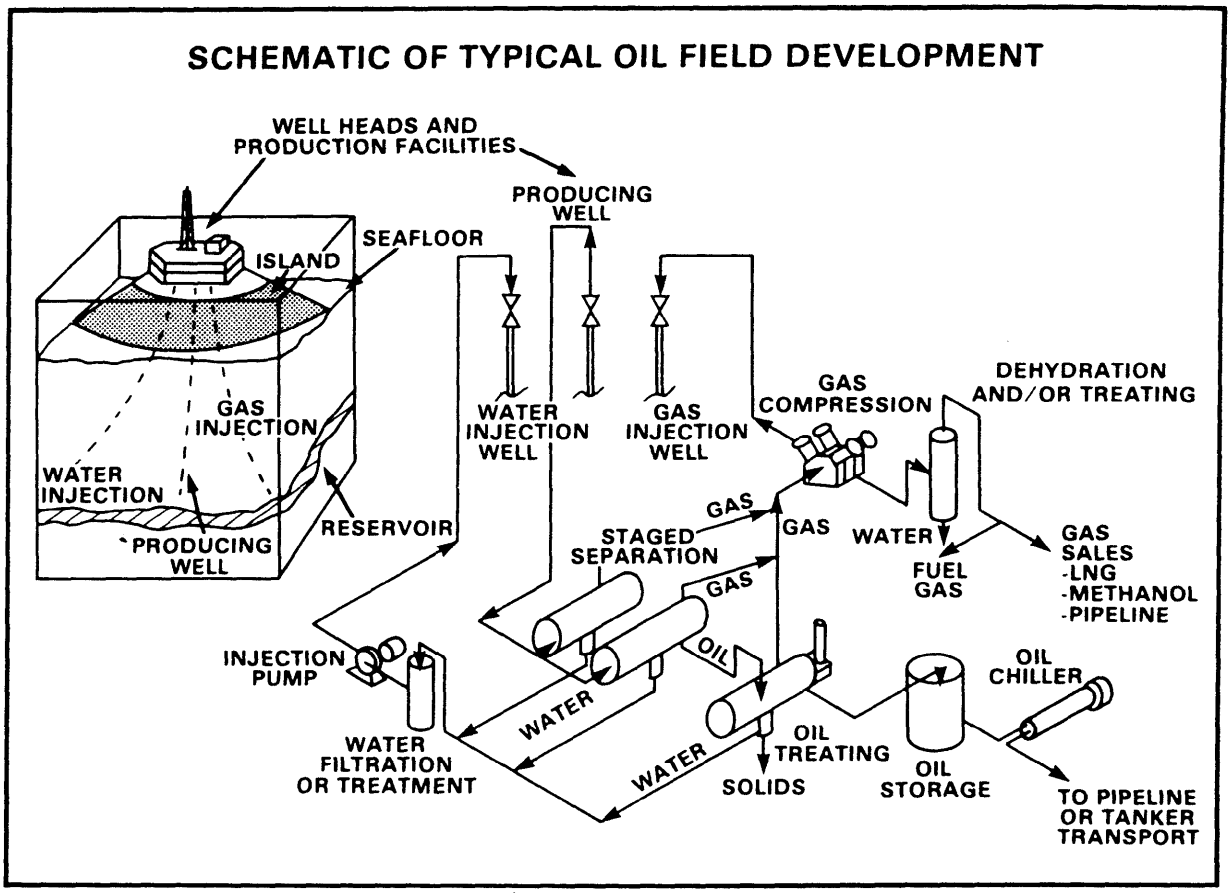



**FIGURE 1-25** *The crude oil processing components, gas use alternatives, production water treatment facilities and the storage and distribution components of a crude oil processing unit.*

and integrated with waste management and accommodation units to save space; some of these systems may be assembled on barges and placed behind protective dredged berms at artificial islands. Where more than one production island is needed to produce a reservoir, each satellite island will have a facility to initially separate gas and water from the crude oil. Final processing to condition the oil for transportation will take place at a central island.

Onshore, processing systems will be identical in function to those offshore, however, spatial limitations are not as severe. Oil well fluids will be piped from well clusters to central processing facilities. Similar to those offshore, a complete onshore production system will be self-contained with its own power, water and waste treatment, disposal systems, and accommodations.

The water separated from the oil well fluid is known as produced water, and is generally treated and injected back into the producing formation. However, in the early phases of oil field development, only oil producing wells will be drilled. Thus at this time, the produced water would be treated prior to discharge to the Beaufort Sea. As reinjection wells are drilled, much of the produced water may be returned to the geological strata.

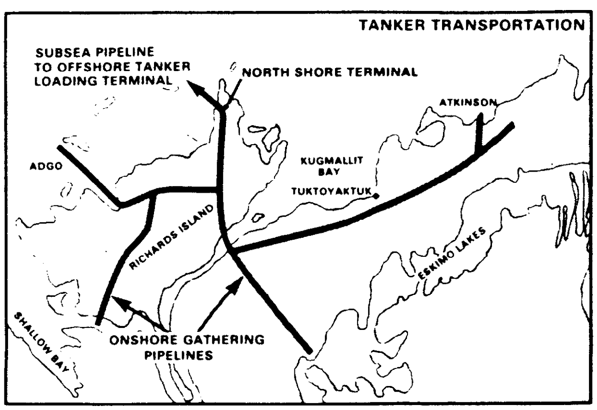
Some of the associated gas separated from the oil will be used for power generation and heat. The excess gas will initially be flared and later injected into the reservoir for pressure maintenance and storage for future gas sales. Once a gas transportation system is in place for the associated gas, non-associated gas will be produced from gas reservoirs both onshore and offshore. The gas would be piped to central gas processing facilities where excess water, carbon dioxide, and liquid hydrocarbons would be removed. Hydrogen sulphide has not been found in the Beaufort Sea gas to date, but could also be removed, if present. The gas would then be compressed and cooled before entering a trunk pipeline.

All production facilities will be designed using state-of-the-art technology with built-in redundancy to minimize the possibility of fire and explosion. Safety systems will include preventative, alarm and control systems which will respond immediately and automatically to process upsets and changes in operating conditions.

Oil storage will be needed, the amount depending on the production rate and method of transporting the oil to southern markets. If Arctic tankers are used, oil could be stored in tanks or vessels within a protected harbour at a tanker loading terminal, or in tanks on an artificial island. Assuming oil was transported by an overland pipeline, a tank farm would be located on land at the northern pipeline terminal.

### 1.4.1.4 Gathering Systems

Oil produced from onshore fields on the Mackenzie Delta and Tuktoyaktuk Peninsula will be gathered through a network of small diameter buried pipelines and moved to the overland pipeline, or to a coastal terminal, and then through a subsea pipeline to an offshore tanker loading terminal (see Figure 1-26). The onshore gathering pipelines, from 219 to 508 mm in diameter, will be buried. Since the oil will be at ground temperature, there is little threat of permafrost degradation.



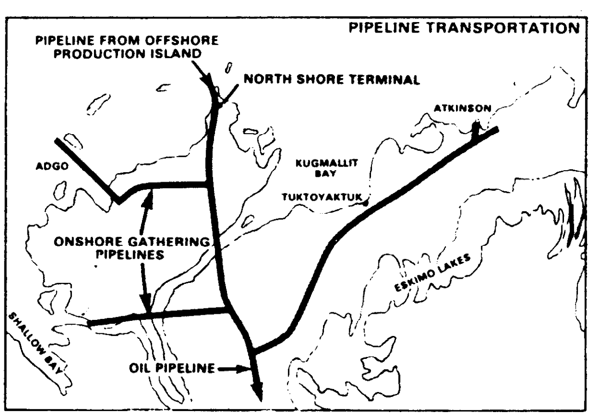




**FIGURE 1-26** *Onshore oil gathering systems. Possibilities are shown for the tanker transportation option (upper diagram) and the overland pipeline transportation option (lower diagram).*

Offshore, subsea pipelines will be used to gather oil from satellite production islands for final processing at central production islands. Similarly, water and gas for injection may eventually be piped between islands. If oil is transported from the region by Arctic tankers, subsea trunklines will be laid to transport oil to a tanker loading terminal (Figure 1-27). Alternatively, offshore oil production would flow through subsea trunklines to a tank farm at the northern pipeline terminal. Subsea trunklines from offshore fields may range in diameter from 508 mm to 762 mm.

Design criteria and operating procedures have been developed for subsea pipelines in the region. Design considerations include the protection of the pipeline from ice scour and the prevention of subsea permafrost degradation.

The operation of gathering systems, whether onshore or subsea, will use state-of-the-art control equipment. Each gathering network would be operated and monitored from a central control room. Sophisticated leak detection capabilities will be built into the system with instantaneous leak recognition down to 0.5% or less of the oil flow.

### 1.4.1.5 Support Bases

Coastal bases are needed to support the exploration, construction, and production activities. These bases would have warehouse facilities for the large quantity of consumables and construction materials needed to supply drilling, construction and production locations. They are also transfer points for rotational personnel and provide facilities for docking, mooring and repair of supply vessels, drillships and dredges. Support bases also function as operation and administrative centres and play a major role in providing weather and ice prediction information to drilling, construction and in the future, production locations.

Currently support requirements are met by Dome and Esso bases at Tuktoyaktuk and Dome's McKinley Bay operation. Gulf's Tuktoyaktuk base will be completed in 1982. As the pace of development increases through the eighties, additional base capacity will be required. Developments under consideration include:

- At Tuktoyaktuk, moderate expansions of bases and improvement of the air terminal and airstrip, and additions to present warehousing, maintenance facilities and docks.

- At McKinley Bay, the building of permanent docks, warehousing, and accommodations and

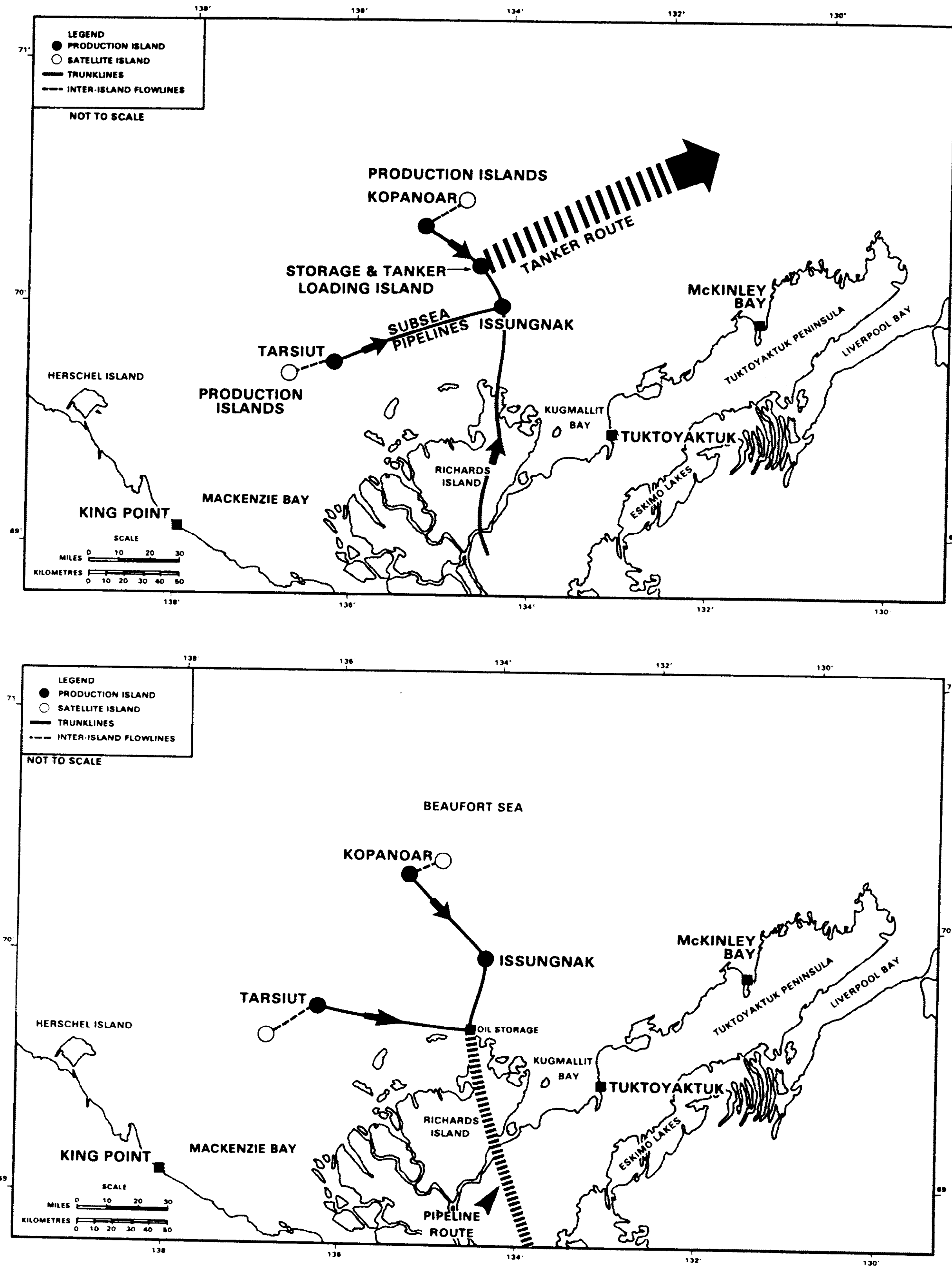



**FIGURE 1-27** *Oil gathering subsea pipelines. The upper diagram shows a possible gathering system for the tanker transportation option. The lower diagram shows a possible system for the overland pipeline transportation option.*

waste management facilities on the artificial island and enlarging of the access channel and mooring basin.

- On the Yukon coast, the establishment of a third major support base possibly at either King Point or Stokes Point. This general area has excellent site conditions and is close to a major source of quarry rock. Furthermore, it is relatively close to areas of proposed short and long-term offshore development. If developed, this major shorebase facility would grow in stages and could eventually occupy 90 to 100 hectares with major docking and mooring facilities and an airstrip.

#### 1.4.1.6 Air and Marine Support

Aircraft and marine vessels are used extensively to support the drilling and construction activities both onshore and offshore. Small aircraft carry personnel and fly ice reconnaissance missions. Helicopters, which are indispensable to offshore oilfield operations around the world, transfer personnel to and from platforms and vessels. Regular flights of aircraft such as Boeing 737's and large turboprop aircraft will move crews in and out of the region. As development proceeds, the number of aircraft needed will steadily increase, from for example, about 30 aircraft in 1985, to over 40 by 1990. In the future, larger, longer range helicopters and larger passenger jets are expected to be in service to move personnel to and from the region.

Marine vessels, crucial to the development of the region, must be specially designed or adapted to Arctic conditions. The current marine vessel fleet includes: supply vessels (Plate 1-1) and barges which routinely supply consumables and construction materials to operation sites; dredges and hopper barges which are used in the construction of islands; icebreakers (Plate 1-2) which are essential for escorting other vessels, for ice defense and for emergency services; specialty barges such as accommodation barges, pipelaying barges and crane barges; seismic ships; standby boats; floating drydocks and a variety of tugs and small boats. The marine fleet required to support drilling, construction and production will increase with the pace of development.

### 1.4.2 ALTERNATIVE OIL TRANSPORTATION MODES

As mentioned earlier, for the transportation of oil and gas out of the region, either overland pipelines or tankers or a combination of the two are considered to be feasible. For these options, the environmental and socio-economic impacts can be managed within acceptable limits.

Although there is general industry agreement on what the oil and gas transportation options are, currently there are differences in the preferred alternatives. These differences arise from individual com-

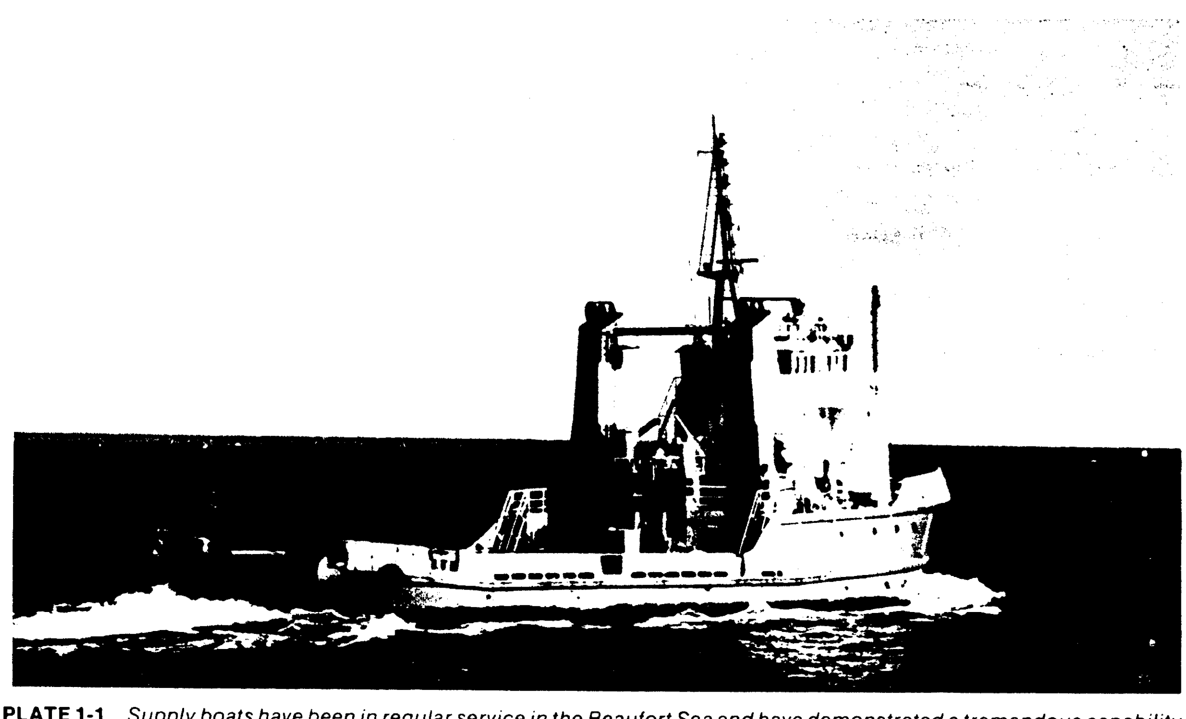


**PLATE 1-1** *Supply boats have been in regular service in the Beaufort Sea and have demonstrated a tremendous capability to work in first-year ice.*

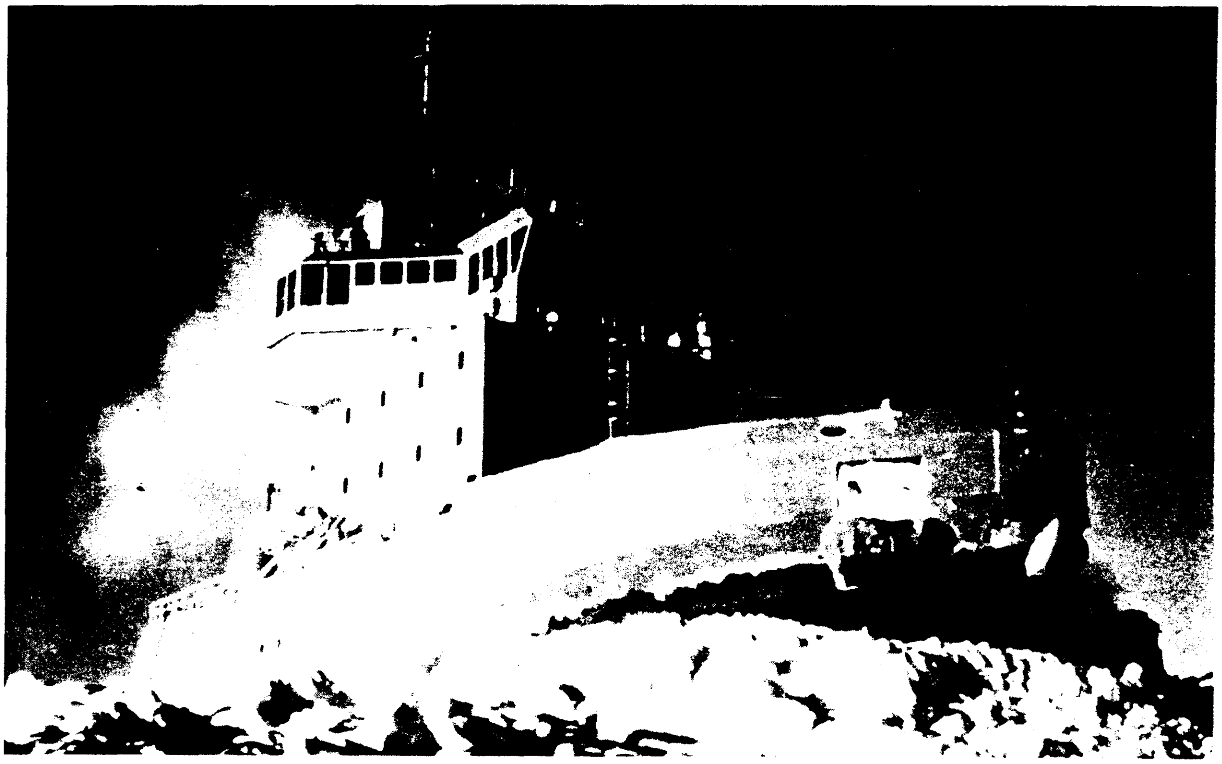


**PLATE 1-2** *Icebreakers are required to assist oil industry operations offshore in the Arctic. The KIGORIAK, which started operations in 1979, was the first icebreaking vessel to be built specially for the Beaufort Sea. It is used both to support drillships and for research purposes.*

pany's experiences with the alternative systems, their acreage and reserve positions, their judgement of the oil and gas potential of the Beaufort region and the time needed to develop this potential.

Perhaps the largest differences between the three proponents relate to the timing and rate of production from the Beaufort. As shown in Figure 1-6, three rates are considered; 1.3 million barrels per day, 700,000 barrels per day and 180,000 barrels per day by the year 2000. The actual rate of production achieved will likely approach the intermediate figure, but even this may be optimistic. Accordingly, it is likely that if pipelines are used to transport oil from the Beaufort region, it is most likely that a smaller pipeline would be constructed first, to be followed with the construction of a larger line as additional reserves are proven. Nevertheless, in order to be compatible with the EIS upper case production rates and to provide data for the worst impacts that could accompany pipeline development, two larger diameter oil pipeline cases, 42 inch and 36 inch, were studied for the high and medium production rates respectively, to provide data for the EIS impact assessment document.

### 1.4.2.1 Arctic Tankers

One option for oil transportation is the Arctic tanker. These vessels could be used to transport oil through the Northwest Passage, thereby establishing a new transportation corridor linking the Beaufort Sea production sites to southern seaports. Current planning is to use mid-sized, specially designed, Class 10 icebreaking tankers. Plate 1-3 shows an artist's rendering and Table 1-3 outlines the basic design criteria for such a tanker.

The full size (200,000 DWT) Arctic tanker would not be as large as some conventional tankers, but the two engines in combination would be capable of producing 112 MW of power; the world's largest icebreaker, the Soviet nuclear-powered ARKTIKA, has only half of this power. The Arctic tanker will be 390 metres long, 52 metres wide and have a draft of 18 to 20 metres. It would carry 200,000 tonnes (1.5 million barrels) of oil cargo and have a crew of 45. The ship will have twin reversing propellers, twin rudders and many other special features which, coupled with the powerful engines, will give excellent maneuverability and stopping capability - far superior to conventional tankers.

Ice conditions in the Arctic are much more severe than conditions encountered elsewhere. However, much has been learned through the years of ice research conducted by industry throughout the Beaufort Sea and Northwest Passage region. In addition to the information obtained from this research, two

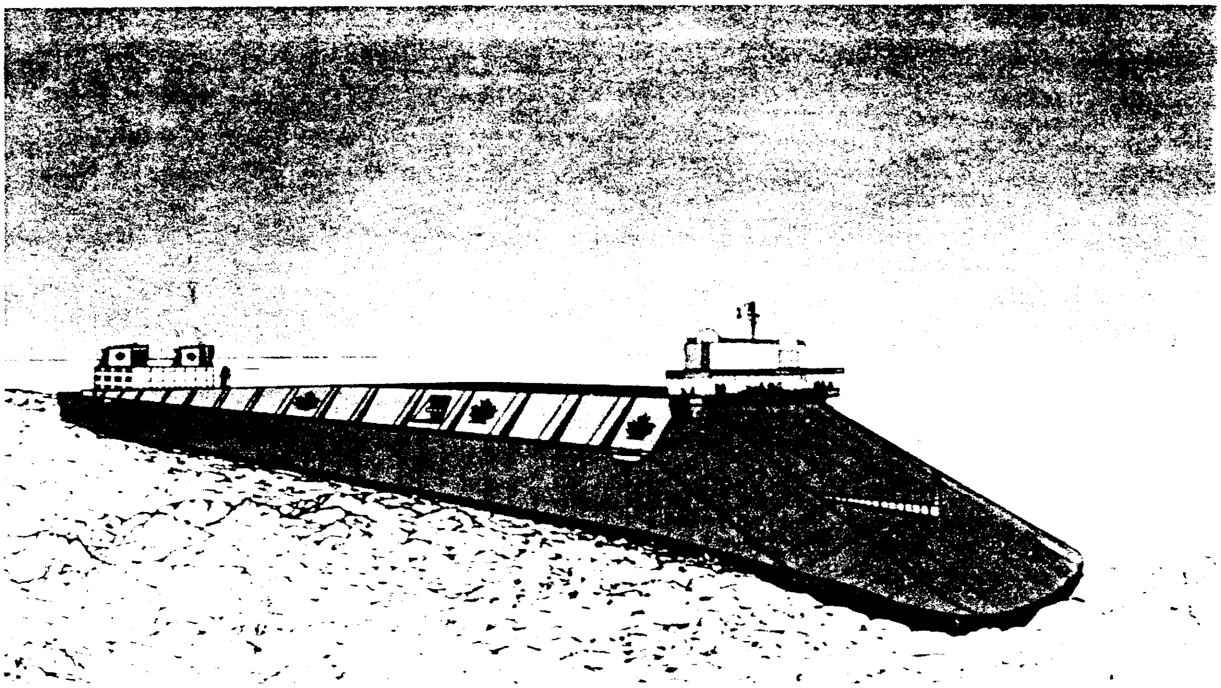


**PLATE 1-3** *The tankers being proposed to transport oil through the Arctic seas will be ice Class 10. 200.000 DWT double-hulled vessels with an oil carrying capacity of 1.5 million barrels.*

| TABLE 1-3 BASIC CRITERIA CONSIDERED IN THE DESIGN OF THE ARCTIC TANKER |
|---|
| • THE VESSEL SHOULD MAKE GOOD SPEED IN LEVEL ICE. |
| • THE VESSEL SHOULD MAKE CONTINUOUS PROGRESS THROUGH RIDGES. |
| • ICE ISLANDS SHOULD BE DETECTED IN ADVANCE AND THE VESSEL SHOULD HAVE THE MANEUVERABILITY TO AVOID THEM. |
| • THE VESSEL SHOULD WITHSTAND A COLLISION WITH AN ICE ISLAND. |
| • THE PROPULSION SYSTEM SHOULD WITHSTAND BLOCKS OF ICE BEING SUCKED INTO THE PROPELLOR. |
| • THE VESSEL'S STRENGTH SHOULD WITHSTAND ALL THE ABOVE AND ALSO STRESSES IF THE VESSEL BECOMES BESET. |
| • LIFE SAVING EQUIPMENT SHOULD BE PROVIDED FOR THE CREW IN ALL OPERATING ENVIRONMENTS. |

marine vessels incorporating innovative systems for Arctic icebreaking are providing practical information about operating in the region - the KIGORIAK a Canadian Arctic Class 3 icebreaker, and the new ROBERT LEMEUR an icebreaker/supply vessel. The ROBERT LEMEUR incorporates several new hull and equipment design features which are planned for the future Arctic Tankers.

An extensive study of the types of failures experienced by oil tankers of more than 200 tonnes between 1967 and 1978 was undertaken to identify those design features and safeguards which could prevent or reduce the size of oil spills. All of the necessary design features and safeguards identified are being employed in the Arctic tanker design and will be incorporated in operating procedures.

The design philosophy of the Arctic tanker is that no single mistake, whether it be in design, operation, navigation or mechanics, will lead to disaster. The ship will have a double hull throughout, built of specially selected steel which will be stronger than that used on any conventional tanker. In the remote event that both hulls were penetrated in an accident, the ship would have sufficient ballast volume to retain any spilled oil between the two hulls.

Many special design features of the Arctic tanker will continue to be tested operationally before a prototype is built. These design features will minimize ice interference with the propellers, increase maneuverability, reduce hull friction, increase accuracy in ice forecasting and increase early detection of icebergs and surface obstructions.

A prototype Arctic oil tanker would first be tested without cargo under conditions which are more extreme than those which may be encountered along the route. After the system demonstrates its capabilities, shipment of oil could then begin, ultimately transporting oil on a year-round basis.

In addition to ship design considerations, a wide array of sophisticated systems will be provided for communication, navigation, weather forecasting and ice detection. The latest satellite systems will be used for communication and highly accurate positioning. A near field ice detection system using a variety of devices will assist the vessel's master to navigate through all ice conditions. For example, radar will be used to detect icebergs and other surface obstructions, while sonar will be used to detect underwater obstructions such as the keels of icebergs and multi-year pressure ridges. (Figure 1-28).

#### 1.4.2.2 Overland Oil Pipeline

For over a decade the oil industry has been studying routes for pipelines to transport hydrocarbons from the Arctic to southern markets. To transport oil from the Beaufort Sea-Mackenzie Delta region, an overland pipeline could be built along the Mackenzie Valley and on to Alberta (Figure 1-29).

A large diameter pipeline would be designed and built using technology proven in the construction of the Alyeska Pipeline across Alaska. About one third of the pipeline would be built above ground in the north where permafrost is prevalent. These elevated sections would be similar to those shown in Plate 1-4 for the Alyeska Pipeline. The pipe would be mounted on vertical supports spaced at intervals to ensure that failure of an individual support member would not cause any damage to the pipe. Cryanchors will be used where necessary. These are metal tubes filled with a refrigerant that conducts heat from the ground whenever the ground temperature is warmer than the ambient air temperature. Because of the wide temperature ranges in the area, the pipeline must be allowed to expand or contract. This is accomplished by placing the elevated pipeline in a 'saddle and slide' assembly which can move both laterally and longitudinally.

About two thirds of the pipeline will be buried in the conventional manner and covered with fill as shown in Plate 1-5. At river and stream crossings and in wet ground, the pipe will be weighted to keep it in place. A protective coating around the pipe will prevent corrosion.

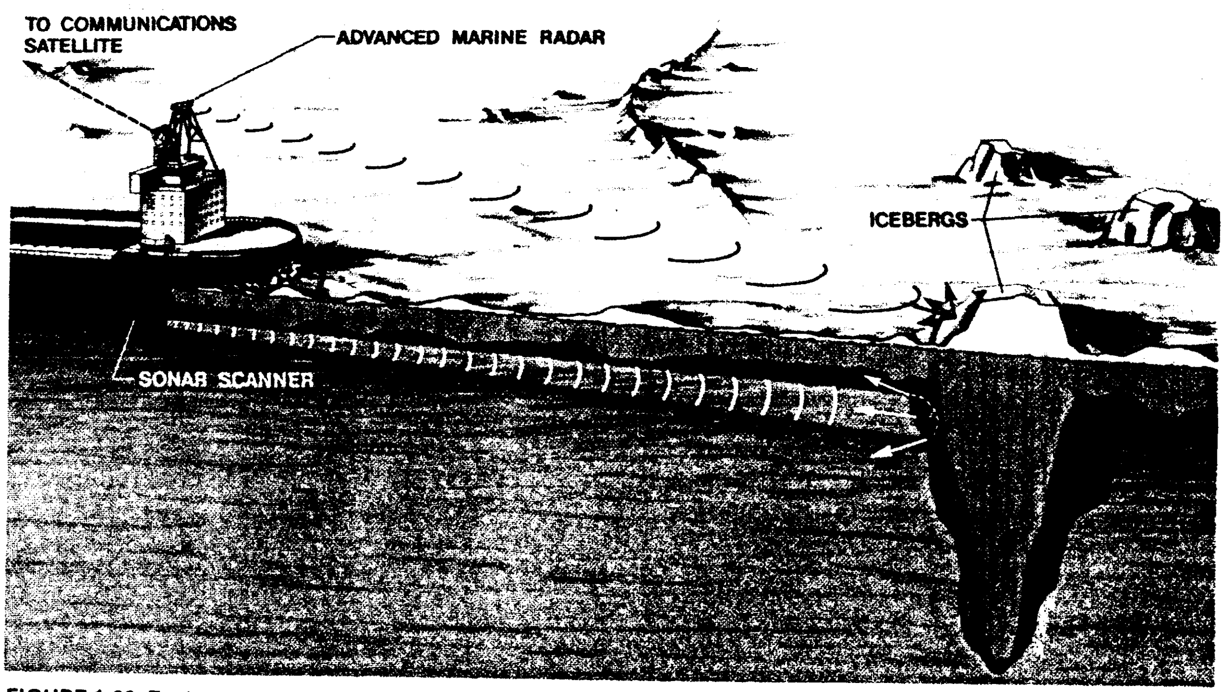



**FIGURE 1-28** *Tankers operating through the eastern tanker route will be equipped with the most advanced communication and navigation systems. Radar and sonar scanner systems will be used to provide up to the minute information on ice conditions and hazards ahead of the ship.*

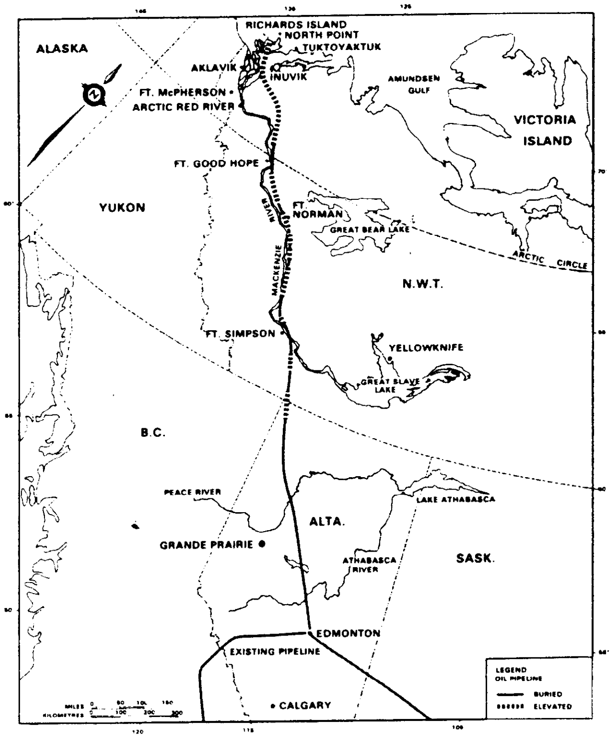



**FIGURE 1-29** *The proposed pipeline would extend from Richards Island to Edmonton. Assuming a 36" or 42" pipeline, the pipeline would probably have to be raised above the ground, due to permafrost considerations in some areas.*

The pipeline right-of-way will comprise a swath of land up to 37 metres wide, to accommodate trenching and backfilling. Where the pipeline is buried, the right-of-way will be restored and reseeded.

Construction of the pipeline along the proposed route will require crossing of six major rivers: the Mackenzie River's East Channel in the Delta, the Great Bear River, the Mackenzie River near Fort Simpson, the Peace River, the Athabasca River, and the North Saskatchewan River. At these points, the line will be buried in the river beds to a sufficient depth to avoid scouring by ice or by water currents.

Pumping stations, as schematically illustrated in Figure 1-30, will be built along the pipeline. Eventually, when oil production peaks, up to 24 pumping stations could be employed along the 2,200 km long route. Pump stations in the north will be specially designed for Arctic weather and permafrost terrain. They will be built on gravel pads, and, where necessary refrigerated foundations will be used to keep the permafrost stable. The northernmost pump station will be a tank farm on the Delta. Most of the pumping stations will have their own small topping plant to refine oil for use as fuel to drive station equipment.

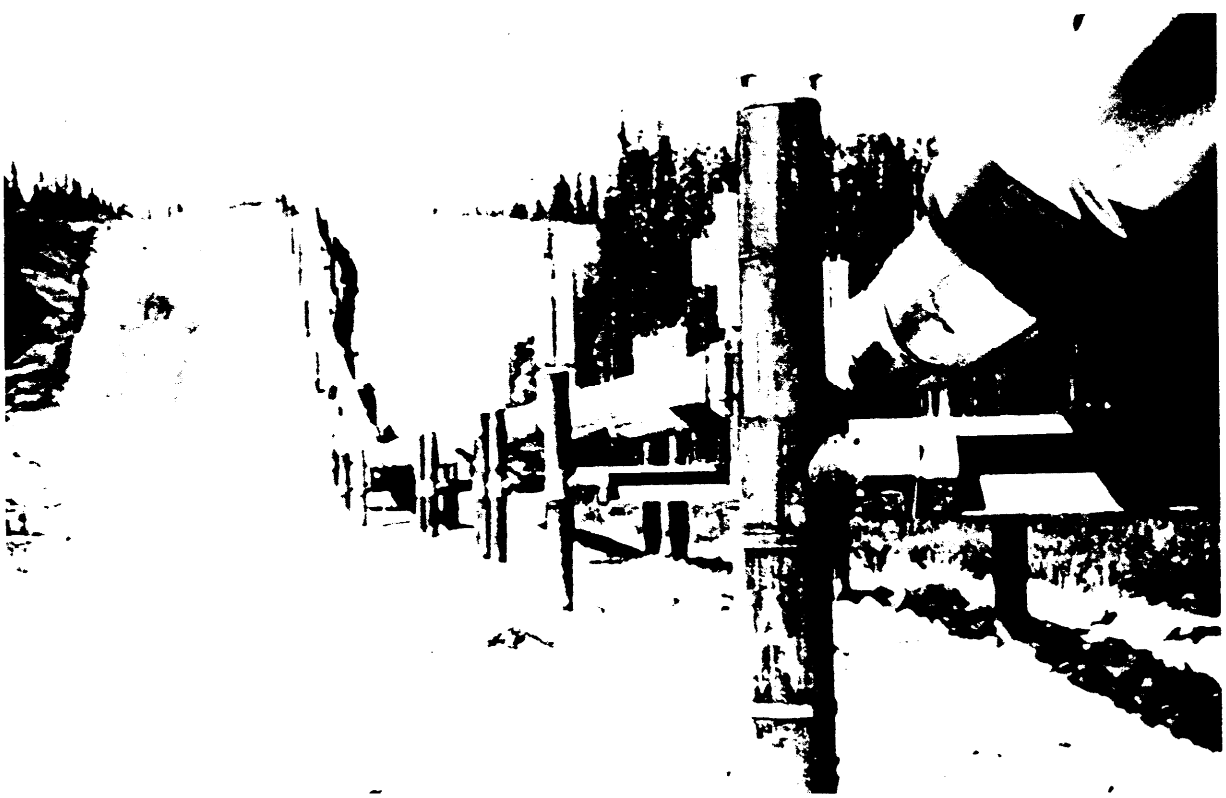


**PLATE 1-4** *The elevated sections of the Alyeska Pipeline can expand and contract by virtue of sliding mounts that support the line. In permafrost regions, as illustrated here, the vertical support members are cryoanchors - the twin metal cylinders atop the support contain gaseous ammonia which by a process of continual condensation and evaporation draws heat from the frozen ground, thereby ensuring the stability of the ground and the pipeline.*

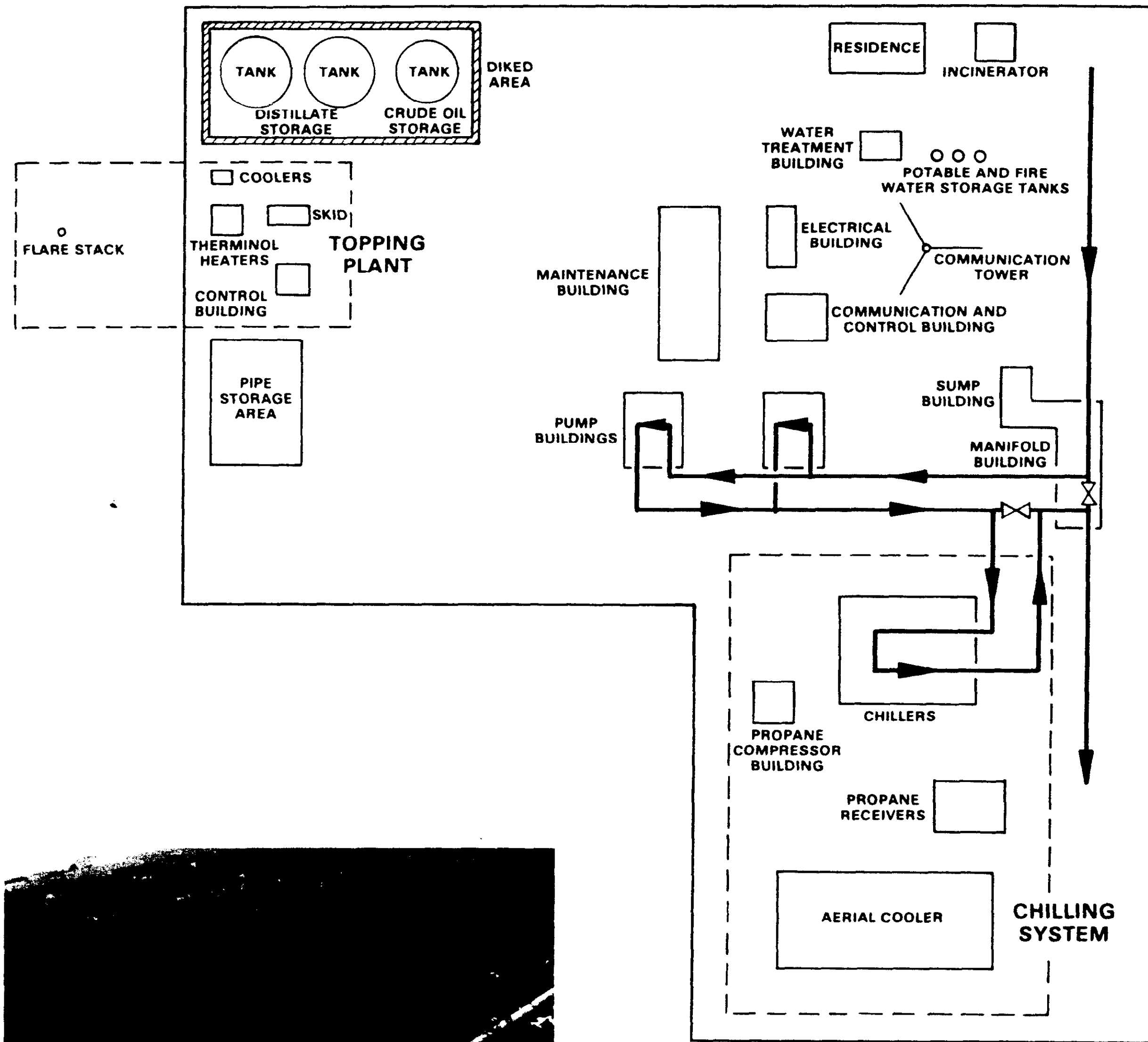



**FIGURE 1-30** *Pump stations will be constructed along the pipeline route, some of them incorporating facilities to chill the oil in order to control thermal induced stress in the pipeline and to prevent raising of soil temperatures. A typical gas turbine pump station is shown here.*

**PLATE 1-5** *The welded sections of pipeline are bent to match the land contours, and are placed in the trench by side-boom tractors. The trench is then covered over, restored and reseeded.*

It is estimated that it will take 4 years to construct the pipeline, with most activity taking place in the winter months when the land is frozen. Construction work undertaken in summer would include the building of the north and south terminals, the pump stations, and completion of river crossings. In the first two winter seasons major efforts would be expended on establishing temporary support facilities, such as wharves, airstrips, camps and access roads. North of the 60th parallel, personnel and camp supplies will be flown-in to airstrips. Some of these airstrips will also be required at certain locations for the later operation and maintenance of the pipeline. Materials, fuel and machinery would be stockpiled at intervals along the route, using primarily the Mackenzie River barge system and, on a limited basis, the Dempster Highway.

At the peak of oil pipeline construction during the third year, more than 13,000 people could be employed. Once the line is completed, about 200 employees will be required to operate and maintain the Northwest Territories portion. This number would increase to about 300 by the year 2000, as more pumping stations are built to accommodate peak oil production.

Once in operation, the pipeline will be monitored 24 hours a day by dispatchers who can control the flow rate, start-up and shut-down pumps along the route, and monitor valves and pressures. A leak detection system will indicate leaks as small as 0.5% of flow. A display panel in the control centre will show where a leak has occurred and the dispatcher will be able to isolate the leak and minimize oil spillage by closing off valves. Continuous maintenance and surveillance with air and ground patrols will enable detection of any potential problems and thus minimize environmental damage.

## 1.5 CANADIAN BENEFITS

The long term development of Beaufort Sea-Mackenzie Delta hydrocarbon resources will have a positive impact on the economic and industrial base of Canada. For instance, development reaching a technically achievable production level of over one million barrels of oil per day by the year 2000 would inject substantial wealth into the Canadian economy (Figure 1-31). It would create new jobs and income for workers in all provinces and territories, create strong sustained demand for Canadian industrial goods and services, and provide the catalyst for significant population and revenue growth in Canada's north. Beaufort oil production could assist in Canada becoming self-sufficient in crude oil supply, and the ongoing activity would stimulate revenues to turn government deficits into surpluses.

The major national economic and industrial benefits of the projected long-term development can be summarized as follows:

a) New investment ranging from 65 to 100 billion (1981) dollars.

b) Strong Canadian industrial demand through targetting Canadian content of expenditures on materials, supplies and services at 75% to 90% of all procurement.

c) The creation of 11,000 to 13,000 new direct jobs by 1990 and 17,000 to 24,000 new jobs by the year 2000.

d) A broad base of Canadian employment opportunities as 80% of all personnel would commute from their regional residence on a 2 to 3 week rotational schedule.

e) Total employment impact in Canada, including direct, indirect and induced jobs, of 200,000 to 240,000 jobs during the highest production year.

f) Provide a foundation for real economic growth in Canada as Beaufort development would add $210 to $220 billion (1981 dollars) to Gross National Product.

g) A cumulative impact on the Federal account in the order of 120 billion (1981) dollars by the year 2000.

The regional economic and industrial benefits of long term Beaufort development can be summarized as follows:

a) Total northern employment of 4,500 to 7,000 jobs by 1990 and 12,000 jobs by the year 2000.

b) The opportunity for territorial governments to become more financially independent due to a higher tax base from a growing population, and from a broader industrial base.

c) Improvements in northern infrastructure and services.

d) Stronger economies in all regions of Canada due to the multiplier effects on regional procurement expenditures and on regional Beaufort personnel incomes.

For Canada as a whole, this development would also induce many indirect intangible benefits, among which are the opportunity for application of new commercial technology in Canada, improved northern transportation, the clear establishment of Canada's Arctic sovereignty and a new generation of labour force with high level skills in new fields of technology.

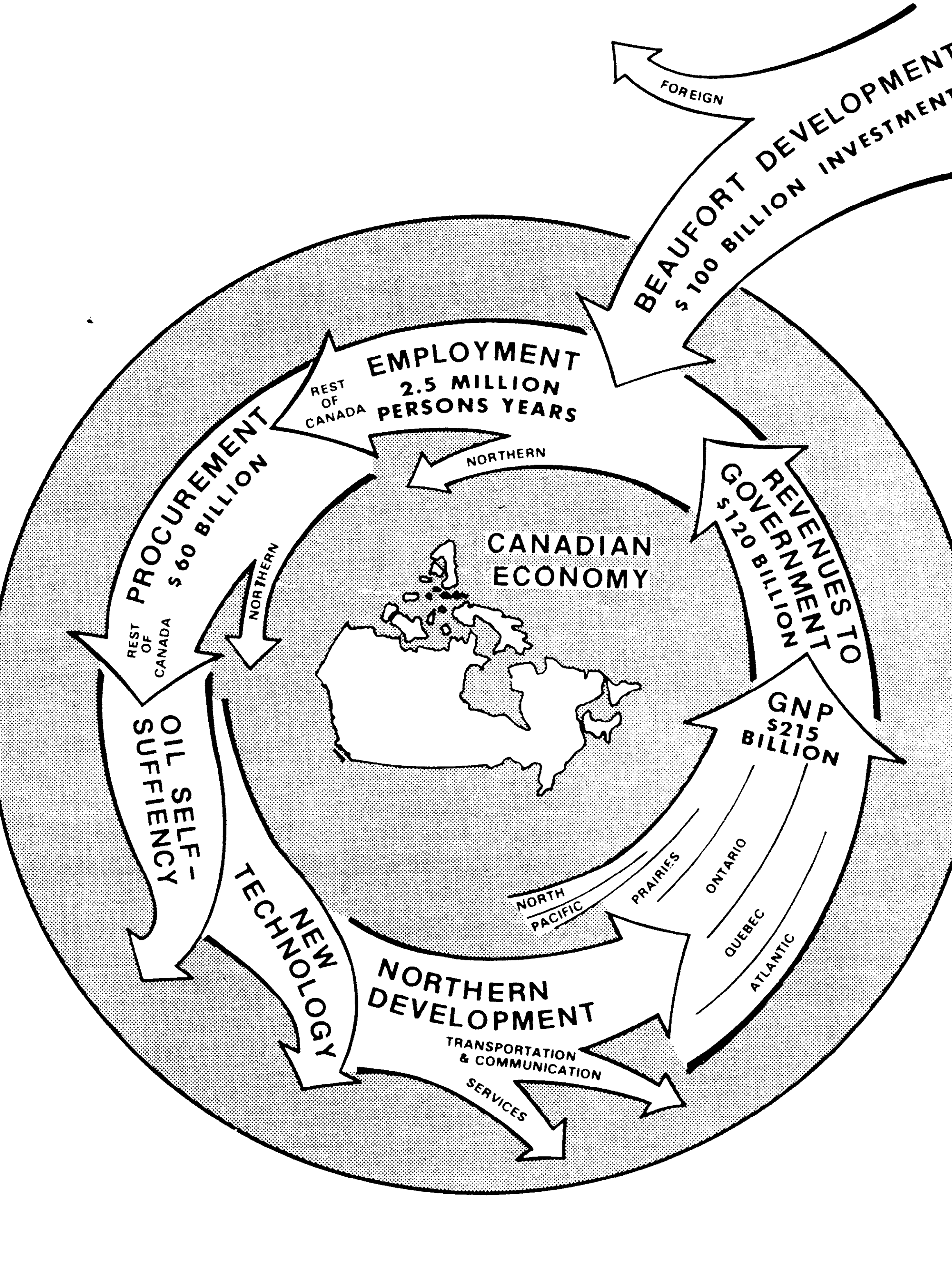



**FIGURE 1-31** *An illustration of the possible benefits and spinoffs of Beaufort development during the period 1982 to 2000.*

# CHAPTER 2
# THE BEAUFORT SEA-MACKENZIE DELTA REGION

Most of the development activity is proposed for the Beaufort Sea-Mackenzie Delta region. The sources of oil will be the oil fields found in the Mackenzie River Delta, near shore, and offshore in the Beaufort Sea on the Arctic Ocean continental shelf. The largest oil reservoirs are presently anticipated to be offshore and much of the development activity will probably be concentrated there (Figure 2-1).

The region of interest extends from the Yukon and Alaska border in the west to Cape Bathurst in the east and from Inuvik in the south (68° latitude) to the edge of the continental shelf in the north (72° latitude). The land is characterized by the numerous waterways and lakes of the flat Mackenzie River Delta, by the rising Yukon Coastal Plain between the Beaufort Sea and the British and Richardson mountains to the west, and by the coastal plain in the eastern region. Terrain elevations are highly variable from sea level to 215 m above sea level.

## 2.1 THE SETTING

In addition to the oil to be produced from offshore areas, oil and gas will be produced from wells drilled in the Delta and on the Tuktoyaktuk Peninsula (Figure 2-1). The actual location of production sites can also be influenced by regional climates, sea and ice conditions.

The region lies within the Arctic Circle, where daylight is continuous for over a month and a half in summer while the period of darkness in winter is equally as long. Summer temperatures average 6°C at the coast while winter temperatures average -30°C.

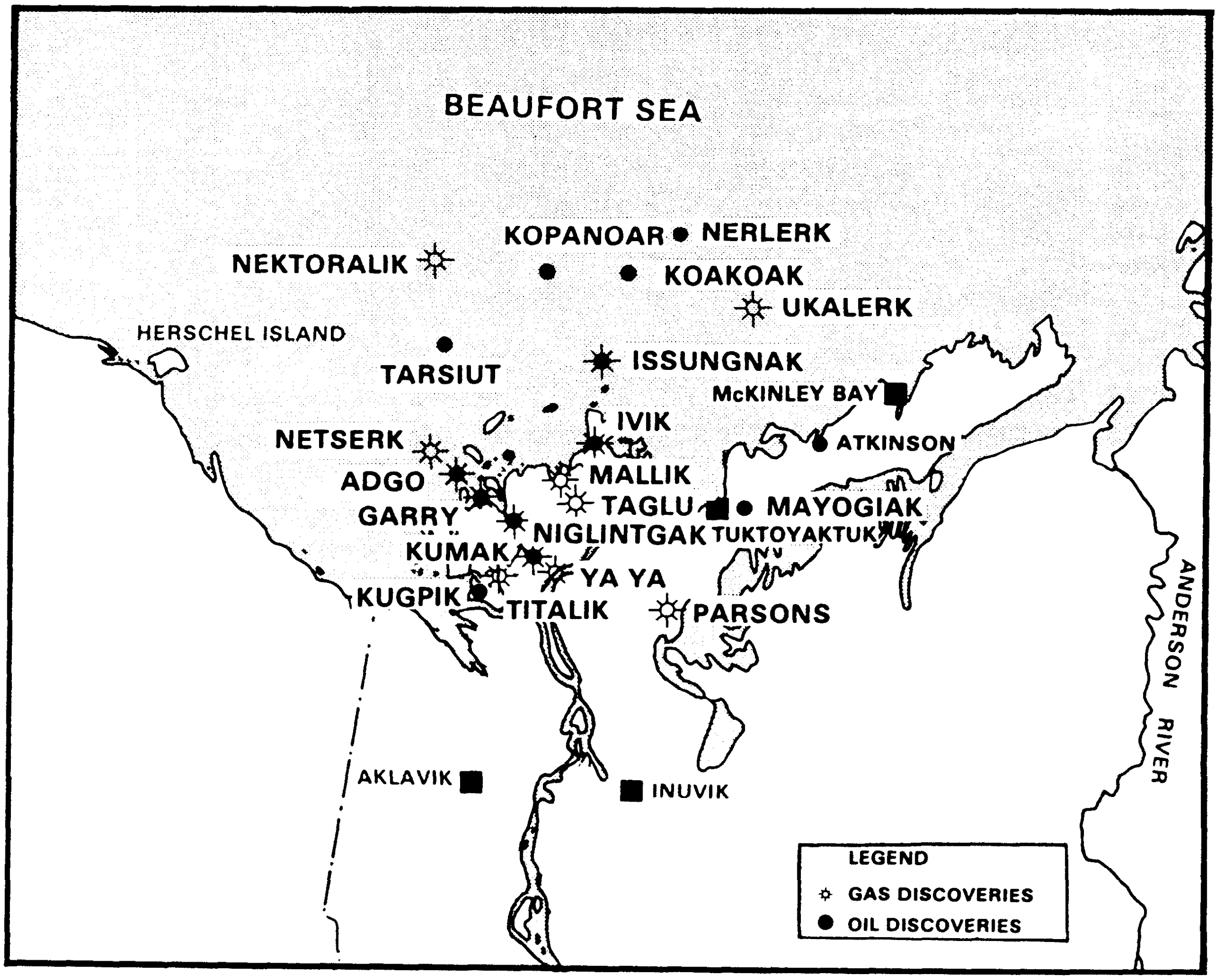



**FIGURE 2-1** *Location of oil and gas discoveries in the Mackenzie Delta and Beaufort Sea.*

## 2.1.1 ICE

Offshore, sea ice is the region's dominant feature. During the brief summer, the ice gives way to open water, which usually occurs from mid July to mid October. The season can vary by several weeks at each end depending on climatic and resultant ice conditions.

In winter, there are three ice zones (Figure 2-2). Far offshore, the polar pack ice circulates clockwise over the Canada Deep in the Arctic Ocean. Attached to the land is landfast ice which usually extends seaward to the 20m water depth by late winter. In between is the seasonal or transition ice zone. All present offshore drilling sites are located either in the landfast or seasonal ice zones.

Landfast ice begins to form and extend seaward in October and by late April reaches a thickness of about 2 metres. By June it begins to break up and melt, and usually by July, aided by offshore winds, has completely disintegrated. Typical winter landfast ice features are shown in Figure 2-3.

The ice in the polar pack zone does not completely melt in summer and comprises multi-year ice averaging 4 m in thickness by late winter. It also contains many pressure ridges which are piles of ice formed when large floes grind against each other. These have keels which can scrape the sea bottom on the shelf to create bottom scours. In summer, the southern diffuse boundary of the pack ice can move south or north depending on winds. Intrusions of polar pack ice can reduce drillship operating periods, particularly at the sites which are farthest offshore. The clockwise circulating pack can also bring with it ice islands, broken from ice shelves on northern Ellesmere Island, and thick hummock fields from the west coast of Banks Island. The characteristics of these ice features are accounted for in the design criteria of artificial islands.

Between the polar pack ice and landfast ice in winter is the seasonal ice, where shearing between the moving pack and the fixed landfast ice occurs. It can vary in width between a few to 300 kilometres depending on northerly or southerly drifts of the polar pack. The shifts and shearing cause many ridges and rubble fields to form.

Break-up in the southeastern Beaufort Sea is generally preceded by flaw leads at the entrance to Amundsen Gulf. These leads expand westward within

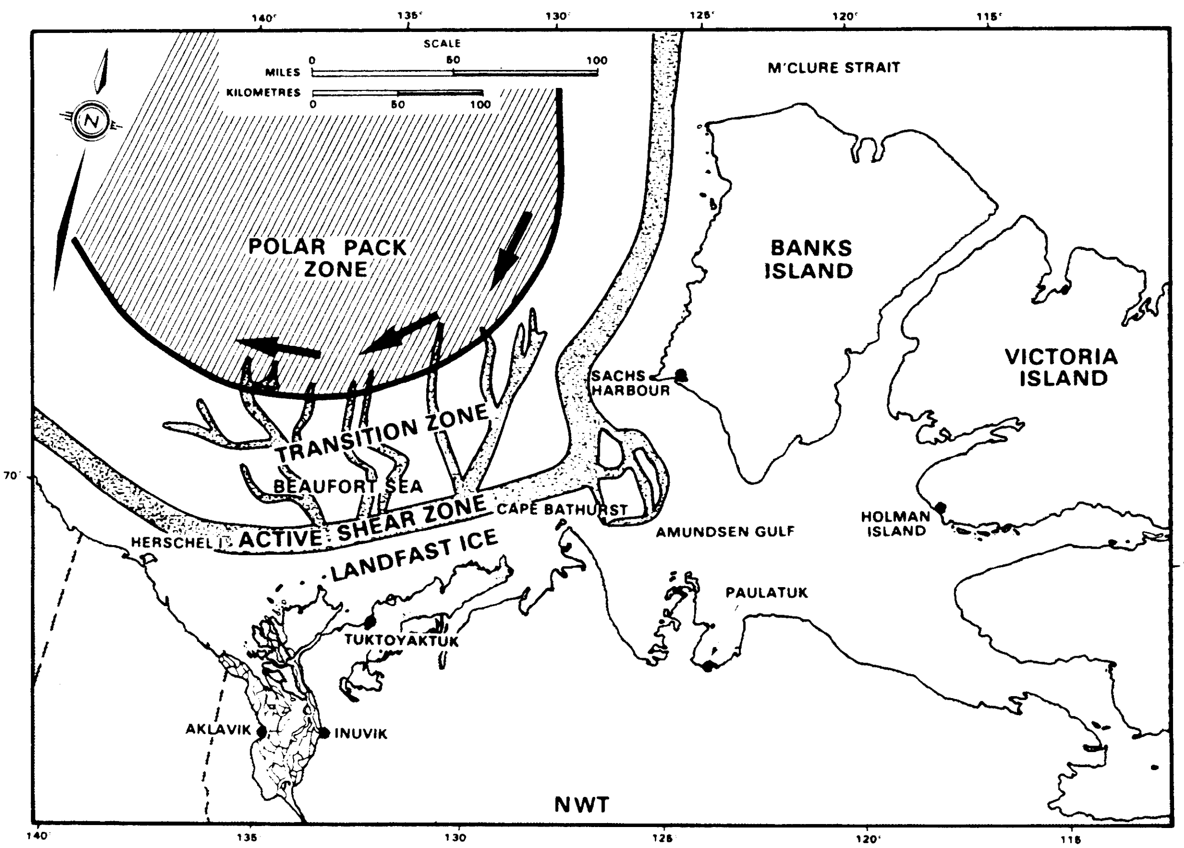



**FIGURE 2-2** *Winter ice zones of the southern Beaufort Sea. Most recent exploratory drilling is taking place seaward of the landfast ice zone.*

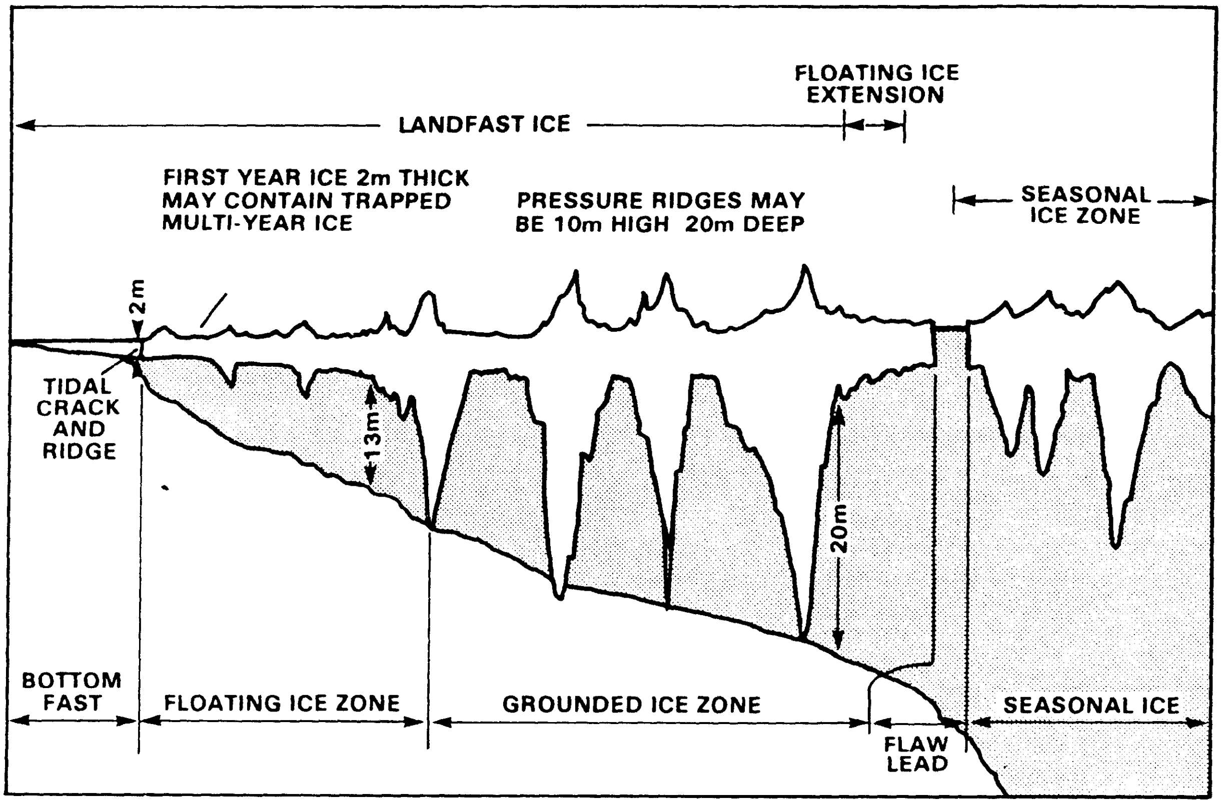



**FIGURE 2-3** *Schematic cross-section of landfast ice. Grounded ridge-keels minimize movement in winter.*

the transition zone with sustained winds from the east, and by May or June, there can be considerable open water north of the landfast ice (Figure 2-4). The leads and the open water are used by the whales and seabirds which migrate annually into the region. Subsequently, the open water is exposed to more solar heating, the melting landfast ice is released from the shores, and drifts out.

## 2.1.2 THE SEABED

All offshore exploration and future production to the year 2000 has and will take place on the continental shelf. The continental shelf's northward limit, at a depth of 100 m, extends about 150 km off the Tuktoyaktuk Peninsula (Figure 2-5). Beyond this depth is the continental slope which drops to the Canada Basin with depths of more than 3,000 m. The shallow portions of the continental shelf are scoured by sea ice, contain permafrost and support pingo-like features. All of these features are incorporated into the design criteria of offshore systems.

### 2.1.2.1 Bottom Scouring

Onshore and alongshore movements of pressure ridges and large ice features in the pack ice cause the seabottom on the shelf to be extensively furrowed. Most scouring occurs where the water depth is 25 m, about 56 km offshore and most scours are less than 2 m deep. In waters deeper than 25 m, there are fewer scours and those present are believed to be mainly ancient scours made when sea levels were lower than they are today. Data on scour frequencies and depths are used as design criteria to ensure that sea bottom installations such as wellheads and subsea pipelines will be placed deep enough below the seabed to avoid any moving ice.

### 2.1.2.2 Subsea Permafrost

Permafrost - that is, soil with a temperature less than 0°C - is widespread on the continental shelf. Sub-bottom temperatures from -0.5°C to -2°C have been recorded in numerous boreholes, and in some locations occur to depths of 700 m below the sea bed. Offshore production wells must account for the presence of subsea permafrost in their design.

### 2.1.2.3 Pingo-like Features

A number of large, conical shaped mounds occur on the floor of the continental shelf. Most are 200 to 1,000 m in diameter and some rise to within 18 m of the sea surface. Their tops often contain ice-bonded sediments. Most occur off the Tuktoyaktuk Peninsula in water depths ranging between 20 m and 100 metres. They are a navigational hazard to deep-draft

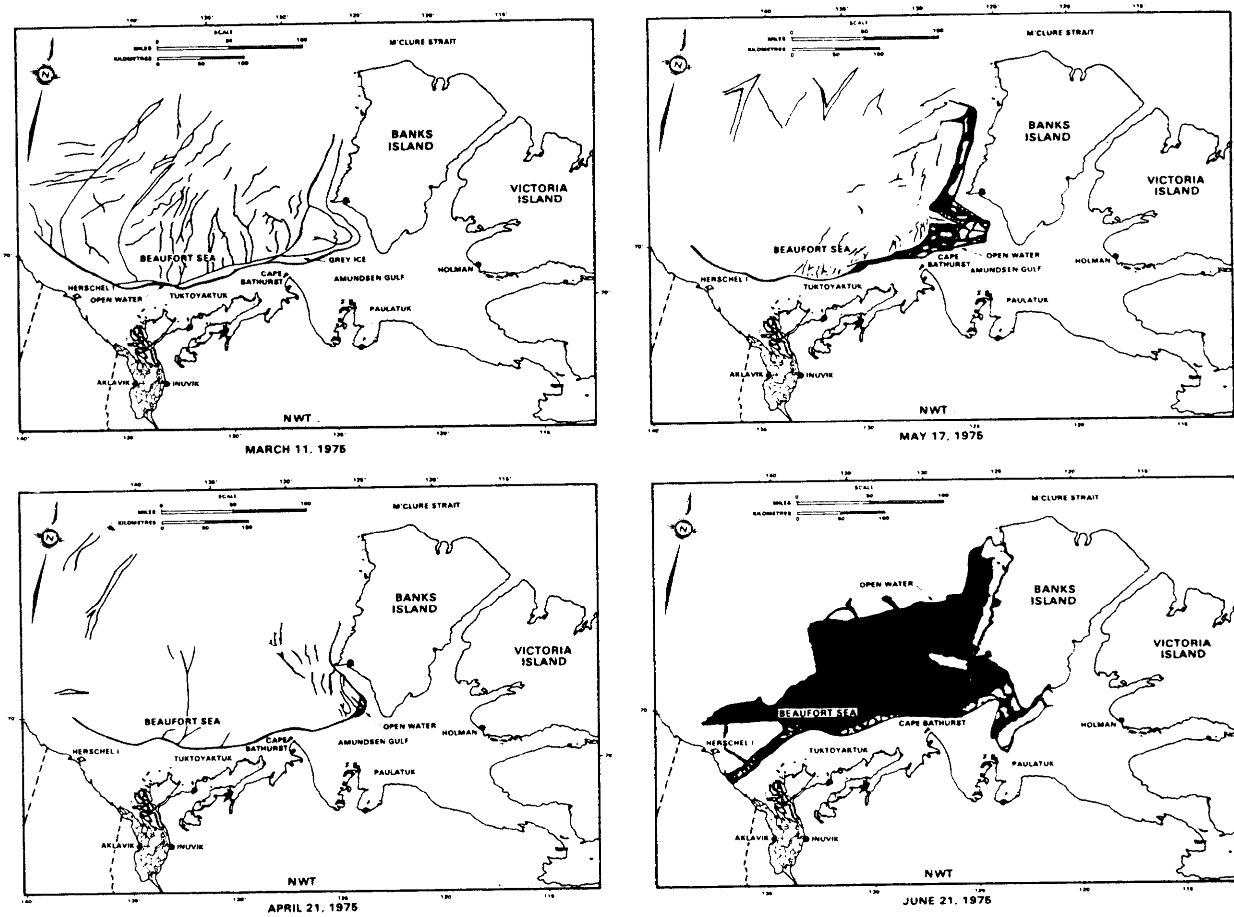



**FIGURE 2-4** *Springtime break-up patterns in the southeastern Beaufort Sea in 1975. In most years, flaw leads develop at the entrance to Amundsen Gulf and expand westward along the landfast ice edge during sustained easterly winds.*

vessels and therefore Arctic tankers will use only thoroughly surveyed corridors on the shelf. Figure 2-6 shows the location of known pingo-like features on the Beaufort Shelf.

### 2.1.3 THE MACKENZIE RIVER

Another major feature of the southeastern Beaufort Sea is the large freshwater runoff from the Mackenzie River, which drains about 18% of Canada's land area. It not only moves silt to the Beaufort Shelf - as much as 145 million tonnes annually - but yields stored heat. The river's heat input in June aids in the break-up of the landfast ice in Mackenzie Bay and Kugmallit Bay. Its mean annual flow rate is about 10,000 $m^3/s$, but the flow peaks to as much as 42,000 $m^3/s$ during freshet near the end of May. The freshwater outflow sits above the more dense salt water, resulting in a two layer water body on the Beaufort Shelf. The upper fresher layer carries suspended sediments from the river which eventually settle on the shelf (Plate 2-1).

### 2.1.4 VARIABILITY

Life at the surface of the Beaufort Sea changes with the seasons, and is governed almost entirely by the short summer's input of energy from the sun. Migratory animals exploit the brief summer season while resident species also depend on energy stored within the region to sustain them over the winter. Climatic and ice conditions can cause the yearly input of solar energy into the Beaufort region to vary widely.

Open water conditions in the southern Beaufort Sea can change from year-to-year as shown in Figure 2-7. As in seas elsewhere, life in the Beaufort Sea ultimately depends on sunlight and nutrients. When these are abundant, marine productivity is increased and when they are scarce, productivity is reduced. Little sunlight can penetrate sea ice, since compared to open water, ice reflects more solar energy back into space. Also, open water can be mixed by winds to warm deeper waters and bring nutrients upward.

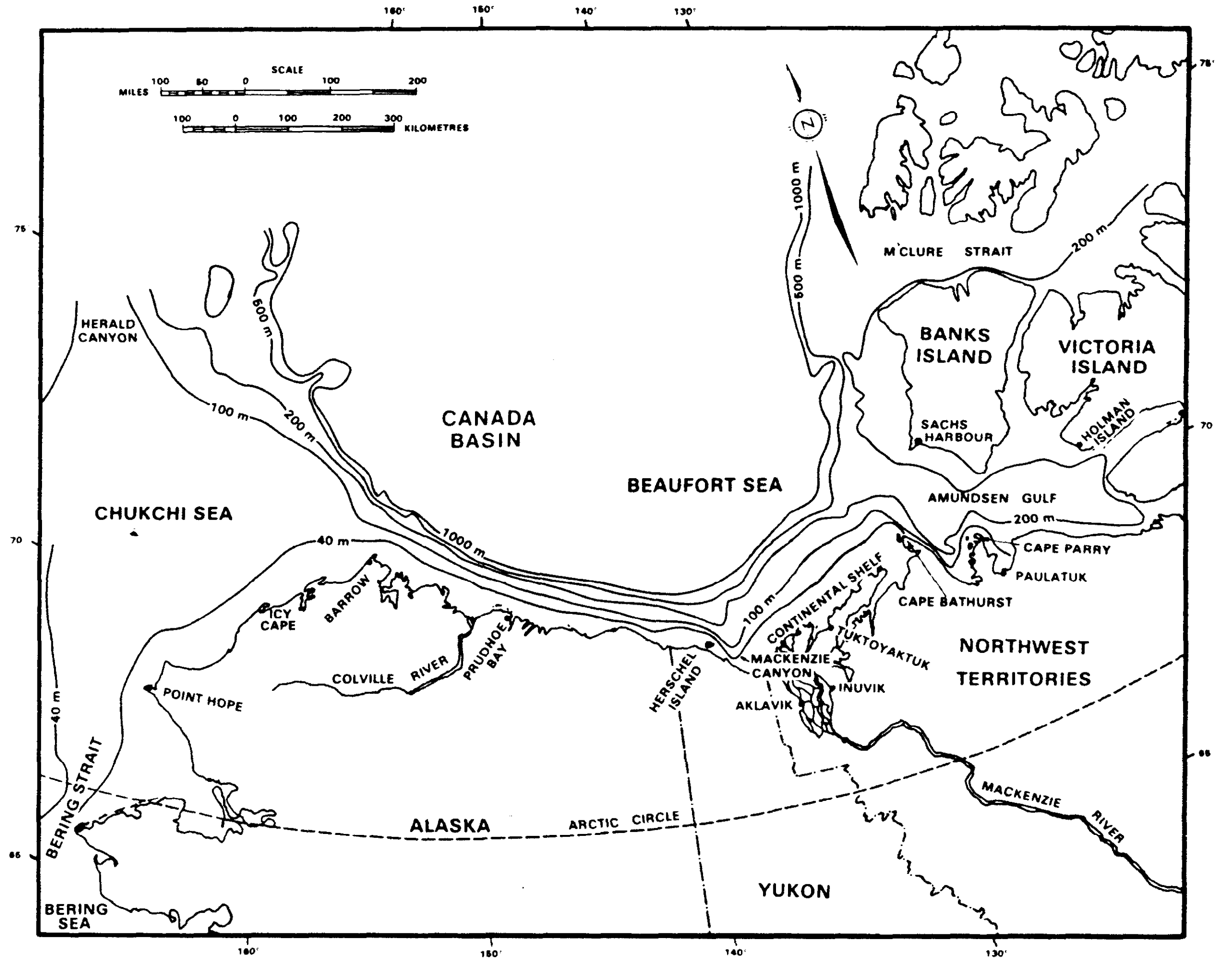



**FIGURE 2-5** *General bathymetry of the Beaufort Sea.*

The presence of nutrients in the spring causes plankton blooms, which fuel the marine food chain.

The area of summer open water in mid August varied by a factor of about five from 1974 to 1977, between the longitudes of Herschel Island and Sachs Harbour. Winds were a key factor in causing the variation. Winds from the northwest sector move this ice into open water. On the other hand, winds from the southeast sector increase the expanse of open water and may cause the upwelling of nutrient-rich water near the coast.

Evidence to verify wide differences in year-to-year biological productivity is generally limited. However, the major decline in the ringed seal population in 1975 was attributed to the heavy ice year of 1974. This was followed by a similar decline, presumably due to out-migration, of the polar bear and Arctic fox populations.

The highly variable parts of the Beaufort region's ecosystem include the atmosphere, the surface waters of the Beaufort Sea and the sea ice itself. It is likely that animals and plants dependent on these parts of the ecosystem will have regional populations that vary within limits not yet determined. Thus, in most cases, the possible impacts of future development on marine animals and plants, on a regional basis, are unlikely to be distinguishable from those inflicted upon various species by nature itself. An exception to this will be those organisms living on the seafloor in deep water, where seasonal and yearly variations are minimal.

### 2.1.5 MARINE ANIMALS

The Beaufort Sea supports far fewer fish and mammal species than do temperate oceans. The species that do live in the region have adapted to sea and ice conditions which are highly variable and subject to seasonal extremes. As a result, many of these species have habitats, migration patterns and diets which are also seasonal.

Several species of marine and terrestrial mammals, 43 species of fish and some 120 species of birds inhabit the Beaufort Sea during all or part of the

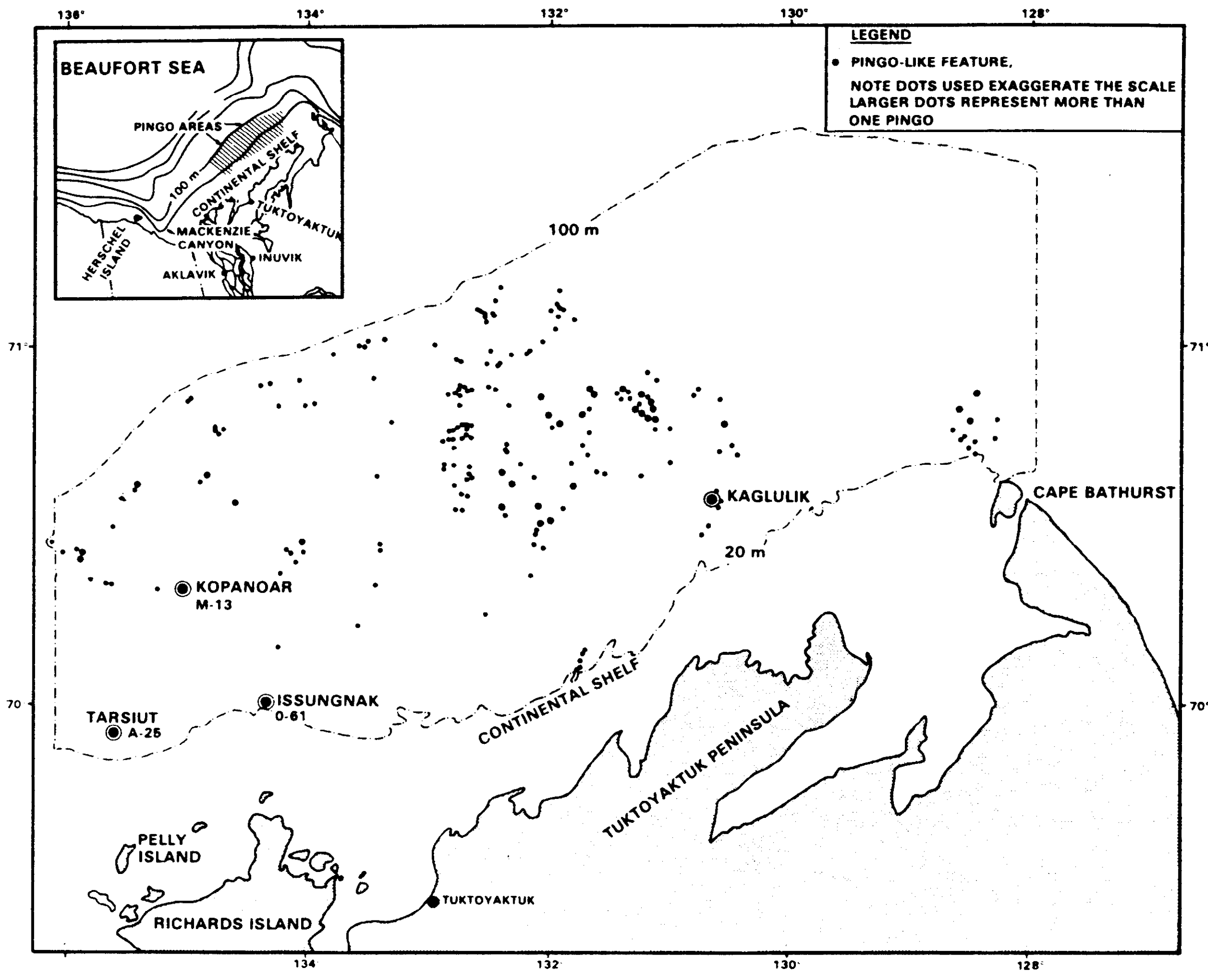



**FIGURE 2-6** *The general area of recorded pingo-like features in the Canadian Beaufort Sea.*

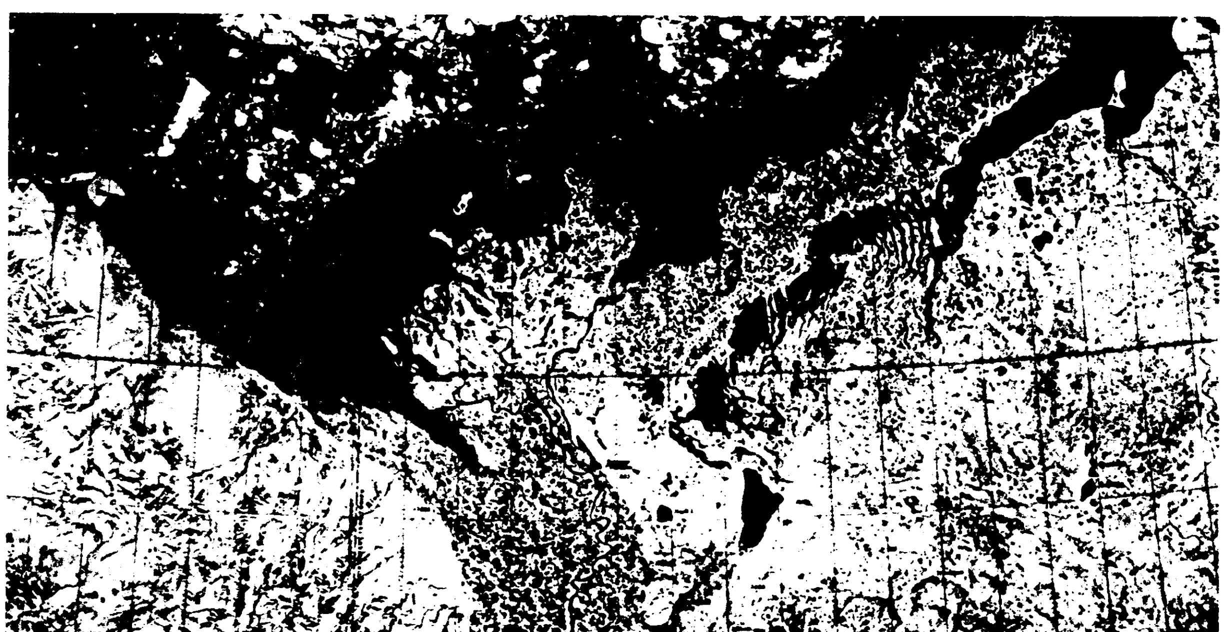


**PLATE 2-1** *Composite satellite photograph of the Beaufort Sea-Mackenzie Delta during summer. Clearly visible are the offshore polar pack ice, the dark (clear) waters of the offshore Beaufort Sea, and the muddy waters of the Mackenzie River plume as it enters the sea.*

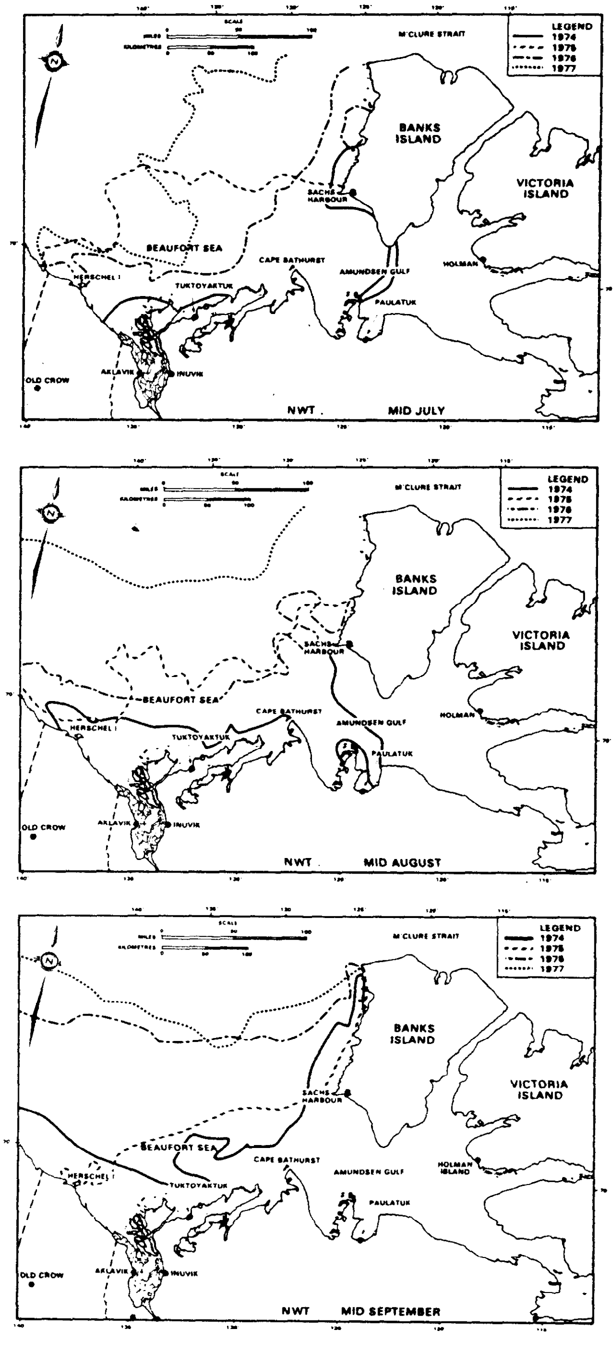



**FIGURE 2-7** *Extent of open water in the southeastern Beaufort Sea in the months of July, August and September for the years 1974 through 1977. Ice edges are defined as the location of 7/10ths ice concentration.*

year. Many are harvested by the residents of the region. The primary mammals include ringed seals, bearded seals, polar bears, Arctic foxes, bowhead whales and white whales. The most common fish species in the coastal waters are Arctic cisco, least cisco, fourhorn sculpin, Arctic char and Arctic cod. Loons, brant, oldsquaws, eiders, phalaropes, jaegers and murres are the most abundant of the many offshore migrant bird species that frequent the Beaufort Sea to breed during the summer of each year.

The ringed seal is the most abundant and widespread of the four major marine mammal species resident in the Beaufort Sea. During winter they maintain breathing holes in landfast or transitional zone ice. Their population in the Canadian Beaufort Sea is estimated to range from 23,000 to 62,000 but has been known to fluctuate by as much as 50% within a year, probably due to severe ice conditions. The less abundant bearded seals are estimated to number 1,300 to 31,000 animals. Their population also fluctuates, probably due to similar causes.

About 75% of the world population of the bowhead whale, an endangered species, migrates into the Chukchi and Beaufort seas in spring, and migrate out in the fall (Figure 2-8). The western Arctic population is currently estimated to be about 2,300. White whales (or belugas) winter in the Bering Sea and spend the summer feeding in Amundsen Gulf and the Beaufort Sea. During late June to mid July, large numbers of belugas congregate in the Mackenzie estuary, where they are traditionally hunted by the Inuit. Their population is estimated to be about 7,000 (Plate 2-2).

Polar bears are usually found on the sea ice throughout most of the year where they prey mainly on seals. Their numbers in the Beaufort Sea appear to fluctuate with changes in ringed seal abundance. Currently, 1,700 to 1,800 bears are estimated to inhabit the Canadian Beaufort region. They den mainly on the south and west coasts of Banks Island and Victoria Island (Plate 2-3).

Arctic foxes are terrestrial throughout most of their range, although they are known to move onto the nearshore landfast ice during winter, and feed on ringed seal pups. During spring and summer they go ashore to den, mainly along the coastal areas of the Mackenzie Delta-Tuktoyaktuk Peninsula. Arctic foxes are the most economically important terrestrial mammal in the southeastern Beaufort Sea, providing a major portion of the fur income of the region.

The coastal areas of the southern Beaufort Sea and Amundsen Gulf contain numerous nesting colonies for millions of seabirds. Snow geese have the largest concentration of nests (Plate 2-4). As many as 198,000 nesting individuals have been observed in one snow goose colony on southwestern Banks Island. Species such as the yellow-billed loon, yellow wagtail and bluethroat have their entire Canadian breeding population in this area.

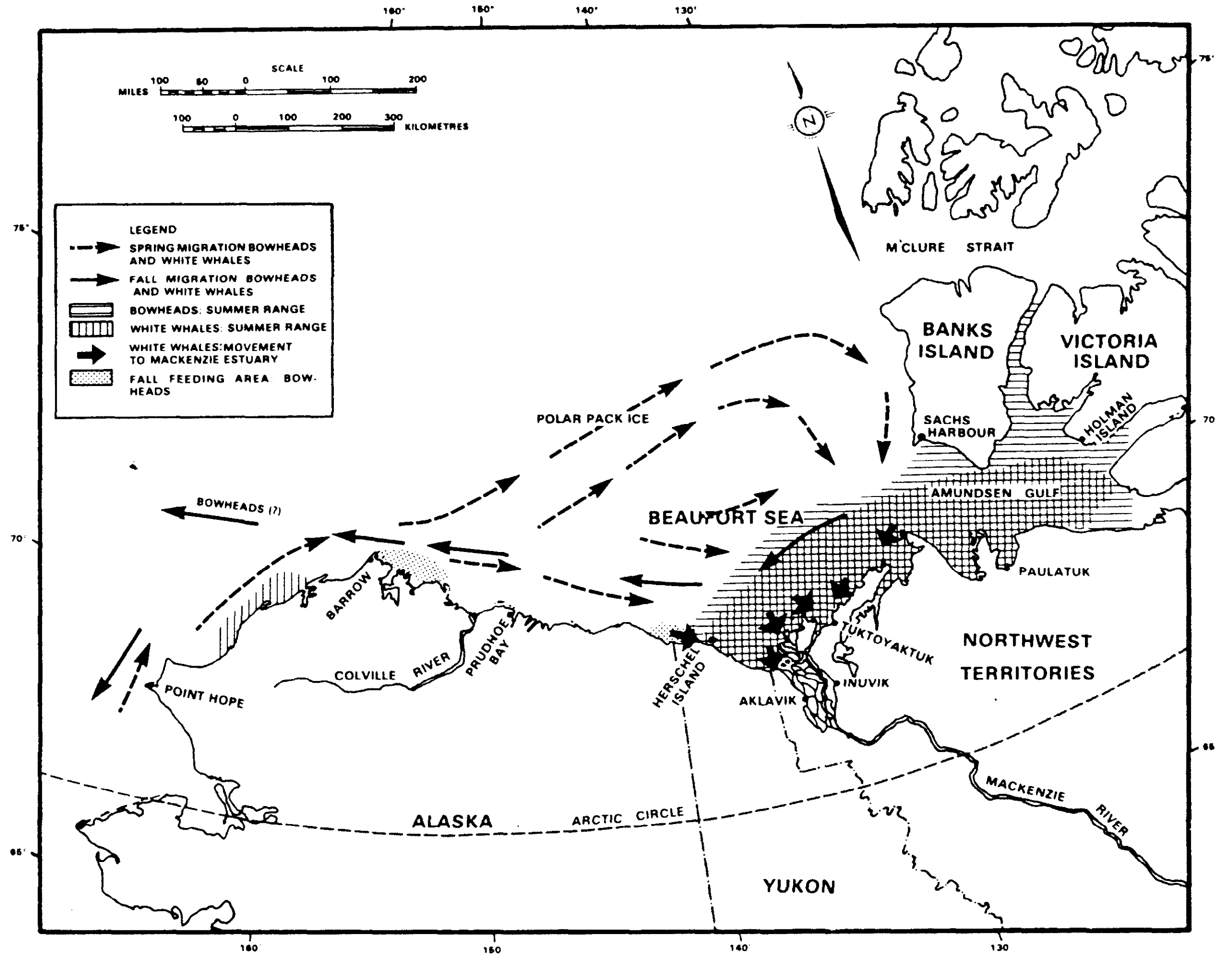



**FIGURE 2-8** *Migration routes and summer range of bowhead and white whales in the Beaufort and Chukchi seas. Bowheads and white whales first arrive at the summer range during early to mid May and usually leave during late August and September.*

**PLATE 2-2** *A group of beluga whales (white whales) in an offshore lead. Up to 7,000 have been counted in the shallow waters of the Mackenzie estuary during the summer season.*

**PLATE 2-3** *Mother polar bear and cubs travelling across sea ice in late spring. The west and south coasts of Banks Island are primary denning areas in the Beaufort region.*

**PLATE 2-4** *Snow geese with their young. The largest snow goose colony in the western Arctic is along the Egg River on southern Banks Island, where approximately 99,000 pairs nested in 1981.*

The most heavily used bird migration pathways are offshore around Alaska and over the Beaufort Sea. Open water patches along the coast are important to migrating marine birds as resting and feeding areas, usually from about May to mid June. Hundreds of thousands of spring migrants congregate to feed in such areas, mostly within one to two kilometres of the landfast ice edge (Figure 2-9). In heavy ice years, when early open water is rare, large numbers of offshore migrants have been known to die from starvation.

Most brood-rearing and moulting occurs from mid July to mid August. Many species are therefore flightless for 2 to 3 weeks during this time. The eggs and young of those species which nest in low-lying coastal areas are also vulnerable to storm surges — wind-driven pile-ups of water that commonly occur in shallow seas around the world. In the Beaufort Sea, these storm surges cause the sea to flood low-lying lands when there are strong onshore winds and large expanses of open water.

Eight of the 120 bird species nesting in the Canadian Beaufort are thought to have low or declining populations. Two of these are considered to be endangered; the Eskimo curlew which breeds only in the Anderson River area, and the peregrine falcon which breeds on the Yukon North Slope, and in the Anderson, Mackenzie and Horton River valleys.

### 2.1.6 COASTAL LANDS AND WILDLIFE

The coastal areas of the Beaufort Sea and the Mackenzie River Delta support many species of terrestrial mammals, birds and fish (Figure 2-10). The terrain is generally low-lying. In the west, the Yukon Coastal Plain is 10 to 25 km wide and extends from the Alaska-Yukon border about 130 km to the western edge of the Delta. The Delta is nearly level and rises only to an elevation of 10 to 15 m above sea level near Fort McPherson. It contains numerous lakes and stream channels. To the east of the Delta is Richards

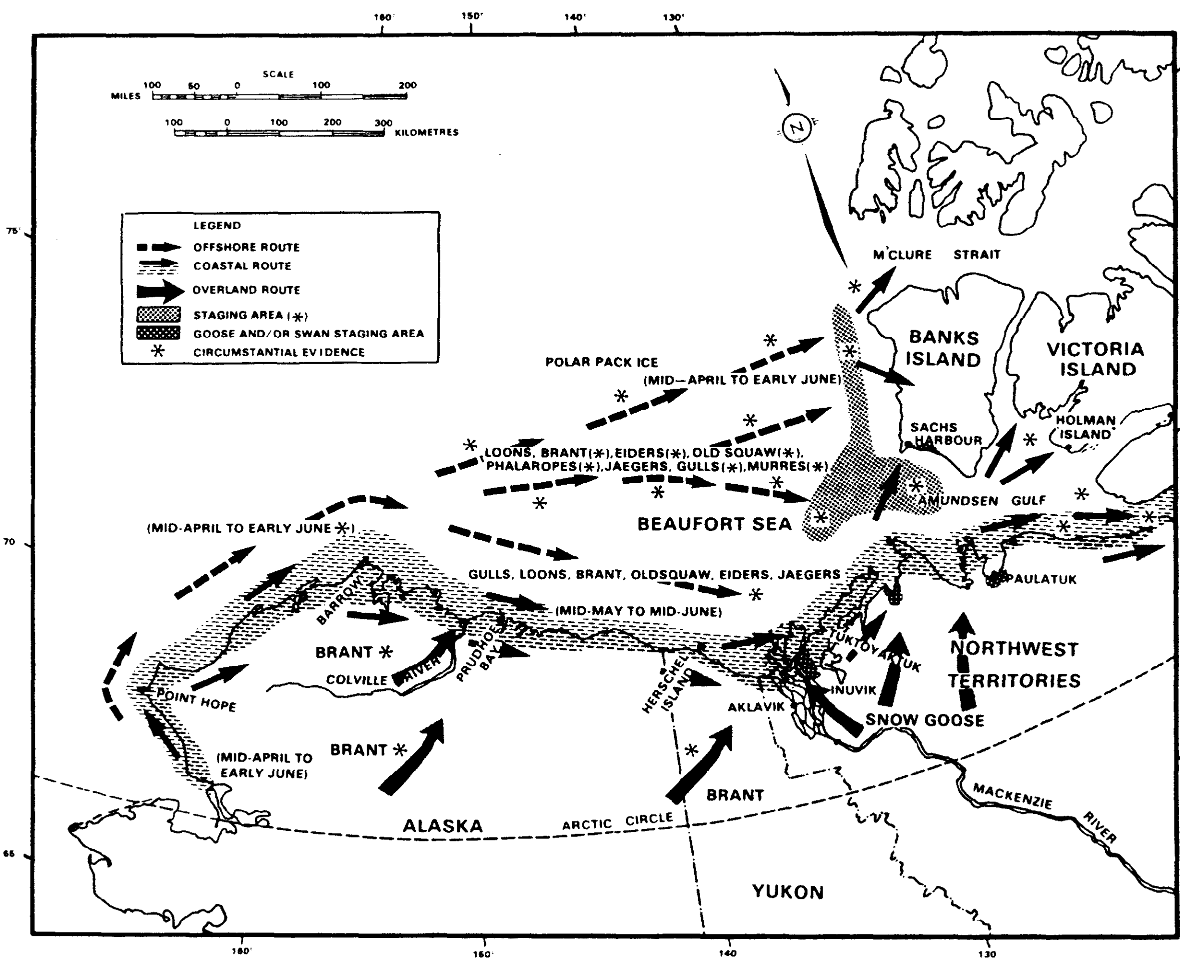



**FIGURE 2-9** *Summary of the spring migration routes of birds through the Northeast Chukchi-Beaufort region.*

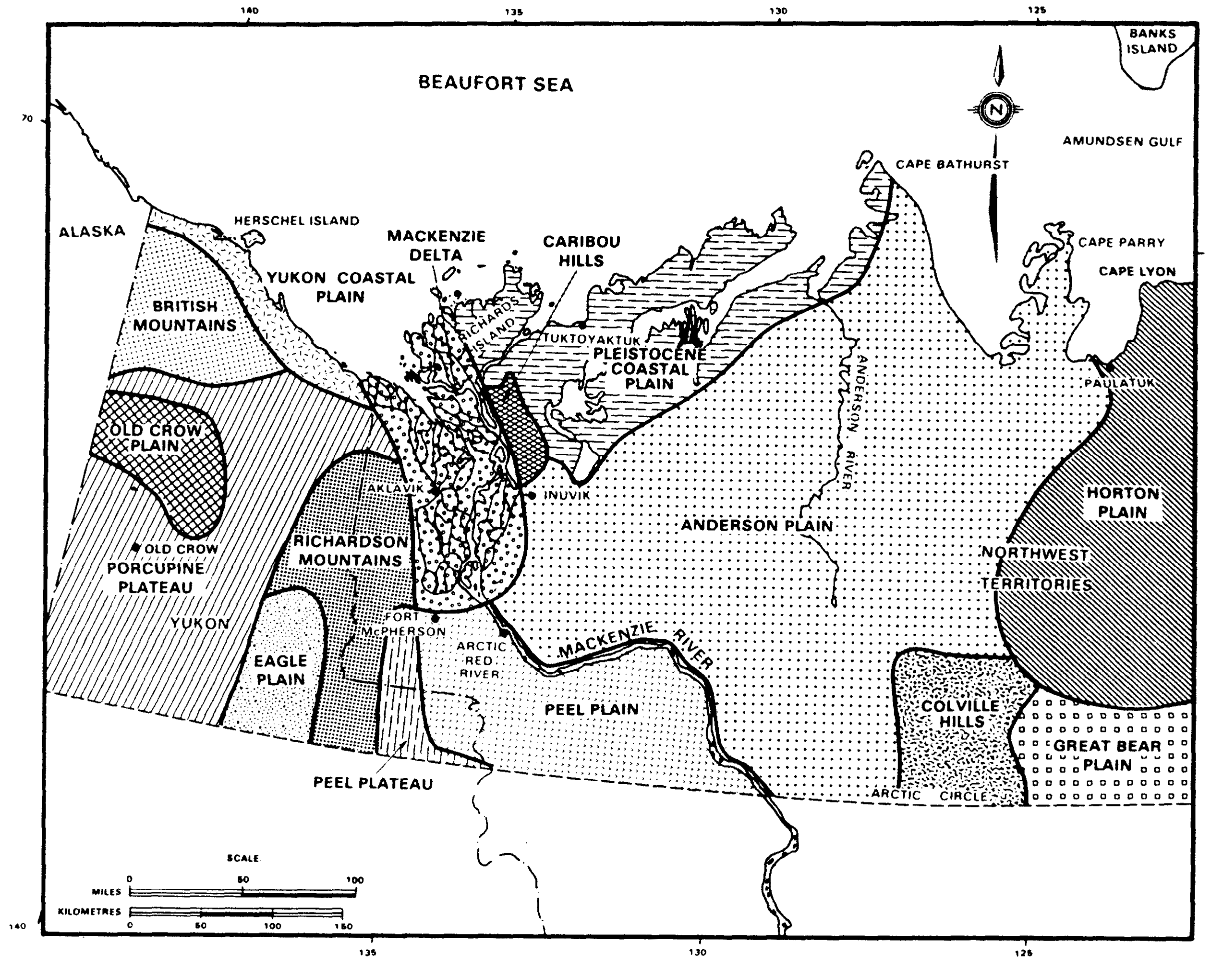



**FIGURE 2-10** *Physiographic divisions of the onshore Beaufort area.*

Island, Tuktoyaktuk Peninsula and an eastern coastal plain, where elevations range from sea level to 100 m on Richards Island, and to 215 m in the Caribou Hills next to the Delta. Numerous lakes are scattered throughout this eastern coastal region.

The entire area is underlain by permafrost. In the Yukon Coastal Plain it is about 500 to 600 m thick. However, in the Delta it can be 20 m to 60 m thick and absent under major river channels. To the east, its thickness ranges from 650 m on Richards Island to 140 m south of Cape Bathurst and it is absent under major rivers and lakes.

The dominant tundra vegetation, consisting mostly of lichens, mosses and peat, forms an insulating layer over the permafrost, minimizing the thickness of the unfrozen surface layer in summer. Damage to the tundra can cause subsidence and erosion problems. These can be avoided by having construction activities carried out in winter using snow roads.

Among the most important terrestrial mammal species to the subsistence hunting and trapping economy are caribou, moose, grizzly and black bears, muskrat, Arctic fox, wolf, marten, lynx and Dall's sheep.

There are three sub-species of caribou in the region, namely reindeer, barren-ground caribou, (Plate 2-5) and Grant caribou. Caribou undergo long distance migrations, because their habitat diet requirements change seasonally (Figure 2-11). Presently, caribou populations in the region have either been stable or in some cases have been increasing. Caribou are the most important terrestrial mammal harvested by the local residents. The calving areas of the two major herds, the Porcupine and Bluenose, are located mainly on upland areas near the coast (Figure 2-12). These are along the Alaska-Yukon coast for the Porcupine Caribou, and on the Bathurst Peninsula for Bluenose Caribou. The reindeer herd is domesticated and occupies the grazing reserve shown in Figure 2-13.

**PLATE 2-5** *The Porcupine caribou herd, which spends most of its time in the northern Yukon, is considered to have a relatively stable population at the present time, estimated at between 98,000 and 110,000 caribou. (Courtesy: G. Calef, Northwest Territories Wildlife Service).*

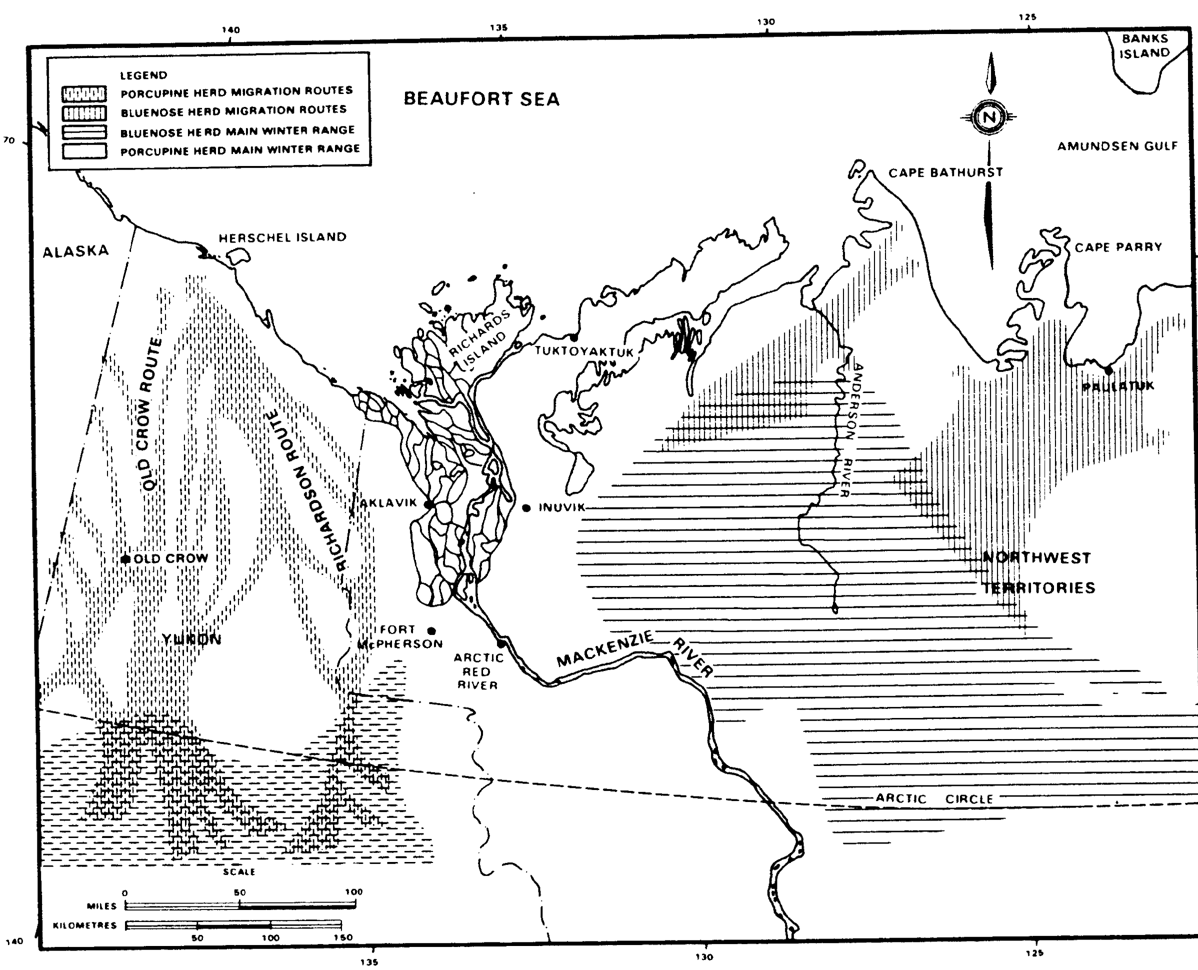



**FIGURE 2-11** *Caribou winter range and spring migration routes. Both the Porcupine herd and the Bluenose herd are noted for their long distance migrations from wintering ranges in the northern boreal forests to summer ranges in coastal tundra areas.*

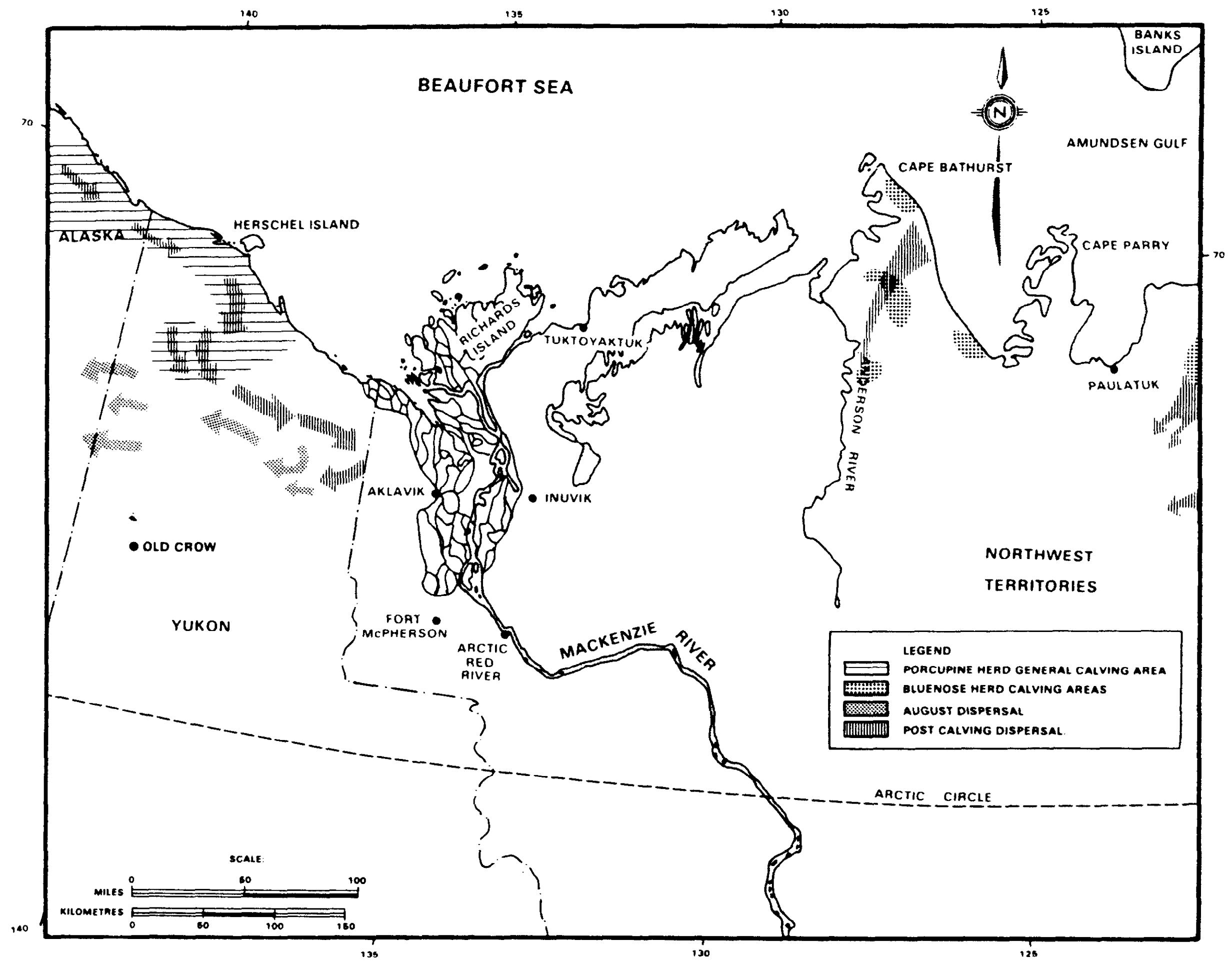



**FIGURE 2-12** *Caribou calving areas, post calving and August dispersals. The calving areas of both major herds of caribou are located mainly on upland areas near the coast, along the Alaska-Yukon coast for Porcupine caribou and on the Bathurst Peninsula for Bluenose caribou.*

Among the inland fish species, whitefish, cisco, inconnu and Arctic char are the most abundant and sought after. They move downstream into coastal feeding habitats during the summer, and return to spawn and overwinter in freshwater during the fall. The numerous channels in the Delta serve as important migratory corridors for these species.

Birds that occur in the Delta and the outer coastal areas include true seabirds which come ashore only to nest; waterfowl such as swans, geese and ducks; raptors which include hawks, eagles, falcons and owls; shorebirds and passerines. Swans, geese and ducks are of particular importance to the diet of the local residents.

Certain areas of the region are recognized for their unique physical or ecological characteristics. Some, such as the areas of interest to Parks Canada and wildlife sanctuaries, have been granted special status, (Figure 2-13), while others are under consideration for special status. Of particular importance are areas identified under the International Biological Program (IBP), including Kendall Island, the Anderson River Delta, Cape Parry and southwestern Banks Island. In addition, a national park is proposed in the Northern Yukon, which could include part of the Yukon coastal plain and most of Herschel Island.

## 2.2 IMPACTS OF HYDROCARBON DEVELOPMENTS IN THE BEAUFORT SEA-MACKENZIE DELTA REGION

The following section discusses the main possible effects of proposed hydrocarbon developments in the Beaufort Sea-Mackenzie Delta region on the environment and its people. Section 2.2.1 briefly reviews

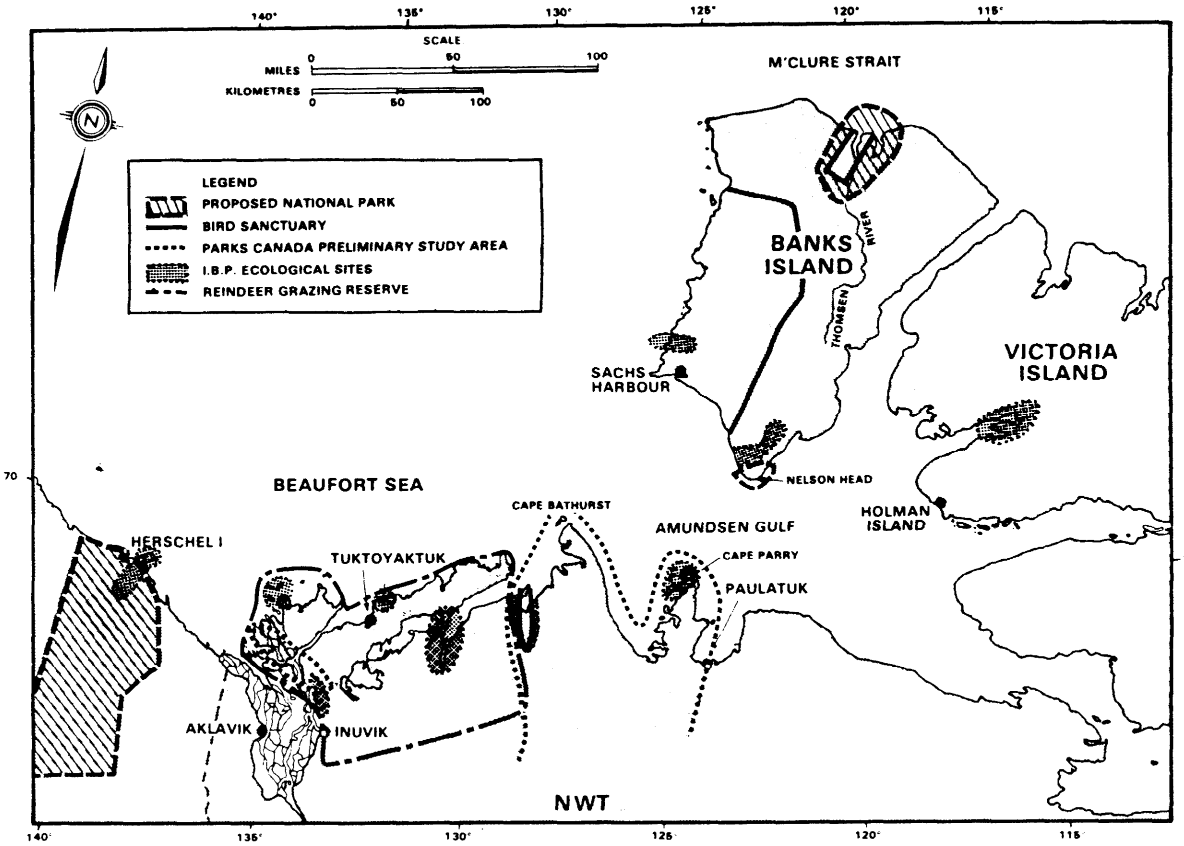



**FIGURE 2-13** *Location of special areas in the Canadian Beaufort Sea region.*

projected offshore environmental impacts, while Sections 2.2.2 and 2.2.3 summarize possible environmental impacts related to onshore production and coastal shorebase developments, respectively. These are followed by brief reviews of the possible effects of major oil spills (Section 2.2.4) and highlights of how development may affect the human environment (Section 2.2.5).

### 2.2.1 ENVIRONMENTAL IMPACTS OF HYDROCARBON DEVELOPMENTS IN THE OFFSHORE PRODUCTION REGION

Possible impacts of the proposed hydrocarbon development on the biological resources and the physical environment of the Beaufort Sea are summarized below. Only those effects which may be of greatest regional concern are highlighted. The possible impacts are assessed on a regional basis due to the large geographic area encompassed by the proposed development, although most effects will be local in nature. The terms used to describe possible impacts are those employed throughout the assessment sections of the Environmental Impact Statement and are defined in Appendix 3 of this volume.

Matrix 2-1 summarizes the projected impacts of proposed development activities on the main marine resources. Most are expected to be NEGLIGIBLE from a regional perspective, although MINOR, and a few MODERATE impacts are considered possible for some resource-development interactions.

#### 2.2.1.1 Water Quality and the Physical Oceanographic Regime

Discharges of sewage, heated cooling water, drilling muds, blowout preventer fluid, ballast water and produced water will have some effects on LOCAL water quality. In general, discharges in offshore waters will be confined to the areas surrounding drilling platforms and vessels, and will be rapidly diluted by the sea. The use of oil-water separators and sewage treatment at all facilities will reduce the quantities of contaminants released to the sea. As a result, the possible effects of most discharges on water quality are not considered to be of significant regional concern. An exception is the possible chronic

**MATRIX 2-1**
**POTENTIAL REGIONAL IMPACTS OF NORMAL HYDROCARBON DEVELOPMENT ACTIVITIES ON THE BIOLOGICAL RESOURCES OF THE OFFSHORE AND COASTAL ZONE OF THE BEAUFORT SEA**
**1982-2000**

| | | MAMMALS | | | | | | BIRDS | | | | | | | FISH | | | LOWER TROPHIC | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | WHITE WHALE | BOWHEAD WHALE | RINGED SEAL | BEARDED SEAL | POLAR BEAR | ARCTIC FOX | LOONS | DUCKS | GEESE/SWANS | SHOREBIRDS | JAEGERS/GULLS/TERNS | ALCIDS | OTHER BIRDS | PELAGIC MARINE | DEMERSAL MARINE | ANADROMOUS | EPONTIC ORGANISMS | PLANKTON | BENTHIC EPIFAUNA | BENTHIC INFAUNA |
| ● **COMMON WASTES AND DISTURBANCES** | | | | | | | | | | | | | | | | | | | | | |
| HUMAN PRESENCE | | | | | | ◊ | O | O | O | O | O | O | O | O | O | O | O | | | | |
| SOLID WASTES | | | | | | ◊ | O | | | | | O | | O | | O | | | | O | ◊ |
| TREATED SEWAGE | VESSELS | O | O | O | O | | | O | O | | | O | O | O | O | O | O | O | O | O | O |
| | EXPLOR./PRODUCT. FACILITIES | O | O | O | O | | | O | O | | | O | O | O | O | O | O | O | O | O | O |
| | SHOREBASES | O | O | O | O | | | O | O | O | O | O | O | O | O | ◊ | O | O | ◊ | O | ◊ |
| AIR EMISSIONS | | | | | | O | O | O | O | O | O | O | O | O | | | | | | | |
| AIRBORNE NOISE | AIR TRAFFIC | | | ◊ | ◊ | O | O | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | | | | | | | |
| | OTHER MOBILE SOURCES | | | O | O | O | O | O | O | O | O | O | O | O | | | | | | | |
| | STATIONARY SOURCES | | | O | O | | O | O | O | O | O | O | O | O | | | | | | | |
| UNDERWATER SOUND | MOBILE SOURCES | ◊ | ◊ | ◊ | ◊ | | | | | | | | | | O | O | O | | | | |
| | STATIONARY SOURCES | ◊ | ◊ | O | O | | | | | | | | | | O | O | O | | | | |
| ARTIFICIAL ILLUMINATION | OFFSHORE | | | O | O | ◊ | O | O | O | | | O | O | O | | | | | | | |
| | SHOREBASES | | | | | ◊ | O | O | O | O | O | O | O | O | | | | | | | |
| ● **OFFSHORE PLATFORMS** | | | | | | | | | | | | | | | | | | | | | |
| SEISMIC PROGRAMS | | O | O | O | O | | | | | | | | | | O | O | O | | | | |
| B.O.P. FLUID | | O | O | O | O | | | O | O | | | O | O | O | ◊ | ◊ | ◊ | | O | ◊ | ◊ |
| TRITIATED WATER | | O | O | O | O | | | O | O | | | O | O | O | O | O | O | O | O | O | O |
| PHYSICAL PRESENCE | | O | O | O | O | ◊ | O | O | O | | | O | O | O | O | O | O | | | O | O |
| DRILLING WASTES | | O | O | O | O | | | O | O | | | O | O | O | O | ◊ | O | O | O | ◊ | ◊ |
| COMPLETION FLUIDS | | O | O | O | O | | | O | O | | | O | O | O | ◊ | ◊ | O | ◊ | ◊ | O | O |
| FORMATION WATER | | O | O | ◊ | ◊ | | | ◊ | ◊ | | | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | O | O | O | O |
| OILY WASTE | | O | O | O | O | | | ◊ | ◊ | | | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | O | O |
| HEATED COOLING WATER | | O | O | O | O | | | O | O | | | O | O | O | O | O | O | ◊ | ◊ | O | O |
| CEMENT | | O | O | O | O | | | | | | | | | | O | O | O | | O | O | O |
| GAS FLARES | | | | | | O | O | ◊ | ◊ | | | O | ◊ | O | | | | | | | |
| ● **DREDGING** | | | | | | | | | | | | | | | | | | | | | |
| PHYSICAL OPERATION | | ◊ | ◊ | O | O | | | O | O | | O | O | O | O | O | ◊ | ◊ | O | | | |
| TURBIDITY PLUMES | | O | O | O | O | | | O | O | | O | O | O | | O | O | O | O | O | O | |
| SUBSTRATE DISTURBANCE | | | O | | O | | | O | O | | | | O | | O | O | O | | | ● | ● |
| ● **SUBSEA PIPELINES** | | | | | | | | | | | | | | | | | | | | | |
| DREDGING | | ◊ | ◊ | O | O | ◊ | | O | O | | | O | | O | O | ◊ | ◊ | O | O | ● | ● |
| VESSEL TRAFFIC | | ◊ | ◊ | O | O | | | O | O | | | O | | O | | | | | | | |
| ICEBREAKING | | O | O | ◊ | ◊ | | O | O | O | | | O | | O | O | O | | O | O | | |
| ARTIFICIAL SUBSTRATES | | | | | | | | | | | | | | | O | O | O | | | O | O |
| SUBSEA COMPLETIONS | | O | O | O | O | | | | | | | | | | O | O | O | | O | ● | ● |
| ● **MARINE VESSEL TRAFFIC** | | | | | | | | | | | | | | | | | | | | | |
| LOCAL TRANSPORT | OPEN WATER SEASON | O | O | O | O | | | | | | | | | | O | O | O | | O | | |
| | ICEBREAK./LANDFAST ZONE | O | O | ◊ | O | | O | O | O | | | O | | | O | O | | O | O | | |
| | ICEBREAK./TRANSITION ZONE | O | O | ◊ | ◊ | | | O | O | | | O | | | O | O | | O | O | | |
| TANKER TRAFFIC | ICEBREAKING | O | O | ◊ | ◊ | | | O | O | | | O | | | O | O | | O | O | | |
| | BALLAST WATER | O | O | O | O | | | | | | | | | | O | O | O | O | O | O | O |

*POTENTIAL IMPACTS (ASSUMING SUCCESSFUL IMPLEMENTATION OF MITIGATIVE MEASURES DESCRIBED IN TEXT)

LEGEND: O NEGLIGIBLE ◊ MINOR ● MODERATE ■ MAJOR local contamination of offshore waters with petroleum hydrocarbons from the LONG-TERM discharge of large volumes of formation (produced) water from offshore oil fields. Even following treatment of formation water with oil-water separators, considerable volumes of emulsified oil could enter the sea if produced water is not injected back into the geological strata. Formation water is also likely to contain some dissolved trace metals. However, at offshore fields, much of the produced water is likely to be injected into reservoirs for pressure maintenance.

Dredging activities and the construction of artificial islands will have LOCAL impacts on water quality as a result of SHORT-TERM increases in suspended sediment concentrations.

Dredging will locally alter the Beaufort Sea continental shelf by creating excavation pits and deposition sites during the construction and eventual abandonment of artificial islands. These features may persist for several decades in local areas, but are not expected to change general bottom currents. In some instances they will be similar to natural ice scours and pingo-like features which are common in this area. Significant impacts on the physical oceanographic environment of the Beaufort Sea are not expected, although the physical presence of artificial islands and dredged depressions in the seafloor could produce LONG-TERM but LOCAL changes.

Artificial islands will not have regionally significant effects on currents or wave patterns. They are also unlikely to alter regional break-up dates or the extent of the landfast ice beyond that encompassed within its year-to-year natural variability. Similarly, effects on the ice regime from icebreaking vessels are likely to fall well within the range of natural year-to-year variability. Icebreakers will be restricted to specific corridors, and their effects will be limited and LOCAL.

Artificial open water leads in the landfast ice are not expected to be formed by icebreaker tracks between November and May. The rapid consolidation of ice rubble in their wake will allow safe crossings to be made soon after the passage of an icebreaker.

#### 2.2.1.2 Air Quality

Gaseous and particulate emissions from marine vessels and offshore platforms in the Beaufort Sea production zone are unlikely to affect regional air quality, although the cumulative effects of emissions from multiple sources during peak production periods are uncertain. A main concern is ice fog formation and the resultant decrease in visibility surrounding emission sites. However, emission sources will be widely separated geographically, and the wind climate over the Beaufort should rapidly disperse most emissions and ice fog that may form.

#### 2.2.1.3 Marine Mammals

Whales

The two species of whales common in the Beaufort Sea region are white (beluga) whales and bowhead whales. The populations of both species winter in the Bering Sea, and migrate annually through the Chukchi Sea and Beaufort Sea to their summer range in the southeastern Beaufort Sea and Amundsen Gulf. The population of white whales has been estimated to number about 7,000, while the bowhead stock includes at least 2,300 individuals.

The possible impacts of most normal activities, wastes and disturbances on white and bowhead whales are expected to be NEGLIGIBLE. The only regional concerns about whales are the possible effects of underwater noise from development activities, and the possibility of cumulative or synergistic effects from multiple sources of wastes and disturbances.

In the offshore production region, underwater noise would be emitted by the construction and operation of islands; installation of subsea pipelines; ships including drillships, icebreakers, tankers, and various support vessels; logistics aircraft; seismic work; and dredging activities. Existing levels of underwater noise in the Beaufort appear to have resulted in NEGLIGIBLE impacts on bowhead and white whales. There is a lack of information for bowheads on the effects of noise masking or disturbance, on their hearing sensitivity and function of vocalizations, and on their habituation to industrial noise. Consequently, the present assessment is purposefully conservative in order to compensate for the lack of available and conclusive data, but concludes that the possible impacts of future levels of underwater noise from all mobile industrial sources, in aggregate, on white and bowhead whales is unlikely to exceed MINOR. This degree of possible impact could be reduced if the whales are able to habituate to increased noise levels, or are able to alter the frequency or intensity of their signals to compensate for industrial noise.

The effects of discharging common wastes including sewage, drilling muds, formation water, heated water, oily waste water, completion fluids, and BOP fluid, will likely be NEGLIGIBLE. This is because of the relative inertness and biodegradability of most of the discharges, the tremendous dilution and buffering capacity of the sea, and the relatively small number of individuals which could be affected, given the mobility of marine mammals and the small areas where discharges will occur. It is also possible that the physical presence of platforms and the noise and activity at industrial sites could deter whales from approaching discharge sites. For these reasons, the combination of various waste discharges are likely to have only a NEGLIGIBLE cumulative impact on whales.

### Seals

The two common species of seals in the Beaufort Sea are the ringed seal and the bearded seal. Both are widely distributed and relatively abundant throughout the region. The estimated size of the Beaufort Sea ringed seal population between 1974 and 1979 has ranged from a low of 23,000 in 1977 to a high of 62,000 in 1978. During the same period, the estimated Beaufort Sea bearded seal population ranged from 1,300 in 1977 to 3,100 in 1978. As development proceeds, the combined sources of underwater industrial noise may have MINOR impacts on regional ringed and bearded seal populations.

Future icebreaking by logistics vessels and icebreakers, in total, could have MINOR impacts on ringed and possibly bearded seals during the spring pupping period. Icebreakers and air traffic may also have a MINOR short-term impact on both species during the 2 to 3 week haul-out period in June by causing animals to dive. With the exception of underwater noise, icebreaking, and aircraft operations, all other normal activities, including the discharge of common wastes and the creation of disturbances, are expected to result in NEGLIGIBLE impacts on both ringed and bearded seals. The only possible exception to this generalization could occur if formation water were discharged to the sea. Seals attracted to production platforms could then be exposed to trace metals and hydrocarbons in formation water for extended periods, and may experience some sublethal effects. The possible impacts of the discharge of formation water on regional seal populations are considered MINOR. This impact rating would decrease to the NEGLIGIBLE rating if formation water were reinjected, as is the intention over the longer term at offshore production platforms.

It is recognized that if seals are attracted to offshore platforms, some combinations of wastes and disturbances could result in possible synergistic or cumulative effects. Several types of wastes may be continuously or intermittently discharged to the sea from offshore platforms. Seals attracted to platforms because of noise or human activity, may then be exposed to the relatively undiluted wastes near outfalls. Such cumulative effects would be limited to those seals actually attracted to the platforms, and would comprise a small proportion of the widespread regional population. Consequently, the possible cumulative impacts of multiple waste discharges and sources of disturbance on seals are not be expected to exceed MINOR.

### Polar Bears

In the Canadian Beaufort Sea, there are two basic polar bear populations, one associated with the west coast of Banks Island and the other with the mainland coast. The estimated total number in the Canadian Beaufort Sea and Amundsen Gulf was 1,700 in 1972 and 1,800 in 1974. During winter and spring, polar bears forage on the transition zone ice, where they prey extensively on ringed seals. Pregnant females den in coastal areas, from November until April, mainly along the coast of Banks Island.

Over the next 20 years, human presence, solid waste disposal, stationary sources of airborne noise, artificial illumination and the physical presence of offshore platforms may have MINOR impacts on the regional polar bear population. This is due to the possibility that wastes and disturbances may alert and subsequently attract bears to offshore platforms. Light, noise and cookhouse odours would probably be the main attraction. Mitigative measures would include continuation of the polar bear monitoring program, and the sedation and removal of problem bears. Nevertheless, some nuisance animals will have to be destroyed for reasons of human safety, and this kind of loss could result in a MINOR impact on the regional population. The cumulative impacts of all sources that may lead to attraction of bears are still expected to be MINOR in a regional context. All wastes and disturbances associated with the development that will not alert or attract polar bears are expected to have NEGLIGIBLE impacts on the regional population.

Changes in the distribution and abundance of ringed seals in the region due to natural causes have been suggested to be the cause of similar changes in the abundance and distribution of polar bears. However, normal industrial activities in the region are unlikely to cause extensive seal kills or fluctuations in seal abundance, so that indirect impacts on bears through reduced prey availability are not expected.

### Arctic Fox

Arctic foxes from coastal populations forage on the landfast ice during winter and spring. As a result, it is possible that some may be affected by on-ice vehicle traffic, icebreakers, and exploration and production facilities operating in the landfast ice area. Possible effects from these offshore industrial activities on Arctic foxes will probably be NEGLIGIBLE.

Foxes in offshore areas may be attracted to, or avoid, industrial sites as a result of noise, artificial illumination, human presence (cookhouse odours), solid waste disposal and the physical presence of structures. However, the combined effects on Arctic foxes are expected to be NEGLIGIBLE because the number of individuals which may be affected would be regionally insignificant and foxes are unlikely to be killed.

### 2.2.1.4 Birds

Over 100 species of birds migrate to or through the Beaufort Sea region annually. From about mid May to mid or late June, hundreds of thousands of spring migrant birds stage in offshore leads and polynyas of the southeastern Beaufort Sea and Amundsen Gulf before flying to their coastal or inland nesting areas. Oldsquaws, king and common eiders, glaucous gulls and loons are the most common species. Other species which may also migrate through offshore areas include thick-billed and common murres, black guillemots, brant, phalaropes, jaegers, Arctic terns and some other species of gulls. Most birds move to coastal nesting areas in summer and remain there until their fall migration in late August and September. Some non-breeding bird species including gulls, jaegers, alcids and other marine species, may continue to forage in the offshore Beaufort throughout the summer. Fall migrants that travel offshore probably include mainly king and common eiders, jaegers, glaucous gulls and alcids.

Possible regional effects on birds of most activities at offshore platforms, and for most of the common wastes and disturbances, including dredging, icebreaking and vessel activities, are expected to be NEGLIGIBLE. MINOR impacts on birds are only considered possible as a result of gas flaring, aircraft disturbances and the discharge of formation water. The only discharges of regional concern are the routine discharge of formation water and oily waste water. Depending on ice conditions and the distribution of spring staging birds, some spring migrants may be lost or experience sublethal effects due to contact with oil. Nevertheless, the number of birds likely to be affected would be a small proportion of the regional populations and possible regional impacts would probably not exceed the MINOR rating. This degree of impact would reduce to NEGLIGIBLE if formation waters were reinjected, as proposed over the longer term at all offshore production fields.

The regional impacts of icebreaking and dredging disturbances on birds are expected to be NEGLIGIBLE due to the ability of birds to use adjacent undisturbed areas, because mortality is unlikely, and because only a small fraction of any regional population could be affected.

On a local scale, possible impacts of dredging and icebreaking disturbances may range from NEGLIGIBLE to MINOR depending on the species, timing and duration of dredging or icebreaking, and susceptibility of the species to these operations.

Some birds may be attracted to and possibly collide with offshore structures as a result of artificial lighting and gas flares, particularly when visibility is low. However, impacts on the regional populations would likely be NEGLIGIBLE, or at most MINOR, over both the short and long-term because the number of individuals affected would be small. Species most likely to be affected by virtue of their migration routes and flight altitudes would include loons, eiders, oldsquaws, black guillemots and thick-billed murres. Gulls will be attracted to offshore platforms by artificial illumination, airborne noise, gas flares, human presence (cookhouse odours), and by solid wastes, but few are likely to be killed. Consequently, the possible regional impact of their attraction to offshore facilities as a result of these factors is expected to be NEGLIGIBLE.

There is concern that airborne noise from helicopters and STOL aircraft operating between shorebases and offshore platforms may affect birds. However, aircraft will comply with route and altitude restrictions wherever possible, so that the possible impacts of airborne noise on all regional populations is expected to range from NEGLIGIBLE to MINOR.

In general, geese are considered to be more vulnerable to aircraft disturbances than other waterfowl and most marine-associated birds. During spring, snow geese and white-fronted geese that stage at Kittigazuit Bay may be disturbed by aircraft overflights. During the breeding period, snow geese nesting at Kendall Island, and brant nesting at colonies in the outer Mackenzie Delta and near Atkinson Point could be disturbed. Under some circumstances, white-fronted geese, whistling swans, peregrine falcons, gyrfalcons, golden eagles, common eiders, black guillemots, glaucous gulls, Sabine's gulls and terns could also be disturbed during the nesting period because they nest in colonies, and are considered vulnerable to aircraft disturbances. During July and August, some moulting and non-breeding geese and swans, and moulting and brood-rearing ducks in coastal areas may be disturbed by aircraft overflights. Of major concern are the thousands of snow geese and white-fronted geese that stage along the North Slope and in the outer Mackenzie Delta during September and early October. These could be subjected to some disturbance from future shorebase activities on the Yukon coast.

Some birds could be disturbed by unregulated aircraft resulting in possibly a wide range of impacts on regional populations, but with the implementation of route and altitude restrictions, impacts from aircraft noise are expected to range between NEGLIGIBLE and MINOR.

Synergistic or cumulative effects on birds could possibly result from specific combinations of wastes and disturbances, and the physical presence of offshore structures. However, the assessment of such effects is highly speculative. The cumulative effects of discharge of all wastes and disturbances associated with the construction and operation of offshore structures could have a MINOR impact on regional populations of some marine birds such as oldsquaws, eiders, glaucous gulls, loons and possibly alcids. Possible cumulative impacts of these effects on most other bird species would likely be NEGLIGIBLE.

### 2.2.1.5 Fish

Offshore hydrocarbon development in the Beaufort Sea is expected to have NEGLIGIBLE to MINOR impacts on fish. Alterations in water quality resulting from the discharge of most wastes will be limited to waters close to exploration and production platforms and vessels. Therefore, few fish are likely to be killed or be otherwise affected by waste discharges. Similarly, disturbances from dredging, vessel traffic and icebreaking will be temporary and only evident close to the sources of disturbance and are not expected to have regionally significant effects on offshore fish populations. Near the shore, however, development-related activities and disturbances may have a greater degree of impact in some instances, since large numbers of important fish species are found in nearshore habitats, particularly during the summer months. Marine species such as herring spawn in nearshore areas, and large numbers of anadromous fish also feed and rear in these locations. Dredging activities are a source of disturbance to fish, and in some coastal habitats it is possible that MINOR to MODERATE impacts could occur if large numbers of fish or fish eggs were entrained in dredges. However, on the basis of previous studies of the effects of dredging in both temperate and Arctic waters, the impacts of dredging on fish will probably range from NEGLIGIBLE to MINOR when known spawning areas or particularly rich feeding and rearing areas are avoided. Other nearshore disturbances, including vessel traffic and sewage, are expected to have NEGLIGIBLE impacts on coastal fish populations.

### 2.2.1.6 Benthic Communities

Populations of organisms living on or in the sea bottom will be directly disturbed by dredging activities during offshore island construction and pipeline installations. They will also be exposed to various discharges from exploration or production platforms. Dredging will obliterate benthic organisms as well as alter benthic habitats. However, in a regional context, the seabottom area disturbed by all combined dredging activities would be small. Also, in many areas selected for dredging, some of the effects are similar to those from ice scour, to which benthic organisms on the Beaufort Shelf are subjected regularly. Nevertheless, the impacts of dredging on benthic populations may range from MINOR to MODERATE in some areas, with the degree of impact depending largely on the number of generations necessary for specific benthic communities to recover. Available data on the recovery of benthic populations following past dredging on the Beaufort Shelf suggest that after disturbances from suction hopper dredges, recovery of disturbed sites begins quickly and should take about 2 to 3 years. In these situations, only a MINOR degree of impact would be expected. Nevertheless, even when MODERATE local impacts occur, the proposed dredging requirements are unlikely to disturb a regionally significant fraction of the benthic habitat or have significant indirect impacts on higher trophic levels.

The discharge of wastes into the sea is not expected to cause significant regional impacts on benthic populations. Wastes would include treated sewage, BOP fluids, drill muds, heated water, drill cuttings, cements and barites, and possibly formation water. All of these wastes will only affect the local area surrounding drilling platforms and are not expected to cause significant losses of benthic populations in the region. The cumulative effects of all of these discharges, however, may contribute to the slower recovery of benthic communities in small areas such as around artificial islands and in dredged holes within which BOP's are mounted. Overall, the cumulative impacts from all of these disturbances may be MODERATE in local areas, but will not affect a regionally significant portion of the existing benthic habitat.

### 2.2.1.7 Plankton and Epontic Communities

Disturbances and wastes from the proposed development are not expected to result in more than MINOR impacts on planktonic and epontic (under-ice) communities. Phytoplankton and zooplankton are widely distributed throughout the region, and although dredging activities and discharges of oily wastes, formation water, and ballast water may affect local areas, the recovery time will be rapid due to reproduction and the natural transport of organisms from the surrounding sea. Nutrients in sewage discharges, formation waters, and warmed water are not expected to cause more than local increases in primary production or organic loading.

Epontic organisms will be mainly affected by icebreaking in the landfast ice and by possible ice management programs using heated water at offshore islands. Nevertheless, only small areas will be affected in relation to the extent of undisturbed habitat available throughout the region, and impacts in these areas will generally range from NEGLIGIBLE to MINOR.

## 2.2.2 ENVIRONMENTAL IMPACTS OF HYDROCARBON DEVELOPMENTS IN THE ONSHORE PRODUCTION REGION

Future development in the onshore production region will likely include production from oil and gas wells in the Delta and on the Tuktoyaktuk Peninsula and the building of oil and gas gathering pipelines as described in Chapter 1. Also, it is likely that a major shorebase will be built on the Yukon coast. This section summarizes possible impacts of onshore production facilities and of gathering pipeline systems, while impacts of shorebases are summarized in Section 2.2.3. Matrix 2-2 summarizes the possible impacts associated with production facilities and an oil gathering system in the onshore Beaufort region.

### 2.2.2.1 Geology and Soils

A main feature of the land is the prevalence of permafrost. In summer the surface layer will thaw and then refreeze in winter. This active layer, if disturbed, may deepen and expose ice lenses which, if melted, will result in thaw settlement. Also the relatively impervious permafrost beneath the active layer makes the control of surface run-off important.

Therefore, impacts on geology and soils of proposed oil and gas production facilities and gathering systems may include active layer deepening, local thaw settlement, and shallow hydraulic erosion. Thermal effects will be greatest where mineral soils are exposed, and where gravel may be salvaged from pads and roads. Shallow hydraulic erosion will likely occur where surface runoff is redirected or diffuse flow is channeled. The potential for erosion is proba-

**MATRIX 2-2**

**POTENTIAL ENVIRONMENTAL IMPACTS RESULTING FROM HYDROCARBON DEVELOPMENTS IN THE BEAUFORT SEA ONSHORE AND MACKENZIE DELTA REGION**

| | | GEOLOGY AND SOILS | | | | HYDROLOGY AND WATER QUALITY | | | AIR | | VEGETATION | | | MAMMALS | | | | | | | | BIRDS | | | | | AQUATIC RESOURCES | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SOIL CHEMISTRY | SURFACE STABILITY | SLOPE STABILITY | GENERAL TERRAIN | WATER QUALITY | SURFACE WATER | GROUNDWATER | AIR QUALITY | MICROCLIMATE | RIPARIAN | CONIFEROUS FOREST | TUNDRA | REINDEER | BARREN GROUND CARIBOU | MOOSE | GRIZZLY BEAR | BLACK BEAR | AQUATIC FURBEARERS | TERRESTRIAL FURBEARERS | GENERAL MAMMAL CONCERNS | RAPTORS | GEESE/SWANS | DUCKS | OTHER | GENERAL/AVIAN CONCERNS | LOWER TROPHIC LEVELS | FISH |
| COMMON WASTES AND DISTURBANCES | SITE PREPARATION & CONSTRUCTION | | L-s | L-s | L-s | L-s | L-s | L-s | | | L-l | L-l | L-l | ○ | ○ | | ○ | | | ○ | | | ◊ | | | ○ | | ◊ |
| | GRANULAR BORROW | | L-s | L-s | | L-s | L-s | | | | | L-m | L-m | ◊ | | | ◊ | | | ◊ | ◊ | ○ | ◊ | ◊ | ○ | | | ○ |
| | BLASTING | | | | | L-s | L-s | | L-s | | | | | | | | | | | | ○ | | | | | ◊ | ○ | ◊ |
| | ABANDONMENT & RECLAMATION | | L-s | L-s | L-s | | | | | | L-s | | L-s | | | | | | | | ○ | | | | | ○ | ○ | ◊ |
| ACTIVITIES AND FACILITIES RELATED TO PRODUCTION AND AN ONSHORE GATHERING SYSTEM | 1 DITCHING, INSTALLATION, BACKFILL | | L-s | L-s | L-s | L-s | L-s | | L-s | | L-s | | L-s | | | | | | | | ○ | | | | | | ○ | ◊ |
| | 2 PIPELINE TESTING, FLUID DISPOSAL | | L-s | L-s | L-s | L-s | L-s | | | | L-s | | L-s | | | | | | | | ○ | | | | | | ○ | ◊ |
| | 3 STREAM & CHANNEL CROSSINGS | | L-s | L-s | L-s | L-s | L-s | | | | L-s | | L-s | | | | | | ◊ | | ○ | | ◊ | ◊ | | | ◊ | ◊ |
| | 4 BURIED GATHERING LINES | | L-s | L-s | L-s | | L-s | L-s | | | L-s | | L-s | | | | | | | | ○ | | | | | ◊ | | |
| | 5 ELEVATED PIPELINES | | L-s | L-s | L-s | | | | | | L-s | | L-s | | | | | | | | ○ | | | | | ◊ | | |
| | 6 TEMPORARY ACCESS ROADS | | L-s | L-s | L-s | L-s | L-s | | | | L-s | | L-s | | | | | | | | ◊ | | | | | ○ | ○ | ○ |
| | 7 PERMANENT ACCESS ROADS | | L-s | L-s | L-s | L-s | L-s | L-s | | | L-l | | L-l | | | | | | | | ◊ | | | | | ◊ | ○ | ○ |
| | 8 WELL CLUSTER, PHYSCIAL PRESENCE | | L-s | L-s | L-s | L-s | L-s | | L | | L-l | | L-l | | | | | | | | ◊ | | ● | | | ◊ | | |
| | 9 DRILLING FLUID DISPOSAL, SUMP | | L-s | L-s | L-s | L-s | L-s | L-s | | | L-s | | L-s | | | | | | | | | | | | | | | |
| | 10 PROCESSING FACILITY & FLARE | | | | | | | | L | L | L | | L | | | | | | | | ◊ | | | | | ◊ | | |
| | 11 STAGING SITES & STOCKPILES | | L-s | | L-s | L-s | L-s | L-s | | | L-s | | L-s | | | | | | | | ◊ | | ● | | | ◊ | | |
| | 12 WHARVES & BARGE TRAFFIC | | | | | | | | | | | | | | | | | | | | ○ | | ◊ | ◊ | | | ○ | ○ |
| | 13 AIRCRAFT & AIRSTRIPS | | | | | | | | | | | | | | | | | | | | ◊ | ◊ | ● | ◊ | | | | |
| | 14 CAMPS | | L-s | L-s | L-s | | | | | | L-s | | L-s | ◊ | ○ | ◊ | ● | ◊ | ◊ | ◊ | | | ◊ | ◊ | | ○ | ○ | ○ |
| | 15 WASTE DISPOSAL | | | | | | | | | | | | | ○ | ○ | ○ | ● | ○ | ○ | ◊ | | | | | | ○ | | |
| | 16 FUEL STORAGE | | | | | | | | | | | | | | | | | | | | ○ | | | | | ■ | | |
| | 17 OFF-DUTY ACTIVITIES | | | | | | | | | | | | | | | | | | | | ◊ | | | | | ◊ | | ○ |

**LEVEL OF POTENTIAL IMPACT**

| BIOTIC | | PHYSICAL | | |
|---|---|---|---|---|
| ○ = NEGLIGIBLE | ● = MODERATE | L = LOCALIZED | m = MEDIUM-TERM | s = SHORT-TERM |
| ◊ = MINOR | ■ = MAJOR | R = REGIONAL | l = LONG-TERM | |

BLANKS INDICATE NON-APPLICABILITY OR ADDRESSED ELSEWHERE bly greatest at stream banks and other slope breaks. However, thermal and erosion effects are manageable with appropriate drainage, erosion control and reclamation. Other local effects may include slope instabilities along sections of pipeline gathering systems, especially at crossings of the Mackenzie River. In the unlikely event of a pipeline failure, emergency repair measures may cause additional terrain damage. Overall impacts on geology and soils resulting from processing systems, gathering pipelines, and support facilities should be LOCALIZED and SHORT-TERM.

#### 2.2.2.2 Hydrology and Water Quality

Drainage alterations and siltation may result from activities such as ditching for pipeline installation, construction of stream crossings, and the construction of permanent access roads. However, these effects will be minimized by appropriate erosion control measures and reclamation. The impacts of oil and gas production facilities on drainage patterns should therefore be LOCALIZED and SHORT-TERM.

#### 2.2.2.3 Atmospheric Environment

The construction and operation of production facilities and gathering pipelines will result in minor noise, particulate and gaseous emissions, and ice fog. Principal sources of noise will include wellsite machinery, processing plant machinery, and, for brief periods, blasting and aircraft. Gaseous and particulate emissions will be generated mainly by processing plants and the flaring of gas. If an atmospheric inversion occurs - with warmer temperatures aloft - plant emissions as well as ice fog may be trapped near ground level for some time. The severity and extent of the effects will depend on emission levels, the duration of the inversion, prevailing winds and other factors. High exhaust temperature and exhaust velocity will tend to concentrate ice fog at higher elevations, where there is a better chance of dispersion by upper level winds. The overall impact of production and gathering facilities on the atmospheric environment is expected to be limited and LOCALIZED.

#### 2.2.2.4 Vegetation

Small areas of vegetation will have to be removed or destroyed wherever construction on land is required. The impact of this disturbance is considered LOCALIZED due to the small areas involved. Vegetation will be surveyed before construction takes place in order to identify any unique or especially sensitive vegetation. If such vegetation exists, facility sites may be relocated. All exposed soils on temporary sites and gathering pipeline rights-of-way will be revegetated. The overall impact on vegetation is considered to be LOCALIZED and SHORT-TERM.

The natural vegetation and surface organic layer insulates the permafrost and its removal may initiate local hydraulic erosion, thaw settlement, drainage interruptions, and thermal erosion, however these effects on vegetation will be LOCALIZED.

#### 2.2.2.5 Mammals

Concerns for wildlife relate to alteration of their habitat, disruption of their movements, disturbances, and loss of life.

Reindeer

Interactions between reindeer and onshore oil and gas development could occur on the Tuktoyaktuk Peninsula and in the western area of the Mackenzie Reindeer Grazing Reserve. Small areas of habitat may be lost for a short time from the development of borrow pits, construction of gathering pipeline systems and temporary access roads, and from the operation of construction camps. Longer term habitat loss will occur at well cluster sites, staging areas, processing plants, fuel storage areas, and along permanent access roads. This loss may result not only from the occupation of the land surface by facilities but also from disturbances caused by the activities of men and machines. This habitat loss will, however, be very small compared to that available in the region and is not expected to affect the carrying capacity of the reindeer range.

Reindeer may encounter short lengths of open pipeline ditches during the construction of gathering pipeline systems. Also they may be disturbed by construction activity along sections of the pipeline routes. The ditches will only exist for a short time and will be relatively short in length and therefore should not present a significant barrier to movements. In addition, herd movements can be controlled to avoid such areas if necessary. Roads and buried pipelines are not expected to present barriers to reindeer movements. Disturbances caused by human activity, noise, vehicles, aircraft, and blasting will be largely restricted to the facility sites and along road and pipeline corridors. Reindeer may be deflected near areas of activity, but effects on them should be minimal because they are accustomed to people, skidoos, and helicopters used during herding operations. Possible interference with reindeer can be minimized by planning range use in advance of gathering pipeline construction.

Improved access to the reindeer range provided by temporary and permanent roads, together with the human influx to the Mackenzie Delta as a result of the oil and gas development may result in increased poaching of reindeer. However, the herd is managed more intensively than herds of wild caribou, so that possible impacts of industry development can be minimized by suitable herd management, and effects should be MINOR.

### The Bluenose Caribou Herd

The western limit of the traditional winter range of the Bluenose herd is southeast of the area where pipeline and production facilities would be built. Therefore, few of these caribou will encounter the development. The herd is currently distributed east of the Tuktoyaktuk Peninsula and the Eskimo Lakes. Although a few caribou may wander within the sphere of influence of the hydrocarbon development activities and some may be exposed to aircraft flights over the westernmost portion of their range, such isolated interactions are expected to have a NEGLIGIBLE impact on the herd.

### Moose

Interactions between moose and onshore development are expected to be few because of the low moose population in the area. Nevertheless, the few moose which do inhabit the area may lose some habitat and encounter barriers to their movement. Some may be disturbed and possibly more intensively hunted. The area of temporary and long-term habitat lost will, however, be very small relative to the amount available and is not expected to reduce the carrying capacity of the range for moose. The types of disruptions and disturbances to moose are similar to those described for reindeer and although moose may be locally displaced near areas of activity, their populations are not expected to be affected.

Additional access provided by temporary and permanent roads, together with more people in the Mackenzie Delta as a result of the development, may result in increased hunting of moose. It will likely be necessary to modify hunting regulations and intensify enforcement of these regulations to avoid a decline in the local moose population.

In general, development in the onshore production region is expected to have a MINOR effect on the moose population; however, because the population is currently very low, it is particularly vulnerable to increased hunting and therefore strict management of the moose population will need to be considered.

### Grizzly Bear

Interactions between grizzly bears and onshore oil development activities may occur anywhere within the onshore production region. Habitat loss will generally be insignificant. The loss of denning areas, a major concern, will be avoided by siting borrow pits and facilities in areas not used by grizzly bears for denning. Disturbances from aircraft, machinery, and human activity will cause some local displacement and stress reactions by bears, but will not likely have measurable effects on the population. The most serious effect will be the need to dispose of problem bears attracted to project facilities. Despite appropriate waste disposal procedures and handling of problem bears, some bears may have to be killed. In addition, improved access and the increased human population in the region may increase hunting pressure on grizzly bears. Current regulations limit the numbers of bears which are harvested, however, the projected increased hunting pressure may result in some illegal harvest. With the strict enforcement of wildlife regulations, it should be possible to maintain impacts at the MINOR level.

### Beaver

Beaver are almost entirely restricted to the active delta, therefore the possibility for direct interactions between beaver and oil and gas development activities is remote. The prime concern regarding beaver is the possibility that oil from a spill or leak would pollute their waterways. The number of beaver which could be affected by such an event would depend on the extent of their habitat downstream from the spill, the amount of oil spilled, the season of the spill, and the effectiveness of clean-up measures. Despite the fact that an oil spill is a serious threat to beaver, their widespread distribution ensures that most of them would remain unaffected. The net effect of future onshore development on beaver is expected to be MINOR.

### Muskrat

Muskrat are much more plentiful in the Mackenzie Delta region than are beaver. Most oil and gas development activities will occur away from wetlands, ensuring that there will be little opportunity for interaction between onshore development activities and muskrat. As with beaver, possible oil pollution of waterways is the greatest concern. However, muskrat are widely distributed and reproduce rapidly so that, at worst, a MINOR impact on the muskrat population might be expected.

### Arctic Fox

Arctic foxes are scattered widely within the Mackenzie Delta region and there are relatively few of them so that interactions with oil and gas development activities will likely be infrequent. Since few Arctic fox dens exist within the area, chances of destroying a den are low. Some foxes may be attracted to construction camps and may be killed if they appear rabid. A concern is that foxes may become dependent on camp garbage or handouts. This possibility is low because of proposed methods of garbage disposal and regulations against feeding any wildlife. A greater human population may result in some increased hunting and trapping of Arctic fox but is unlikely to significantly affect the population. The overall impact of oil and gas development activities on the Arctic fox population is expected to be MINOR.

Red Fox

Interaction possibilities with the red fox will be higher than those with Arctic fox because red fox are more common in the Mackenzie Delta region. As with Arctic fox, dominant concerns relate to the destruction of den sites, attraction to camps, and increased hunting and trapping. Because of the widely dispersed nature and high reproductive potential of the red fox, industry-related effects on the population are expected to be MINOR.

Wolf

Wolves are uncommon in the Mackenzie Delta area, hence interactions with oil and gas development activities will be infrequent. Any habitat alteration will have little impact on wolves, although some beneficial effects may result from construction of transportation rights-of-way which in the past have been often used by wolves when hunting. Conversely, their food supply may become depleted by the over-harvesting of moose by hunters. Wolves could also be adversely affected by having their dens or rendezvous sites disturbed; however, such sites will be avoided if possible, making it unlikely that any will be disturbed. Improved access and the increased human population may result in a larger harvest of wolves, but this increased harvest is unlikely to significantly decrease the wolf population. Overall, the effects of development on wolves are expected to be MINOR.

Other Mammals

Mink, weasels, squirrels, wolverines and other furbearers are generally widely distributed in the Mackenzie Delta. As a result, few of these mammals are likely to have their habitat altered or disturbed, although increased trapping may result in local depletions of those species susceptible to over-harvesting. The effects on regional populations of these animals are likely to range from NEGLIGIBLE to MINOR.

Other mammals such as shrews, small rodents, and hares are numerous and widely distributed. Only small fractions of their populations are expected to interact with onshore oil and gas development and therefore impacts on these species are expected to be NEGLIGIBLE.

#### 2.2.2.6 Birds

In winter, few birds are present so that few interactions between birds and exploration and construction activities are expected. In spring, summer and fall, on the eastern outer Delta and Tuktoyaktuk Peninsula, impacts may take the form of a general reduction of breeding range and a decrease in productivity for waterbirds, waterfowl, shorebirds, gulls, terns, jaegers, cranes, and others. Overall impacts on these birds are likely to range from MINOR to MODERATE. The western outer Delta is important for spring staging, nesting, brood-rearing, moulting, and fall staging of waterfowl and other birds. In addition, flocks of non-breeding birds may summer there.

Impacts on birds will depend on the location and number of production facilities, the type and timing of activities undertaken and the intensity of related disturbance. Regional impacts for normal activities may range from MINOR to perhaps MODERATE for snow geese, white-fronted geese, brant geese, whistling swans, other waterfowl and sandhill cranes; and generally MINOR for other species, including raptors. A major oil spill in the western outer Delta could have impacts that range from NEGLIGIBLE to MAJOR (e.g. snowgeese and white-fronted geese during fall staging) depending on the location, size, timing and clean-up of the spill.

#### 2.2.2.7 Freshwater Fish and their Food Organisms

Sedimentation of Waterways

The construction of pipeline stream crossings, permanent road bridges and culverts and other activities in or near streams will contribute somewhat to stream sedimentation. The ability of aquatic organisms to tolerate long term siltation when concentrations are low, and to tolerate short-term exposure to high sediment loads has been determined.

Even with an aggressive program of inspection, reclamation, and revegetation, failures of stream banks, slopes, and erosion control measures are likely to add suspended sediments to some streams at intervals throughout the life of gathering pipeline systems and production facilities. Sediment contributed by onshore development will mainly occur when there are acute erosion problems, which means that any effects will usually be both local and short-term. Unless the sedimentation becomes chronic at a single location, recovery of both fish and other aquatic life will also be short-term. Fish populations in the region are well-adapted to tolerating brief periods of extremely high sediment concentrations, and have developed strategies to avoid such waters during sensitive periods of their life histories. Streams will normally flush out suspended sediments. This, together with the ability of aquatic biota to recover rapidly from the effects of sediment introductions, makes it unlikely that long term effects would exist.

Although a few local reductions in fish populations might occur, the cumulative effect of all sediment introductions to fish populations in the region is expected to be MINOR.

Habitat Modification

Aquatic habitat could be altered or lost as a result of stream crossings, access roads, alterations of stream channels, spills of toxic material, sediment introductions, and other environmental modifications that accompany development. Although a few of these may be beneficial, the majority will reduce habitat quality. Most aquatic habitats in the region serve only as summer feeding areas and migratory corridors; they are not considered critical to fish populations. As a rule, large fish will readily seek alternate habitat if faced with unsuitable conditions. However, in spawning, rearing, and overwintering waters, alternative habitat is often scarce so that reductions of habitat quality in these waters may be harmful to regional fish populations.

Although most of the streams which may be crossed by gathering pipelines serve as migratory routes for fish moving to and from sensitive habitats, possible habitat modifications are not expected to interfere with these migrations. Many such habitat modifications are expected to occur for a short term only, likely for less than one year. Given the small amount of aquatic habitat which might be affected, and the brief duration of most habitat modifications, the cumulative effect of proposed activities on fish habitat is expected to be NEGLIGIBLE.

Fish Kills

Direct fish mortality may result from machinery operating in streams, spills of toxic materials, blasting in streams, entrapment and blocked passage to and from critical habitats. Were all these disturbances to occur at a single location, their effect may reduce local fish populations. However, such disturbances are likely to be widely separated within the onshore region and would not collectively affect a single area. A short-term local decline in fish populations resulting from such a disturbance would have only a MINOR impact.

Increased Recreational Fishing

The presence of more people in the region, both new residents and industry employees, will result in increased recreational fishing. Lake trout and Arctic char populations are at most risk and without stringent measures to regulate angling, would undoubtedly decline. Other species in the region are less vulnerable to overfishing. It is likely that heavy angling pressure will continue as long as fish are available. Assuming that regulations to ensure the protection of fish concentrated on spawning grounds are enforced, overall effects of increased angling will be NEGLIGIBLE.

Water Requirements

Withdrawals of water from overwintering fish habitat can kill fish by dewatering the habitat or reducing dissolved oxygen concentrations. This concern does not apply to the Mackenzie Delta region where there is an abundant year-round water supply. Water withdrawal sites will be selected in consultation with regulatory agencies. Where water availability is in doubt, studies on the status of overwintering fish will be carried out before any water is withdrawn. Assuming that the habitat requirements of local fish populations are met, the effect of water withdrawals will be NEGLIGIBLE.

Lower Trophic Levels

Lower trophic levels include the plants and animals in an aquatic habitat that contribute food for fish. Sedimentation, nutrient enrichment, and spills of toxic fluids can alter the productivity of lower trophic levels and have indirect effects on fish. With the exception of oil spills, such disturbances are only likely to affect lower trophic levels in a local area at or near a disturbance.

Sewage can provide nutrients which will increase the productivity of certain lower trophic levels, but sedimentation and toxic spills may reduce the number of organisms at most trophic levels. These disturbances may alter the local aquatic community structure, which in turn may affect the feeding distribution of local fish populations. Because they can quickly recolonize previously disturbed waters from nearby unaffected waters, lower trophic levels recover rapidly from disturbance, often in a single generation. Many species display a high reproductive potential, often producing many generations in a single year.

With the exception of large oil spills, and sites where sewage will be discharged, disturbances affecting lower trophic levels will be short-term, generally affecting local waters for less than one season. Until populations of prey organisms have recovered enough to provide food for fish, fish may temporarily seek food in alternative habitats. Such local redistributions have little significance, and fish will quickly return to their original habitat once lower trophic levels are replenished.

In this region, communities of consumer organisms (algae, zooplankton, and zoobenthos) are ubiquitous, so it is unlikely that disturbances will affect any unique feature of their distribution. Most disturbances will be both local in effect and brief in duration, consequently overall effects on lower trophic levels are expected to range from NEGLIGIBLE to MINOR.

### 2.2.3 IMPACTS OF COASTAL SUPPORT BASES

The industry now operates support bases at Tuktoyaktuk and an advance supply centre and winter mooring harbour in McKinley Bay. Approval has been given to build a fuel tank farm at Wise Bay, although there are currently no plans to proceed with development there. Gulf may develop a base of operations at Stokes Point to support its deeper draft offshore exploration drilling equipment. In the longer term, a major base may be needed at either Stokes Point or King Point to support production-related activities. Since proposed shorebase developments at Tuktoyaktuk and McKinley Bay will be incremental expansions of present activities, with few new environmental impacts, most of the following discussion will focus on potential shorebase developments on the Yukon coast and associated activities such as roads and quarries.

#### 2.2.3.1 Existing Base Expansions

At Tuktoyaktuk, little further expansion is planned beyond that which will be completed in 1982. Assuming that larger aircraft are eventually used to transport personnel and priority supplies to the region, the airstrip and service facilities will be expanded. Improvements will continue to be made to the dock areas, storage yards and service facilities at the existing bases.

McKinley Bay will continue as a winter mooring basin and advance supply centre for the conventional offshore drilling fleet. As these operations expand, the mooring basin and island will be enlarged. The man-made island in McKinley Bay could be used as the site for a marine base in support of early production-related activities. Proposed further developments at McKinley Bay will include the addition of permanent dockage, accommodations and an airstrip on the enlarged artificial island. A gradual change from seasonal to year-round operation is envisaged.

The types of impacts of current and future industry shorebase activities at Tuktoyaktuk and McKinley Bay are expected to be similar to those associated with a future shorebase on the Yukon coast.

#### 2.2.3.2 Yukon Shorebase

King Point and Stokes Point along the Yukon coast are under active consideration as sites for a future shorebase. For assessment purposes it is assumed that only one of these sites would be developed.

Use of a site along the Yukon coast could begin as early as 1983 with the establishment of a harbour for the overwintering of vessels and the construction of a supply base camp and STOL airstrip. Granular material and rock would eventually be extracted from quarries and gravel pits. These would need support camps and haul roads extending to the base on the coast. At Stokes Point, on-site granular materials could be used during initial development phases. These activities would be expanded gradually to accommodate the rate of development. Major shorebase construction activities would take place during the years 1983 to 1987, and after that time, the level of activity would remain relatively constant. The development scenario currently envisioned by Dome includes the construction of an all-weather road for base resupply between the shorebase and the Dempster Highway. An all-weather road would also be required between the shorebase and a quarry at Mount Sedgewick for hauling rock. Shorebase development envisioned by Gulf does not require a road to the Dempster for base resupply; water and air transportation would be relied upon. Figures 2-14 and 2-15 illustrate how development at either King Point or Stokes Point may appear by the early 1990's. Using this information as a basis, Matrix 2-4 was compiled to summarize the possible impacts of a Yukon coast shorebase development on the wildlife of the area, assuming that mitigative measures were applied.

Impacts on Marine Wildlife

Marine wildlife could be affected by treated sewage, solid waste and wastewater disposal, air emissions, artificial illumination, the physical presence of artificial structures, human presence, and icebreaking. However, possible impacts on most marine wildlife in the vicinity of a Yukon coast shorebase are expected to be NEGLIGIBLE with the application of appropriate mitigative measures. Disposal of sewage and solid wastes, and air emissions will conform to regulatory guidelines, and industry will encourage personnel to avoid sensitive coastal marine habitats.

Human presence, landfill sites, airborne noise and artificial illumination at a Yukon coast base may attract polar bears, Arctic foxes and terrestrial mammals despite the implementation of mitigative measures. The combination of these sources of attraction may have a MINOR impact on local fox populations if some animals are destroyed. Similarly,

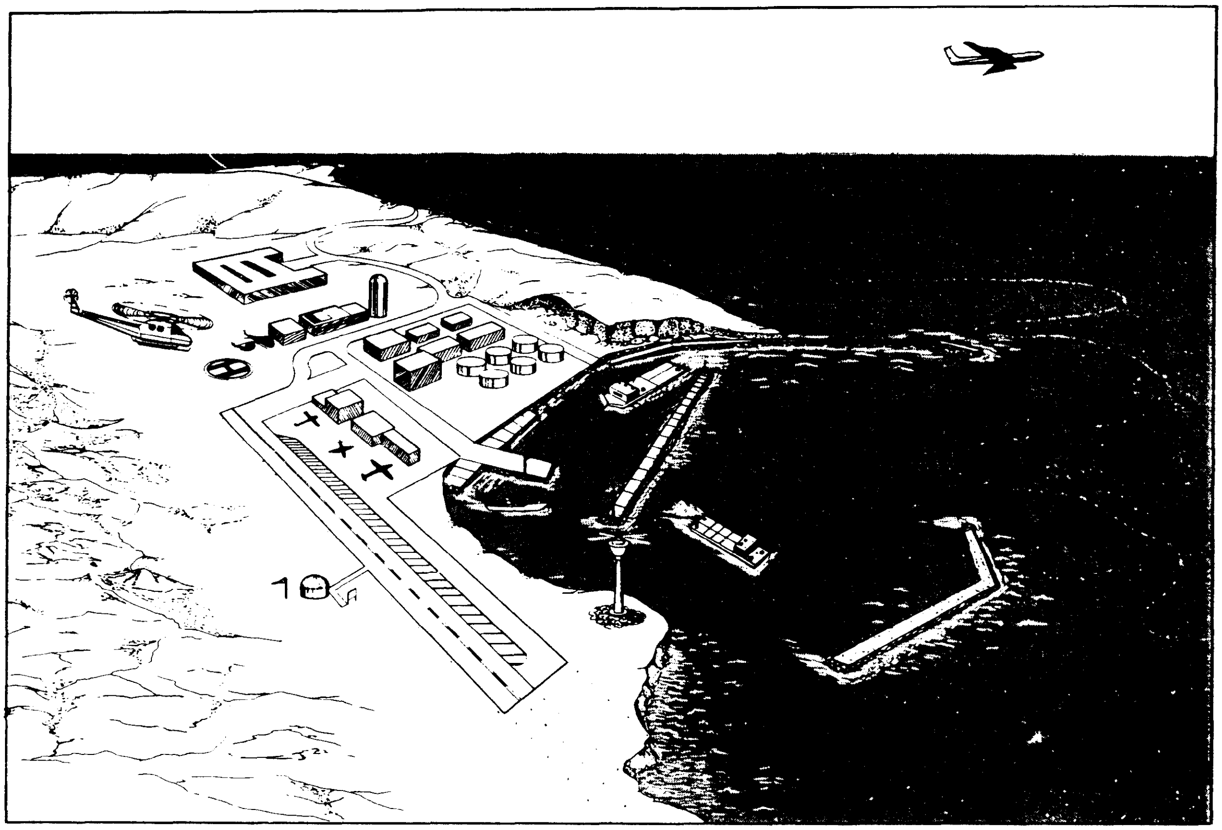



**FIGURE 2-14** *If further expansion is required for support facilities, King Point is proposed as one of the preferred sites. It has potential for development as a deep water year-round port and is close to the offshore development sites. Shown here is an artist's rendering of the King Point support base as it may look by the early 1990's.*

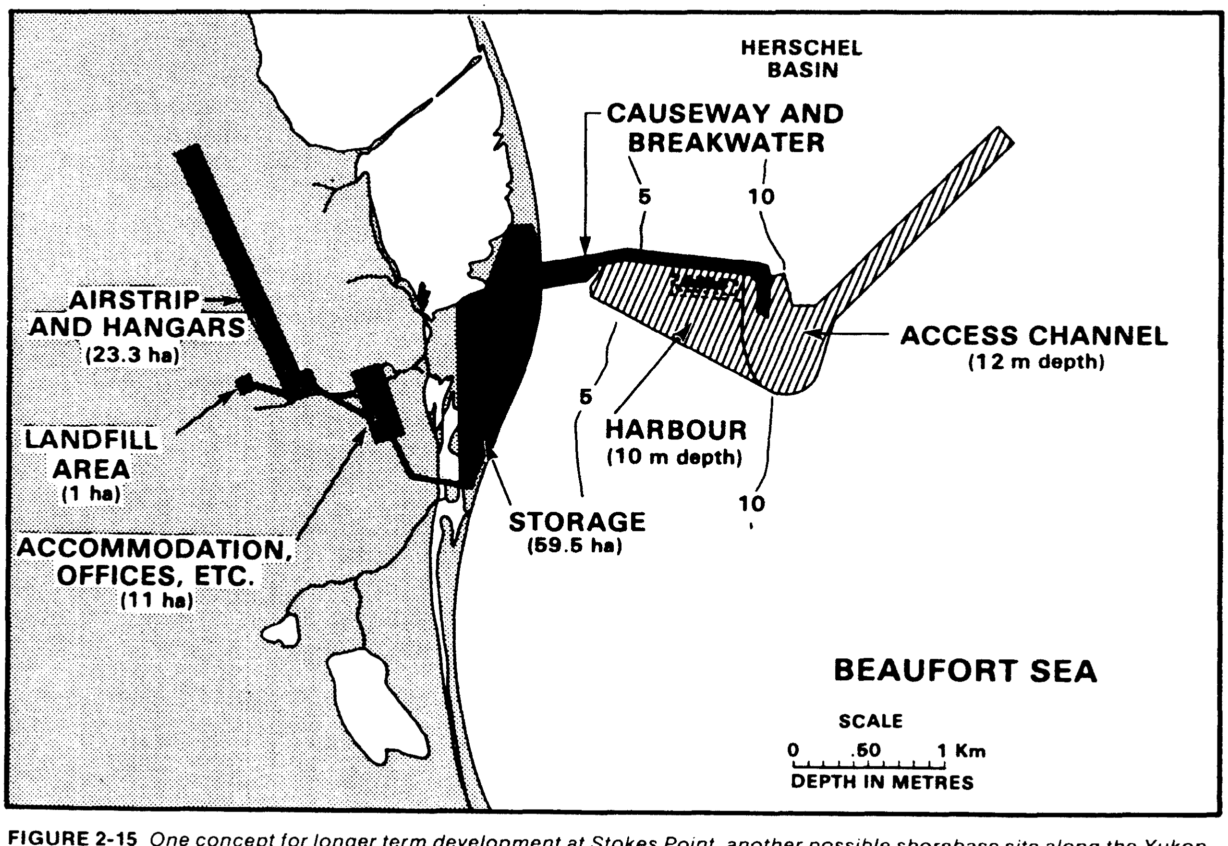



**FIGURE 2-15** *One concept for longer term development at Stokes Point, another possible shorebase site along the Yukon coast, is shown in this illustration.*

| MATRIX 2-4<br>POTENTIAL LOCAL IMPACTS* OF THE YUKON COAST DEVELOPMENTS | MARINE MAMMALS | | | | TERRESTRIAL MAMMALS | | | | | | | | | BIRDS | | | | | | | FISH | | | | LOWER TROPHIC LEVELS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SHOREBASE ON THE YUKON COAST | WHITE WHALE | BOWHEAD WHALE | RINGED SEAL | BEARDED SEAL | POLAR BEAR | ARCTIC FOX | GRIZZLY BEAR | TUNDRA WOLF | RED FOX | OTHER FURBEARERS | CARIBOU | REINDEER | OTHER UNGULATES | LOONS | SNOW GEESE | OTHER GEESE | DUCKS | RAPTORS | SHOREBIRDS | GULLS | PELAGIC MARINE | DEMERSAL MARINE | ANADROMOUS | FRESHWATER | EPONTIC ORGANISMS | PLANKTON | EPIBENTHIC INVERT. | INFAUNA INVERT. |
| HUMAN PRESENCE | | | | | ● | ◊ | ● | ◊ | ◊ | ◊ | ◊ | | ◊ | O | ◊ | O | ◊ | ◊ | ◊ | ◊ | | | | | | | | |
| SOLID WASTES | | | | | ● | ◊ | ● | ◊ | ◊ | ◊ | | | | | | | | | | ◊ | | | | | | | | |
| TREATED SEWAGE | | O | O | O | | | | | | | | | | | | | | | | | O | O | O | O | O | O | O | O |
| WASTE WATER DISCHARGE | | | O | O | | | | | | | | | | | | | | | | | O | O | O | O | O | O | O | O |
| AIR EMISSIONS* | | | | | O | O | O | O | O | O | O | | O | O | O | O | O | O | O | O | | | | | | | | |
| AIRBORNE NOISE: AIRCRAFT | | | O | O | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | | | | | | | | |
| AIRBORNE NOISE: OTHER SOURCES | | | | | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | | ◊ | O | O | O | O | O | O | O | | | | | | | | |
| ARTIFICIAL ILLUMINATION | | | | | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | O | | | O | O | O | O | O | O | O | | | | | | | | |
| DREDGING | | O | O | O | | | | | | | | | | O | | | O | | | O | ◊ | ● | ● | | | ◊ | ◊ | ● |
| ICE BREAKING | O | O | ◊ | O | O | O | | | | | | | | | | | O | | | O | O | | | | O | | | |
| UNDERWATER SOUND | | ◊ | O | O | | | | | | | | | | | | | | | | | ◊ | ◊ | ◊ | | O | O | O | O |
| ROCK QUARRIES AND CAMPS<br>ACCESS/HUMAN PRESENCE<br>GRAVEL PITS | | | | | | ◊ | ● | ◊ | ◊ | ◊ | ◊ | | | | ◊ | O | O | ● | | O | | | ◊ | ◊ | | | | |
| SOLID WASTES | | | | | | ◊ | ● | ◊ | ◊ | ◊ | | | | | | | | | | O | | | | | | | | |
| SEWAGE | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AIR EMISSIONS | | | | | | O | O | O | O | O | O | | O | O | O | O | O | O | | O | | | | | | | | |
| AIRBORNE NOISE | | | | | | ◊ | ● | ◊ | ◊ | ◊ | ◊ | | O | ◊ | ◊ | ◊ | O | ◊ | | O | | | | | | | | |
| PHYSICAL PRESENCE/ ARTIFICIAL ILLUMINATION | | | | | | ◊ | ● | ◊ | ◊ | ◊ | ◊ | | ◊ | O | O | O | O | ◊ | | O | | | | | | | | |
| ROAD - QUARRY OR GRAVEL PIT TO SHOREBASE<br>HABITAT LOSS | | | | | | ◊ | O | O | O | O | O | | | ◊ | ◊ | O | O | ◊ | | | | | ◊ | ◊ | | | ◊ | ◊ |
| DISTURBANCE | | | | | | O | ◊ | O | O | O | ◊ | | | ◊ | ◊ | O | ◊ | ● | | O | | | | | | | | |
| ACCESS | | | | | | O | O | O | O | | ◊ | | | | O | O | O | O | | | | | O | O | | | | |
| ROAD - YUKON COAST - DEMPSTER HIGHWAY<br>HABITAT LOSS | | | | | | ◊ | O | O | O | O | O | | ◊ | ◊ | O | O | ◊ | ◊ | | | | | ◊ | ◊ | | | ◊ | ◊ |
| DISTURBANCE | | | | | | O | ◊ | O | O | ◊ | ◊ | | ◊ | ● | O | O | ● | ◊ | | | | | | | | | | |
| ACCESS | | | | | | O | O | O | O | O | O | | O | | O | O | O | O | | | | | O | O | | | | |

LEGEND

O NEGLIGIBLE

◊ MINOR

● MODERATE

■ MAJOR

*POTENTIAL IMPACTS
(ASSUMING SUCCESSFUL IMPLEMENTATION OF MITIGATIVE MEASURES DESCRIBED IN TEXT)

regional impacts on polar bears are expected to be MINOR, while local impacts could increase to MODERATE.

Before 1985, mainly STOL aircraft and helicopters would use the airstrip; later the airstrip would be lengthened for use by larger aircraft including Boeing 737 and the much quieter 767 jets. Aircraft noise may temporarily disturb certain marine mammals, such as breeding ringed seals, possibly hauled-out ringed seals and bearded seals, and denning Arctic foxes. Possible impacts of overflights on breeding and hauled-out seals would probably be NEGLIGIBLE, however, disturbance of denning Arctic foxes could result in a MINOR impact on the local population because the area is an important denning location for this species.

Aircraft over land disturb birds more than those over the sea. Over the sea, the noise would most likely affect moulting and staging ducks. However, since the potential shorebase sites have not been identified as important areas for moulting ducks, the possible impacts of regulated air traffic on ducks along the coast are expected to be MINOR.

Assuming a protected harbour is built at the Yukon coast shorebase, there will be a need for dredging of a basin, and the dredge spoils would likely be used for constructing a breakwater-causeway. In general, the impacts of dredging at a Yukon coast shorebase on water quality and most wildlife are expected to be NEGLIGIBLE because the activities and subsequent effects will be local and of short duration. Impacts of dredging will include the destruction of the local benthic infauna in borrow areas, but are expected to be MINOR on local epibenthic invertebrate populations since recolonization would be rapid.

Possible effects of dredging on fish may include a local alteration of marine spawning habitat and removal or burial of benthic food sources. Disturbance of feeding habitats may result in NEGLIGIBLE to MINOR impacts on local fish populations, while disturbance or loss of spawning areas may cause MINOR to MODERATE impacts on some species. Based on experience elsewhere in the Beaufort Sea, the impact of fish entrainment in dredges is expected to be NEGLIGIBLE.

If granular materials are required for the construction of offshore platforms, icebreaking barges would deliver these materials throughout the year. In winter and spring, these vessels would follow a 100 to 150 m wide corridor through the landfast ice. In general, icebreaking in the area will probably have NEGLIGIBLE impacts on local populations of polar bears, Arctic foxes, bearded seals, white whales, bowhead whales, pelagic fish and epontic (under-ice) flora and fauna. However, icebreaking effects on ringed seals may approach the MINOR rating since a few probably breed on the landfast ice off the Yukon coast, and some pups may be killed during the 6 week pupping period in the spring. Impacts on hauled-out seals during June would probably be NEGLIGIBLE, since only a few individuals would be temporarily disturbed and it is unlikely that any would be killed.

In general, underwater industrial noise along the Yukon coast is expected to leave most local marine mammal populations unaffected, hence impacts are expected to be NEGLIGIBLE. Nevertheless, underwater noise originating from the shorebase area may have some effect on bowhead whales, particularly during late summer and fall before and during their autumn migration. To ensure that impacts of shipping and resultant noise on whales would be minimized, industry-sponsored whale monitoring programs, similar to those employed at Tuktoyaktuk, will be carried out. The possible impacts of underwater noise from a Yukon coast shorebase on bowheads would probably be NEGLIGIBLE until 1987, while increased activities after that time could result in NEGLIGIBLE to MINOR local disturbance.

### Impacts on Terrestrial Wildlife and Freshwater Resources

It is recognized that certain land areas adjacent to a projected Yukon coastal shorebase are biologically important. Hence, mitigative measures have been identified to ensure that possible impacts of such a development are minimized.

Common wastes and disturbances expected from a shore base are: human presence, air emissions, sewage and solid waste disposal, artificial illumination, and stationary airborne noise. At a King Point or Stokes Point base or at a rock quarry site such as Mount Sedgewick, these are not expected to result in impacts greater than MINOR on most terrestrial wildlife. Some species of mammals and birds including grizzly bears, red foxes, tundra wolves, wolverines, ravens and gulls may be attracted to a Yukon coast base and to quarry or gravel pit camps. For grizzly bears, mitigative measures include monitoring of bears and sedation and removal of problem animals; some individuals may have to be destroyed for reasons of human safety. If mitigative measures are largely successful, the regional impacts on grizzly bears would likely be MINOR although the local impact on this population could approach MODERATE.

The attraction of other scavengers to a shorebase development should be minimized by careful handling of food and incineration of wastes, although some mammals such as foxes, wolves and wolverines, may have to be destroyed if they become a nuisance or exhibit the behavioural traits of rabid animals. Some birds may be killed in collisions with structures at these sites. However, impacts on the regional populations of these species should be NEGLIGIBLE to MINOR.

Some terrestrial species may be affected by increasing levels of airborne noise from aircraft landing at a Yukon coast shorebase, or operating in the area, or travelling between the airport and other locations in the Beaufort region. Affected species may include: caribou during spring migration, calving and post-calving; moose; nesting raptors; staging geese; moulting ducks and ground nesting birds.

To reduce or avoid adverse air traffic effects on the Porcupine caribou herd, overflights of spring migrating, calving and post-calving caribou will be prohibited whenever possible between early May and early August. Also, between August 15 and September 30, overflights of traditional goose staging areas such as the North Slope and parts of the Mackenzie Delta, will be avoided to the extent possible. If these and other mitigative measures are followed, potential impacts of aircraft disturbance on terrestrial birds and mammals will be confined to the immediate vicinity of a Yukon coast shorebase and should vary from NEGLIGIBLE TO MINOR.

Birds and mammals may be affected by the construction and operation of roads, quarries and gravel pits. Impacts may result from: industrial disturbance, direct loss of habitat, increased hunting and harassment, and direct mortality due to interaction with vehicles or facilities. Most impacts would occur due to increased hunting and trapping access to the area. The death of mammals or birds directly due to industry activities is expected to have a NEGLIGIBLE impact on local populations, while possible cumulative impacts from disturbances, habitat loss and hunting could range from NEGLIGIBLE to MODERATE, depending on species and the success of mitigative measures. The species most likely to be affected by disturbances are caribou, raptors and waterfowl. Effects of disturbances on other mammals and birds are expected to be NEGLIGIBLE.

During some springs, portions of the Porcupine caribou herd migrate along the Yukon coast past locations such as Stokes Point and King Point (Figure 2-16). Migration routes are generally parallel to and south of the route between King Point and the Dempster Highway. Within the Yukon coast shorebase area, spring migration generally begins in late April and continues until late July, and calving generally occurs between the last week of May and mid June. In most years, the eastern extremity of the calving grounds would include the Mount Sedgewick quarry site, the haul road route and the proposed shorebase sites, although only scattered calving activity generally occurs in the vicinity of these sites. In late June and early July, large post-calving groups begin an eastward migration from Alaska across the northern Yukon to the Richardson Mountains. The routes connecting the Mount Sedgewick quarry site with shorebase sites are almost perpendicular to the primary main eastward migration corridor, however, few caribou are likely to encounter the shorebase sites. Later movements of the caribou herd are generally south of all the proposed facilities.

The physical presence of a road and quarry are not expected to disturb the caribou, but, the activities of personnel and vehicles are of concern. To minimize disturbances, construction and quarrying at Mount Sedgewick and use of the all-weather haul road may have to be restricted from time to time between early May and early August. Although hauling on the road from the Dempster Highway to a Yukon coast shorebase would not interfere with spring migration of the herd in most years, aerial monitoring of the roads will be conducted during the migratory period in order to control traffic. It may also be possible to accomplish all rock hauling using only a winter road. Successful implementation of these and other mitigative measures should reduce the impact from road and quarry operations on caribou to a MINOR level.

High densities of raptors, such as falcons are found in the upland and foothill portions of the Buckland Mountains along the Trail and Babbage rivers, particularly in the area adjacent to Mount Sedgewick. Disturbance of raptors is only likely if activities such as aircraft traffic, heavy construction, or blasting occur near nest sites during the pre-nesting and nesting period, or if personnel approach nest sites. Mitigative measures that will be used to reduce disturbance to nesting raptors will include identication of active and historic raptor nest and perch sites so that development can be planned to avoid their locations if feasible. Some raptors may be disturbed by quarrying and road construction activities despite the successful implementation of mitigative measures. The overall impacts of activities along the road right-of-way between Fort McPherson and a Yukon coast shorebase on regional populations of raptors would likely be MINOR. The disturbance caused by quarrying and use of the quarry haul road could result in MINOR to perhaps MODERATE local impacts on nesting peregrine falcons, gyrfalcons and golden eagles, depending on their abundance and distribution where activity is most intense.

Possible disturbance of autumn staging geese is of concern with respect to a Yukon coast shorebase. Also, nesting and moulting ducks, as well as nesting loons, shorebirds and passerines may be disturbed by air traffic and road construction and operation. Autumn staging geese, and particularly snow geese

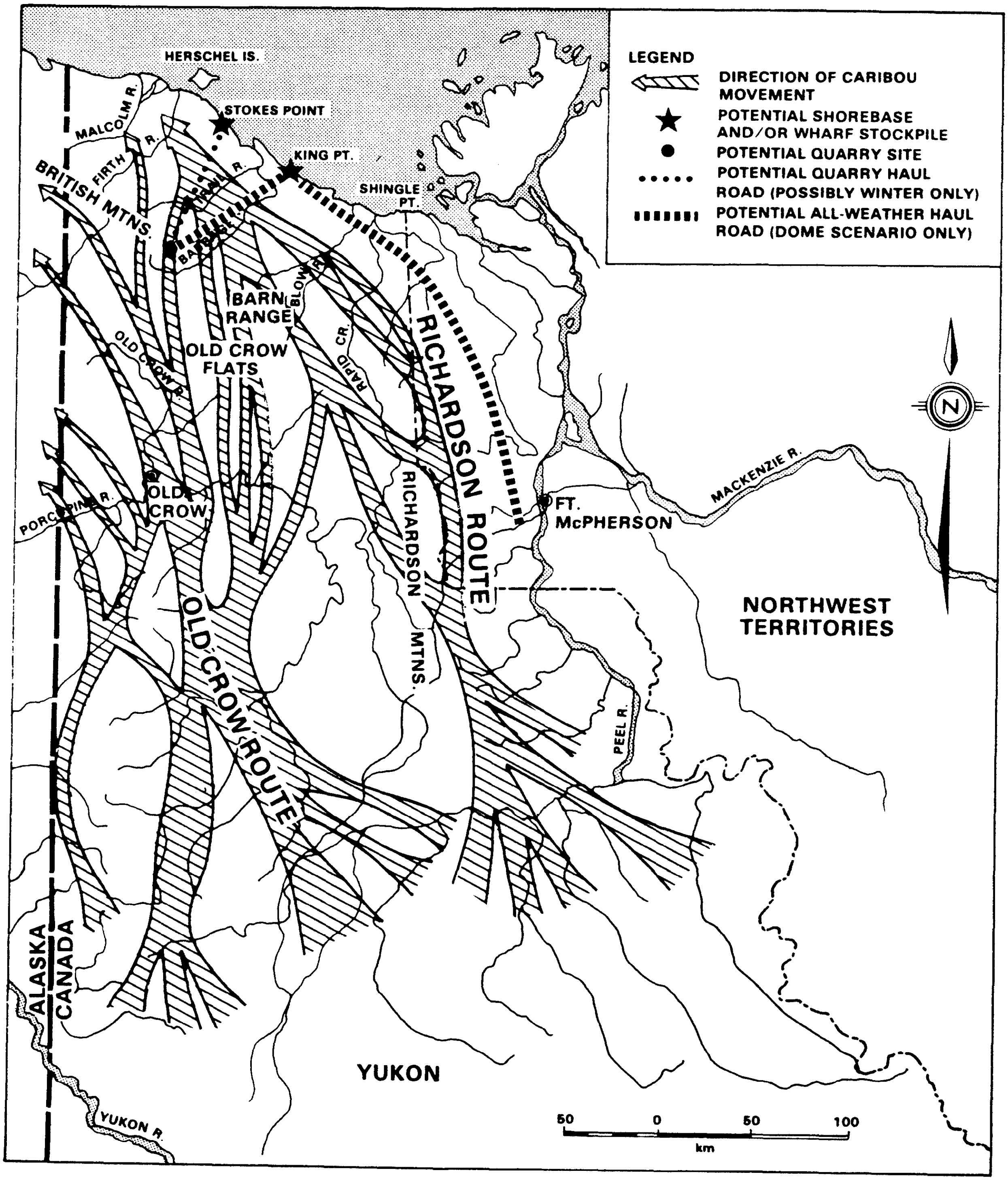



**FIGURE 2-16** *Spring migration routes of the Porcupine caribou herd relative to proposed onshore developments along the Yukon coast.*

appear to be sensitive to disturbance by aircraft. There are also indications that snow geese may be sensitive to ground-based sources of disturbance and would be repelled by such disturbances. To ensure that autumn staging geese are not disturbed and excluded from traditional feeding areas by use of a route from the Yukon coast to the Dempster Highway, road use could be restricted between roughly August 15 to September 30 if necessary. This restriction, along with limitations placed on aircraft routes and altitudes, is expected to reduce the disturbance of impacts on autumn staging snow geese and other geese to MINOR. Although construction and operations on the quarry haul road could disturb and displace staging snow geese, this area does not appear to be particularly important to staging snow geese in most years.

Birds, particularly loons and waterfowl, may be disturbed if they attempt to nest or moult along the road and adjacent to shorebase facilities. Although the potential local impacts of the road from the Yukon coast to the Dempster Highway on nesting loons and waterfowl and on moulting waterfowl could approach MODERATE, regional impacts would probably be MINOR.

Habitat reduction is another concern. Birds, mammals and fish may have their habitat physically destroyed or modified, or may be repelled from their habitat by disturbance. Physical reductions in habitat area would occur during construction of roads and facilities, from alterations in drainage patterns and from chronic dusting.

Roads could directly and indirectly disturb the most habitat, while comparatively little habitat loss would result from development of a Yukon coast shorebase and a rock quarry at Mount Sedgewick. Mitigative measures applied in relation to roads would include design and routing to minimize changes in water levels and drainage patterns. This would protect muskrat and beaver habitat, breeding habitat for waterfowl and shorebirds, and the hunting habitats of raptors. In addition, road dust could be prevented by use of water sprinklers as required.

Only insignificant direct losses of caribou habitat are expected due to project activities. Indirect loss may result from the blocking of migration routes. The road from the Yukon coast to the Dempster Highway would be essentially parallel to the direction of migration, and therefore not likely to interfere with caribou movements. On the other hand, the all-weather quarry haul road would be perpendicular to migration routes, and caribou may not cross this road. However, recent data on the effects of the Dempster Highway on the Porcupine caribou herd, derived from a three year joint project between the Yukon Government and the Canadian Wildlife Service, indicated that caribou had little difficulty crossing the highway, even at steep gravel banks. In fact, two of the major crossing sites documented during their study had the highest, steepest berms. The researchers concluded that for the years of their study, the road environment did not appear to impede caribou movements, although they cautioned that they had not had the opportunity to measure crossing characteristics under deep snow conditions. On this basis, it is assumed that caribou would have little difficulty crossing the proposed roads (Plate 2-6). Possible exclusions from preferred habitat due to barrier effects should have no more than a MINOR impact on the herd.

Direct habitat loss could also result from road construction if fox, wolf, wolverine and grizzly bear dens are destroyed. Den sites are often traditional, and there are few suitable denning sites in some areas. Denning areas will be avoided wherever possible and the impacts of habitat loss on these and other mammal species are therefore expected to be NEGLIGIBLE.

Where possible, the proposed roads will avoid low-lying wet areas which are the preferred habitat of loons and of most ducks and shorebirds. Rock outcrops and cliffs favoured by nesting raptors will also be avoided. Quarrying activity is the only operation likely to represent a direct threat to raptor habitat. Successful implementation of mitigation measures is expected to reduce impacts of direct habitat loss on birds to NEGLIGIBLE or MINOR levels. Indirect habitat loss could occur in the vicinity of project activities as a result of disturbance. This may have a greater effect on nesting and moulting birds than direct habitat loss.

Habitat loss for freshwater fish can result from sedimentation in stream beds, mechanical disruption of stream beds and banks, and improperly placed culverts. Also, water withdrawal from streams with low flows could cause fish losses. Fish habitat will be protected using various means, such as: the use of bridges instead of culverts to cross the rivers and large streams having upstream fish overwintering or spawning areas; the adherence to special guidelines for the placement of culverts in smaller streams; and the scheduling of construction for mid summer or winter to avoid conflicts with fish migration and spawning. Successful implementation of these and other mitigative measures should reduce possible impacts of the development on important fish habitats to NEGLIGIBLE or MINOR.

In conclusion, the proponents are committed to ensuring that environmental disruptions will be minimized at all existing and projected future shorebases in the Beaufort region. Through the application of appropriate mitigative measures, the natural resources can be protected.

**PLATE 2-6** *In general, caribou appear to habituate to northern roads and have little difficulty crossing them. These caribou were photographed in the Prudhoe Bay development area (Courtesy: Alyeska Pipeline Service Co.).*

### 2.2.4 ACCIDENTAL OIL SPILLS

The risk of an oil spill during development or production of an oil field is of fundamental concern to the oil industry. A great deal of effort and expense is placed on preventing oil spills and on the development and testing of equipment and contingency plans to respond to an oil spill. The industry has conducted numerous studies over the last 15 years to understand the Arctic environment: the ice, weather, animals and birds. There is risk with any activity but the oil industry is convinced that the level of risk of a major oil spill associated with drilling and development of oil fields in the Arctic enviroment is extremely low. All reasonable measures are enacted to ensure that an oil spill will not occur. The probability of a major spill resulting in significant environmental impact is dependent upon many factors, including the amount of oil spilled, the location of the spill and the nature of the receiving environment.

The steps taken to minimize the level of risk include:

1. Prevention - design of equipment, training of personnel, development of safe operating practices, and use of redundant safety systems.

2. Research - Accident statistics, computer modelling of hypothetical accidents, knowledge of the physical and biological environment, research on the fate and behaviour of spilled oil in the Arctic, and development and testing of clean-up equipment and techniques.

3. Spill Clean-up and Contingency Plans - Development of equipment, practice, appropriate equipment use, levels of responsibility, and presence of back-up equipment and personnel.

#### 2.2.4.1 Prevention

As the development of the Beaufort Sea-Mackenzie Delta region enters the production stage, the potential sources of accidental hydrocarbon releases will include drilling systems, production systems, transportation systems such as pipelines and tankers, and storage systems. Accidents which may result in a major oil spill include oil well blowouts, tanker accidents and storage system spills. While also of significant concern, leaks from subsea pipelines would be detected and the line shut down before major losses of oil occurred.

Much of the planning involved in drilling and operating a well is directed towards the selection of equipment and procedures to control pressures, which in turn prevents blowouts. The use of weighted drilling muds, the application of fail-safe blowout preventers, the use of experienced crews and proven and established procedures, and adherence to rigorous government drilling regulations are some of the factors which contribute to the low probability of blowouts.

As the design of production facilities proceeds, safety is one of the priority considerations in the selection of processes, components, and control and safety systems. Analyses of the causes of historic offshore production accidents form the basis for the design of safety and control systems, the establishment of procedures and the training of personnel.

For example, the proposed Arctic tanker, which is described in Chapter 1 is designed and equipped so that the risk of a spill from such a ship is estimated to be 120 to 160 times lower than that from a conventional well-maintained tanker operating in more temperate waters. Much of the reduction in risk is associated with the vessel's double hull, which is strengthened for icebreaking and which would provide much greater protection to cargo tanks in the event of collision or grounding. The tanker's navigation systems, the superior maneuverability of the vessel and sophisticated ice detection and prediction systems combined with the superior training and crew management practices planned, also contribute to the reduction in accident risk.

It is clearly evident from analyses of the causes of reported oil spills worldwide that human failures are the cause of the majority of oil spills. Safety and control systems and established procedures are reliable in design and function. Most oil spills are caused by missapplication of these systems and procedures, and by poor maintenance. Accordingly, the proponents have set into place policies which govern design, installation, operation, maintenance, safety, and the selection, training and testing of personnel. These policies will minimize human errors and their consequences.

### 2.2.4.2 Research

Planning to achieve an advanced state of preparedness includes analysis of accident statistics, research into the behaviour of oil spills in the Arctic environment with particular emphasis on spills in ice-infested waters, studies of the resources in the region and their vulnerability to oil spills, and development and testing of spill clean-up equipment and techniques in the Arctic environment (Plates 2-7 and 2-8).

Statistics of accidents worldwide have been reviewed in order to examine the causes of major oil spills, particularly relating to the transport of oil by tankers

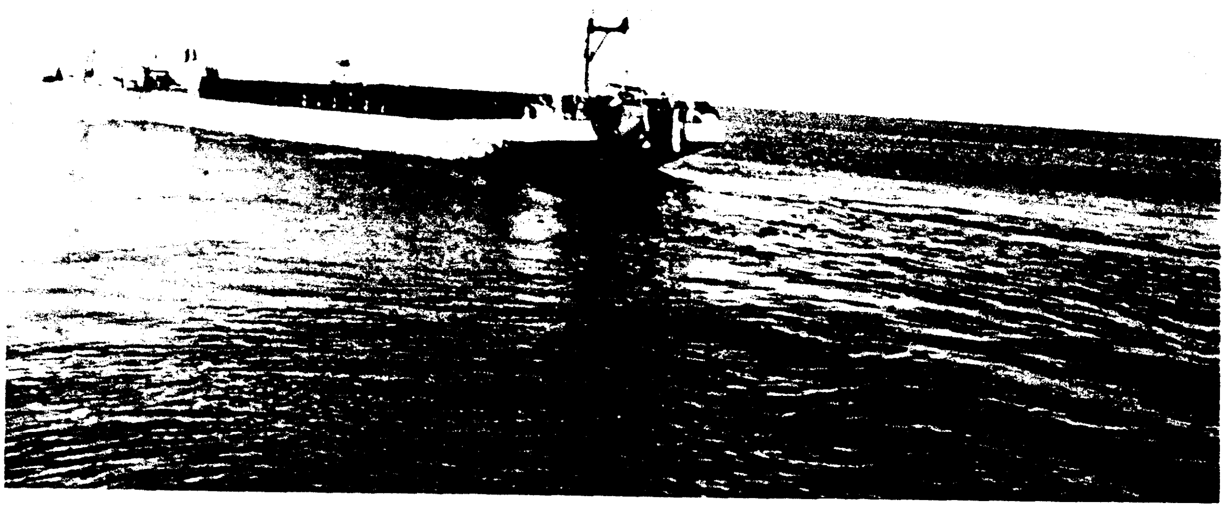


**PLATE 2-7** *Considerable research and development effort has been directed towards the testing and development of oil spill clean-up equipment and techniques in the Arctic environment. The "oilspill response barge" pictured here is equipped with a variety of countermeasure devices for effectively responding to an oil spill.*

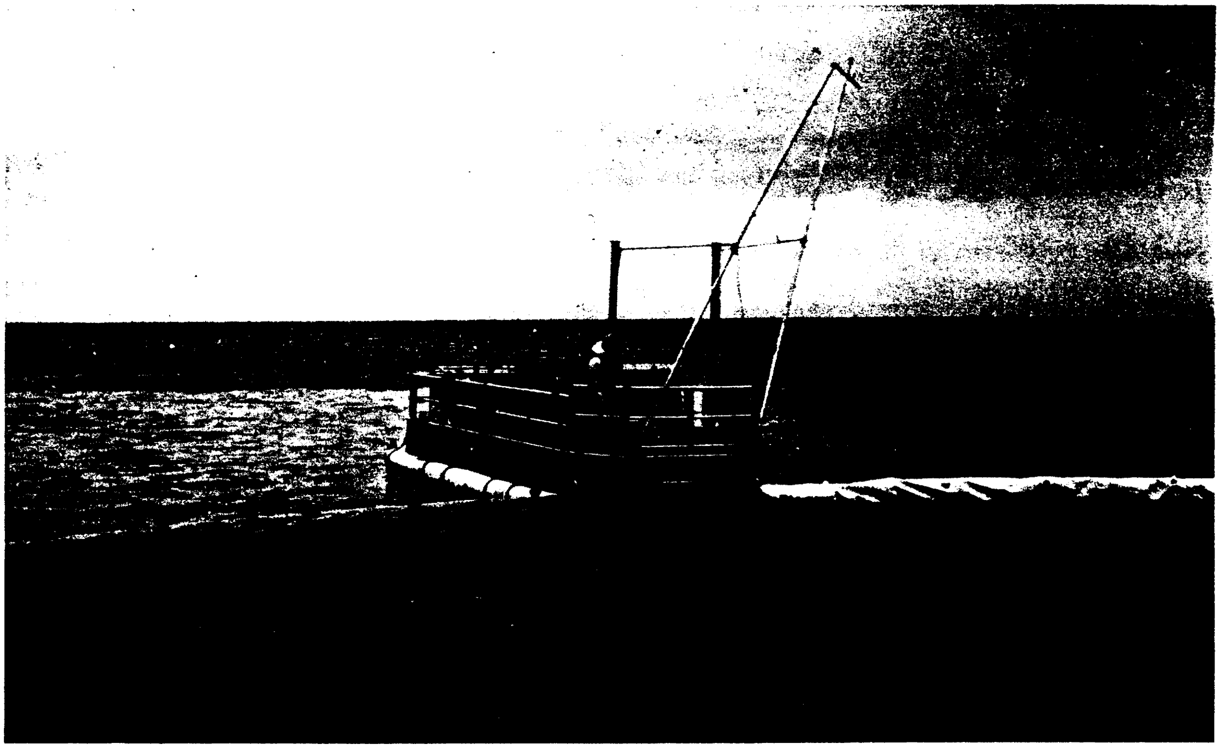


**PLATE 2-8** *The newly developed Arctic skimmer is designed to recover oil from cold Arctic waters and recently completed a successful open water trial in the Beaufort Sea.*

and offshore oil and gas operations.

From analyses of accident data from the U.S.-Gulf of Mexico offshore production operations, there have been, on average, 2.5 accidents per 100 wells drilled and operated per year. Of these, three quarters of the accidents have resulted in spills. The majority of these spills (91%) involved less than 50 bbls (8 $m^3$); however, almost 95% of the total spilled oil resulted from a few large spills (greater than 1,000 bbls). Blowouts have occurred in the U.S.-Gulf of Mexico on an average frequency of 0.13 blowouts per year per 100 wells over the past nine years. Over the past 25 years, when an average of 4,630 wells were in operation per year, 98 blowouts have occurred. Oil spills occurred in 12% of these blowouts and spilled 69,000 bbl (11,000 $m^3$) of oil. Most of the oil spilled resulted from one blowout, which released 52,000 bbl (8,300 $m^3$).

Looking at tankers, it is of interest to note that during the period 1967 to 1978, there have been 78 recorded oil spills greater than 180 tonnes from tankers, representing a total of 1.5 million tonnes of spilled oil. In the majority of these accidents, less than 15,000 tonnes of oil was spilled. Further, only 1 spill in 7 involved tankers owned by the oil industry. About 40% of the world's tankers are owned by the oil industry.

A number of large hypothetical marine oil spills in the Beaufort Sea have been postulated and with the aid of computer modelling, oil spill trajectories have been generated. Predictions of the movement of oil spilled from these hypothetical accidents, coupled with knowledge of the physical and biological environment, permit an estimation of the possible impacts and form the basis for the determination of countermeasures required to minimize impacts. The events which would follow a real accident will differ from the hypothetical case studies, mainly as a result of variations in winds, currents, and other factors; however, a value of the case study approach is the identification and planning of countermeasures strategies.

The consequences of a major oil spill are a function of a variety of factors which include the operations that are underway at the time of the accident, the success of corrective measures, the time of year, the location and duration of the spill, ice cover, weather conditions, the success of spill control and cleanup measures, and the type of habitat which may become oiled. Of particular concern, are the effects of a major oil spill on the marine resources of the region. The impact of an oil spill on birds, marine mammals, and fish is highly dependent on the time of the event, the areas contaminated and the species present.

Birds would generally be the most likely to be affected by contact with oil. An oil spill during the period from April to September could have considerable impacts on a number of species of birds which annually migrate to the Beaufort Sea.

Bowhead and white whales are most vulnerable during their spring migration as they follow leads in the ice. The most serious impact on ringed seals could occur if oil reached their primary pupping ground in the large bays of Amundsen Gulf and the inshore landfast ice areas along the Tuktoyaktuk Peninsula and the west coast of Banks Island.

Fish resources could be affected by the potential disruption of spawning migration and effects in the coastal areas influenced by the Mackenzie River and other fresh water drainages.

Although difficult to predict, a range of potential effects from an oil spill can be anticipated. For three hypothetical accidents in the production area which result in major oil spills, the potential effects on biological resources have been estimated. Since a prediction of the spill response effectiveness would be unrealistic, the potential effects have been estimated assuming no countermeasures are applied. Table 2-1 provides a summary of possible significant impacts on regional resources. Other species could be affected to a less significant degree; for instance, the impact of each of the three hypothetical spills on the bowhead whale population were projected to be MINOR. A MINOR impact exists when a population is affected in a localized area and over a short time period (one generation), but is not regionally significant. A MODERATE impact affects a population over more than one generation but is unlikely to affect the integrity of the regional population. A MAJOR impact affects the regional population for several generations.

Oil spill countermeasures which would be applied to contain, divert and remove spilled oil, will likely reduce the overall impact on biological resources. The biological resources at risk largely determine when and where spill response efforts are concentrated. For example, action would be initiated to prevent oil from reaching the more important bird concentration areas, and attempts would be made to prevent or minimize the number of birds coming in contact with oil.

Considerable work has been undertaken in developing equipment and techniques for cleaning up spills in the Arctic environment. The clean-up and control of a large oil spill is a difficult task even under ideal conditions in temperate climates. The ice, temperature and remote location of the Arctic are three major factors which influence spill clean up. Research and development work completed to date have resulted in the development of spill clean-up equipment and techniques uniquely suited for the Arctic environment.

**TABLE 2-1**

**POSSIBLE SIGNIFICANCE OF A MAJOR OIL SPILL IN THE BEAUFORT SEA ASSUMING NO COUNTERMEASURES ARE EMPLOYED.**

| Resource | #1 | #2 | #3 |
|---|---|---|---|
| White Whale | ● | | |
| Ringed Seal | ● | | ● |
| Bearded Seal | ● | | |
| Polar Bear | ● | | |
| Red-Throated Loon | ● | | |
| Arctic Loon | ● | | |
| Black Brant | ■ | ● | ● |
| White-fronted Goose | ● | ● | ● |
| Scaup and Scoter | ● | | ● |
| Oldsquaw | | | ● |
| Common Eider | ■ | | |
| King Eider | ● | | |
| Shorebirds (1) | ● | ● | ● |
| Glaucous Gull | ● | ● | ● |
| Arctic Tern | ● | | |
| Alcids(2) | ■ | ■ | ■ |
| Fish(1) | ● | ● | ● |
| Phytoplankton | ● | | |
| Benthic Invertebrates(1) | ● | ● | ● |
| Terrestrial Vegetation | ● | | |

■ Major ● Moderate

NOTES:

(1) Dependent on species and/or habitat affected.

(2) Dependent on number affected.

Hypothetical Major Oil Spills

#1 Subsea blowout at Kopanoar from a well being drilled from a floating vessel.

#2 Blowout on a production island in the Beaufort Sea

#3 Tanker collision in the Beaufort Sea

### 2.2.4.3 Spill Clean-up and Contingency Plans

An important step in spill response planning is the development of contingency plans to ensure a quick, coordinated, effective response in the event of an oil spill. Contingency plans are already in place for the proponents' exploration activities and will be expanded to cover all aspects of production and transportation. These plans define responsibilities, reporting networks, and lines of authority; provide information; outline main decisions which must be made; and identify the resources available to deal with a spill. The industry contingency plans are developed in close cooperation with government as it is essential that the plans interrelate with government contingency plans.

Countermeasure strategies have been developed for hypothetical major oil spills and provide the spill response team with valuable information on the application of specific measures under given conditions. The ability to predict the trajectory of a spill under specific environmental conditions, knowledge of the biological resources, and detailed information such as the Shoreline Protection and Clean-up Manual and the videotape file of the shoreline are essential to the development of countermeasure strategies.

In the event of a spill, control and clean-up measures may include the burning of oil, deployment of booms and barriers, operation of skimmers and vacuum units, tracking and charting the location of slicks by visual observations and by remote sensing, deployment of buoys for tracking oil in ice, burning of oil in cracks or leads in ice and in melt pools in the spring, placement of nearshore booms, use of devices to discourage birds from entering oiled areas, and collection and disposal of oil and oily debris.

Based on the proven existing exploration spill contingency plans, the contingency plans for production and transportation will ensure that an effective response can be made to any spill in the area of interest. The on-going training and exercise programs and research will continue and expand, to maintain and improve industry's high level of response capability in the event of a major oil spill.

### 2.2.5 THE PEOPLE

The Beaufort Sea region is home to 7,000 people of whom more than half are native Inuvialuit, Inuit, Dene and Metis. The native people of the region have a strong sense of their traditions, and dependence on regional animals for subsistence. Cash income and recreation are also important. While profit from business and wage employment, and government transfer payments are significant sources of income throughout the region, traditional harvesting is still essential to communities like Aklavik, Old Crow, Ft. McPherson, Arctic Red River, Paulatuk, Holman Island, Coppermine and Sachs Harbour (Figure 2-17). The people of Tuktoyaktuk also engage in hunting, trapping and fishing (Plate 2-9), even though this community's economy is changing rapidly because of its involvement with oil and gas exploration. Inuvik was

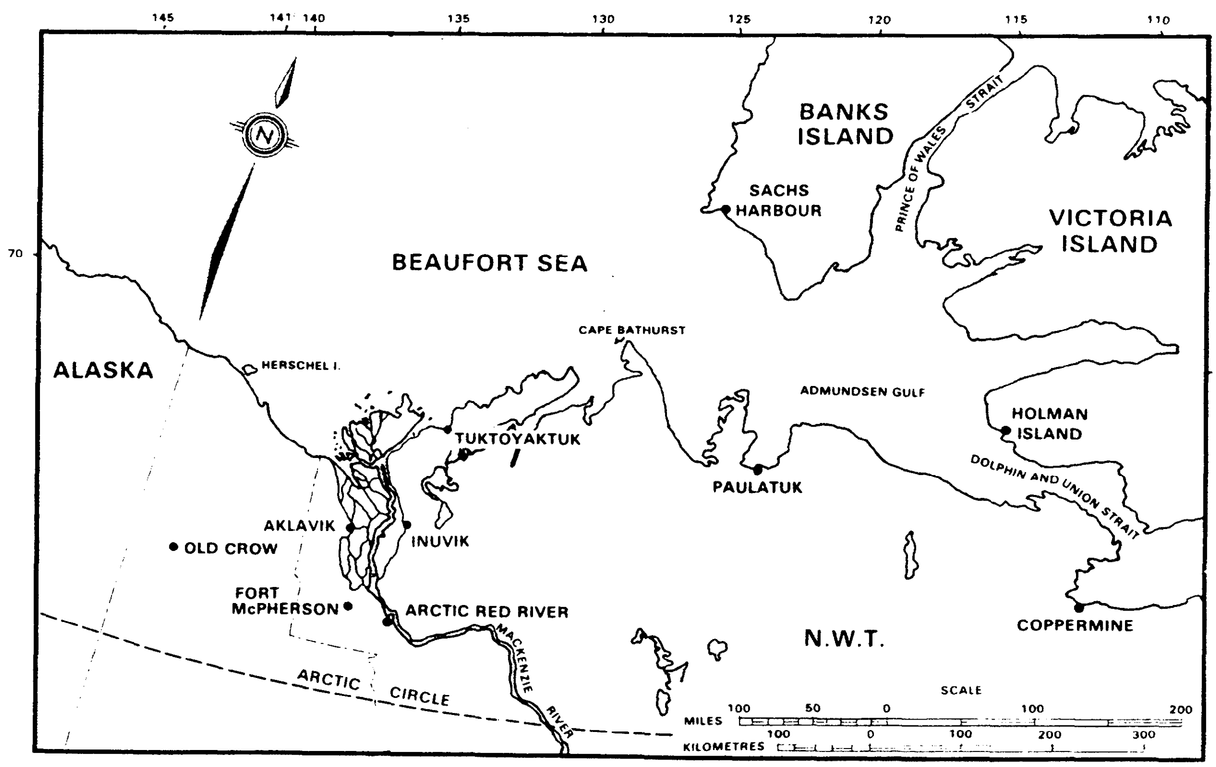



**FIGURE 2-17** *Beaufort Sea-Mackenzie Delta region communities.*

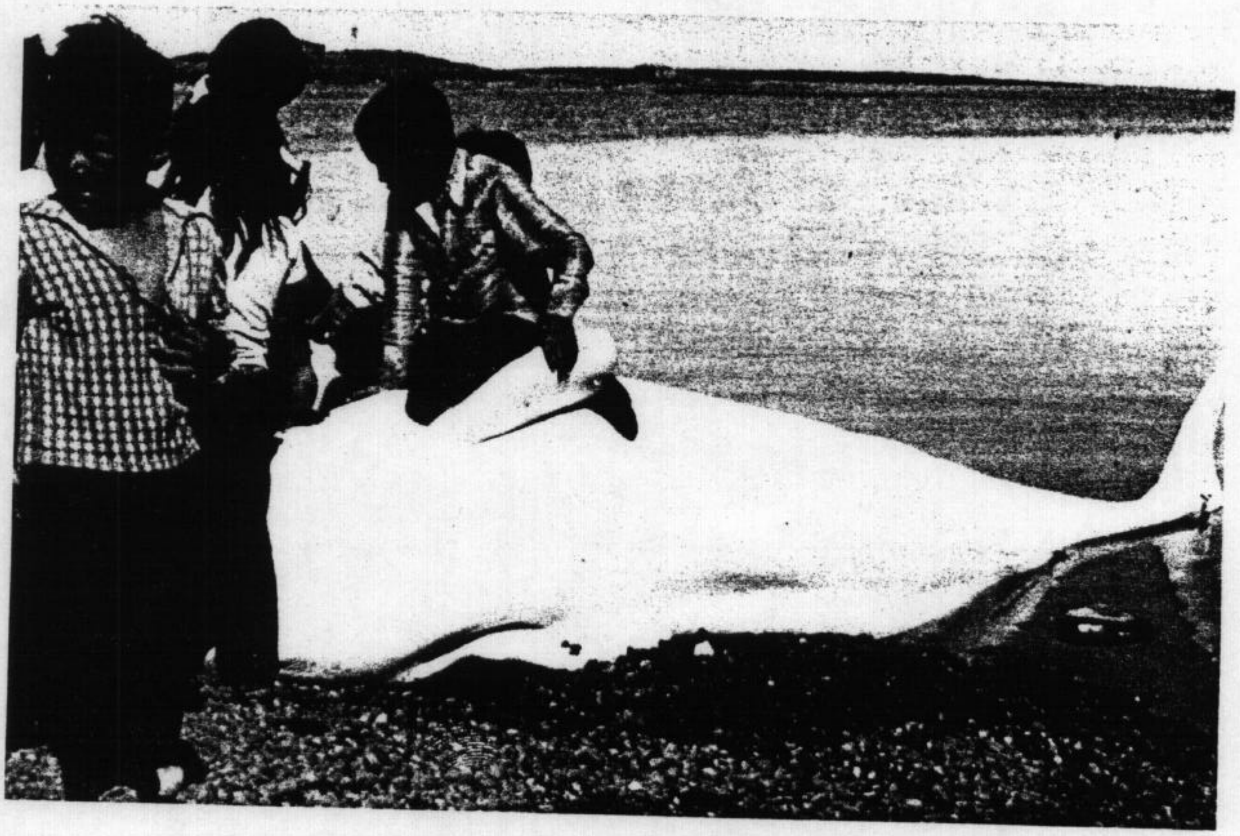


**PLATE 2-9** *Traditional harvesting activities continue to be of considerable social and cultural importance to the people of the region. Above a landed white whale; below fish drying.*

built during the 1950's as a centre for government administration and economic development. Its population of about 3,000 is largely non-native, and tends to be business and development oriented.

The Beaufort region has been inhabited by hunting-gathering peoples for some 4,000 years. Initial contact between native and non-native people began about 200 years ago and it was, for a long time, so infrequent that it had little effect on the native people. Major changes occurred only in the last 100 years. Gold seekers, whalers and traders came to the region in the late nineteenth and early twentieth centuries. Since then, the region and its people have undergone a series of transformations. The fur trade began in the mid-1800's, followed by whaling at the turn of the century, by government expansion in the 1950's and 1960's and, of late, oil and gas exploration, with attendant industrial-commercial development. Each of these development stages have left their marks on the region and its peoples.

The move from a semi-nomadic way of life to a more sedentary urban one accelerated during the 1950's and 1960's with the introduction, by the Federal Government, of major initiatives in education, health, housing and employment programs. Simultaneously, the wage economy and small business sectors became increasingly more vital features of daily life. The administration of the new government programs and the increasing level of private activity, including rising oil and gas activity during the 1960's and 1970's, led to a considerable influx of non-native people. Today, the region has a sizeable and moderately diversified economy, although subsidies and income transfers from government and private sources in the south are a major contributor to its economic well-being.

Today's social and economic conditions in the region are characterized by diverse lifestyles, encompassing both modern and traditional ways of living. Many native people have now had experience in combining rotational wage employment with continued hunting, trapping and fishing. The presence of rising cash income, greater exposure to non-native values, and the increased availability of choices in goods have led to different and often rising expectations. At the same time, native groups have experienced a growing sense of urgency that the adoption of new lifestyles should not submerge valued traditions. As one response to the events of recent decades, some native people have organized political groups such as the Committee for Original Peoples' Entitlement and the Dene Nation, which have lobbied for the recognition of their aboriginal rights and the settlement of their land claims. Many individuals have become active in politics at all levels of government (Plate 2-10), while others have become successful business people.

**PLATE 2-10** *The Northwest Territories Legislative Assembly in session. A majority of the present members are native people. Beaufort development will raise questions concerning geographic and intergovernmental political arrangements.*

Available statistics indicate that, while native people now spend less time harvesting fur, fish and game than in the past, more effective equipment and quicker transportation enable higher individual harvest returns. There are fewer full-time and more part-time trappers and hunters today than was the case even in the relatively recent past. Even so, the quantity of harvest has not declined. Indeed an emerging problem is one of over-harvesting in areas that are readily accessible from communities, as harvesting takes place closer to settlements because of the more sedentary, comunity-based way of life.

The oil and gas industry has broadened the economic possibilities of the region, making people less dependent on the uncertainties of the traditional economy, on government, and on social assistance. It has provided training and employment opportunities for younger people (Plate 2-11). Considerable local employment and business have been generated in some communities, particularly when the industry stepped up its exploration activities in the mid 1970's. Much of this has benefited the communities of Inuvik and Tuktoyaktuk, but other communities such as Aklavik, Coppermine and Fort McPherson have also benefited.

In today's north, the health of the traditional sector is not independent of the industrial sector. Earnings from industrial employment provide the cash for equipment purchases to sustain or increase productivity in the traditional sector. The industrial sector has also played a role in providing people not fully engaged on the land with alternative work. It has had some effect in placing the renewable resource sector on a more commercial footing by encouraging the growth of markets for products such as reindeer and Arctic char, which industry has purchased from regional suppliers. Industry has thus grown to be an integral part of, and indeed an important foundation for, the economy of the region.

Many non-native people have now resided in the Beaufort region for some time, and, in some cases, for two or more decades. Small businessmen have, during the past ten years, experienced both rising and declining opportunities and expectations, and have at times demonstrated a remarkable ability to endure adverse circumstances. Given their changing fortunes of the past decade, and especially events such as the failure of the Mackenzie Valley gas pipeline proposals, it is understandable that they are eager for industrial development.

Within the next ten years, there will be a shift from seasonal exploration drilling programs to year-round exploration and the production and transportation of oil. This shift will bring about a wide range of social and economic changes in the region. There will be substantial increases in the demand for labour. Some communities will expand to accommodate an influx of people. The region's economic base will be diversified through new investment opportunities and there will be increases in transportation for the movement of people and goods, and continuing changes in lifestyles. In the absence of mitigative measures, such rapid growth may lead to local shortages, inflation and social problems. Increased activities and increasing numbers of non-native permanent residents could raise difficulties as well as opportunities for native harvesting of renewable resources.

Communities that are strategically located with respect to oil and gas development would be most affected, especially Inuvik and Tuktoyaktuk. The effect of Beaufort development would, however, extend far beyond the Beaufort region itself. Yukon and the Great Slave Lake region, especially major centres such as Whitehorse, Yellowknife and Hay River, could play especially significant supply roles. The central Arctic, eastern Arctic and Keewatin could also provide manpower and occasionally some business services and supplies.

#### 2.2.5.1 Population Growth

Population growth in the region will depend on the rate of oil and gas production and the level of northern activity associated with it. Current estimates of industry manpower needs vary with different development rates. Excluding manpower needed for pipeline construction, personnel on the payroll in the Beaufort region could range from 11,000 to 13,000 by 1990, and from 17,000 to 24,000 by the year 2000. However, only a small fraction of total personnel, some 2,000 workers, would likely reside in the region in 1990 and 4,000 by the year 2000. The remainder would commute between their homes outside the region and work sites in the region. There will also be an induced labour force; that is, people who are not on the industry's payroll but supply the industry with goods and services, both directly and indirectly. The increased demand on the region's commercial and government services would also generate additional jobs and in-migration.

Taking the entire oil and gas induced labour force, and its dependents, into account, the extra people resident in the region over and above the current population could range from 3,000 to 10,000 by 1985. By 1990, the additional population could range between 12,000 and 15,000, and by 2000, it could be from 16,000 to 23,000. Thus, it is conceivable that the region's total population could range from 20,000 to 30,000 by the year 2000.

**PLATE 2-11** *The oil and gas industry has provided many new training and employment opportunities for younger people of the region.*

To minimize the impact of population growth, the industry believes that a target level or range should be established for planning purposes. Industry is prepared to work closely with government planners and local people to control regional population growth at levels deemed appropriate.

Inuvik, which already has a well developed infrastructure and considerable available land for new housing, could be expanded to accommodate much of the population growth, provided, of course, that the community concurred. Tuktoyaktuk could also experience some further growth, although a much lower rate of growth would be envisaged than in the case of Inuvik.

### 2.2.5.2 Community Expansion

The population growth of Inuvik, at the rate and size indicated, would require a major expansion of community capital such as houses, schools, recreation facilities, roads and utilities. Also, increased personal services would be needed such as those related to health care, education and financial management matters.

A possible scenario for the community of Inuvik is that its population could exceed 10,000 by 1990, and 21,000 by the year 2000. This would mean that over 70% of the possible population growth of the region would take place at Inuvik during the next 20 years, and that the present community population could rise seven-fold. Such growth would only be possible if the community has the physical capability to allow infrastructure and services to expand accordingly.

Possible growth at Tuktoyaktuk is foreseen to be of a different nature. Because of its traditional hamlet character and the wishes of local residents, the industry believes that the growth of its personnel and that of support and service companies should proceed more slowly at Tuktoyaktuk. Based on this premise, the population of the community may increase from its present level of about 800 to about 2,000 by the year 2000. As is already the practice, community residents would be consulted on all important aspects of further development at Tuktoyaktuk.

Major population growth is not expected to occur in the other communities in the region. However, their residents will be able to participate in hydrocarbon development through rotational employment. As well, more employment should be available locally because of a general expansion of the regional economy.

### 2.2.5.3 Business and Income Effects

Hydrocarbon development would have a marked effect on regional employment and income. The wages paid to industry personnel would be high. It would be advantageous for people now living in the region to undertake training to qualify for skilled employment.

Employees resident in the region could earn up to $60 million in wages from industry employment by 1990 and over $150 million by the year 2000 (in terms of 1981 dollars). These earnings would have significant first round multiplier effects.

As a result of hydrocarbon development, many local firms could make the supply of goods and services to the industry their principal line of business. Others could become involved in retail trade, personal services and residential and commercial construction. The industry already purchases considerable volumes of goods and services from regional firms. Purchases would increase as oil and gas development progressed.

The region has a small but vigorous group of business people. However, to take full advantage of the wide range of opportunities that would be generated by hydrocarbon development, existing firms, together with new ones, would need encouragement by government and the industry. Positive policies such as small contract packages, advice on bidding, and preferential government loans are already being pursued and would require some expansion to meet the requirements of a growing regional business sector.

### 2.2.5.4 Problems at the Community Level

The experience with rapid industrial development is that, while most people benefit, effects arise which may be difficult to control or mitigate. Despite responsible measures such as the preparation of advance plans by industry, and the expansion and application of a variety of government programs, the Beaufort region will experience some social and economic dislocations during the next twenty years. These could include problems such as local shortages, family and personal stress, alcohol abuse and anti-social behaviour. These problems would likely occur mainly at Inuvik and Tuktoyaktuk, because they are the prime communities in the development area.

Since the region is not as well served by transportation compared to areas further south, temporary backlogs or delivery delays could cause occasional shortages of goods. Short-term accommodation shortages are also likely to arise. These situations could lead to an inflation of rents and consumer prices in affected communities. In part because of the high wage payments characteristic of the oil and gas industry, the whole regional wage and salary structure could rise, a factor which could prove stressful to local businesses which operate on small profit margins. People on fixed incomes could be worst off in some instances since their incomes would not rise as rapidly as the cost of living. Special governmental measures might be needed to ensure that their standard of living would be maintained.

Hydrocarbon development would produce increased opportunities and options for employment, skill upgrading and financial security. At the same time, it could bring strains on the quality and availability of local services and stresses in personal, family and community relationships. Communities would have to adjust to changes such as more transients, more new faces and more residents working long hours, with less time for community or family affairs. Long-term residents could find it difficult to adjust to changing circumstances.

The degree to which growth would intensify problems at the community level would depend, in some measure, on how carefully the social aspects of such growth were planned and conducted. Above all, approaches to handling community change must involve both native and non-native people, and must be based on the respect of these groups for each other.

#### 2.2.5.5 Potential Conflicts with Native Harvesting

Employment in the oil and gas industry is not in itself expected to deter traditional native land use activities. Industry will continue to offer rotational employment that should allow native employees enough time to hunt, trap or fish. Nonetheless, people living in the Delta communities could experience a substantial increase in job opportunities and may choose to rely less on hunting, trapping and fishing. People living in communities that are further away from the locale of oil and gas development will likely continue to hunt, fish and trap as long as the resource base is healthy and the market for furs remains strong.

The industry is keenly aware of the need to protect the land and marine ecosystems on which native harvesting depends, and will exercise attention, care and responsibility in its construction and operation activities. It will ensure that hunting and trapping regulations are strictly adhered to by its employees while they are on the job.

Some conflicts with native harvesting may arise from the location and possibly the operation of shorebases, roads, and pipelines and expansion of townsites. However, the most serious conflicts may occur with increased recreational land use due to population growth in the region. The hinterlands of Inuvik and Tuktoyaktuk may be the most affected. Priorities for access to game by native and non-native people may need to be established. It may become necessary to regulate recreational activities and to minimize interference with activities such as ratting, fishing and hunting, which will be of continuing importance to the livelihood of native people.

#### 2.2.5.6 Government Responsibilities

If revenues from development are channelled into one level of government while another has to deal with most of the social costs, there is a potential for problems. Currently, the Federal Government would receive most of the royalty benefits, while territorial and community governments would be confronted with increased responsibilities and costs. Both territorial and local levels of government would seem to require increased budgets to cope with the demands generated by development. It would seem especially important to review the fiscal status of Inuvik and Tuktoyaktuk.

The resources and economy of the region's native people will have to be strengthened if they are to play an effective role in the broader regional economy. It is suggested that government make sufficient funds available to native economic development corporations to enable them to develop native business and expertise, improve skills and help upgrade the native educational base. The industry believes that government should clarify the political status of native people at an early date.

#### 2.2.5.7 Industry's Policies for Development

The industry has many years of experience in the Beaufort and elsewhere in the north, and is willing to work with all interested parties and individuals to achieve objectives important to the long-term development of the region. Examples of policies and programs which have been, and will continue to be implemented are briefly described.

Industry has developed ways to allow northerners as well as government to participate in its planning and decision-making, particularly with respect to environmental and socio-economic matters. Important links with the communities exist through various locally and regionally representative groups.

Employment policies have been developed to involve a wide range of northerners, particularly in career positions. A rotational employment system is in effect, which enables northerners to take part in wage employment without having to abandon their resource harvesting activities. Orientation programs have been developed for all employees. Job progression is facilitated by conducting training programs during the off-season and by assisting northerners to take courses at educational institutions.

The industry is supporting the expansion and diversification of the northern business sector by working closely with northern firms, development corporations and government. It spends several million dollars on local purchases each year. It will continue to encourage business growth and development by giving priority consideration to regional suppliers, encouraging firms to expand the range of services available, and encouraging the training and development of young regional residents.

Industry believes that it has a good record in matters of social and cultural support in the region. It is working closely with residents, governments and native organizations to identify, avoid, or minimize impacts on key resource harvesting and cultural areas. Over the years, the industry has supported community services such as day care, broadcasting, and alcohol education.

Inuvik is likely to play a key role as Beaufort development proceeds. Some industry personnel would become resident in the community. Some accommodation for crews in transit to and from industry camps and offshore facilities might be provided near the airport, away from the community. The integration of industry staff with the community would require the provision of housing for employees and suitable cultural and recreational facilities. The industry would adhere to the principle that the provision of social services is the general responsibility of government and the community, although it would assist in planning such services. It will study possibilities of meeting community needs while developing services to meet its own requirements.

Since there would appear to be limits to how much industrial development Tuktoyaktuk residents want to see at their community, the industry proposes to limit the expansion of facilities there and to locate most additional facilities elsewhere in the region.

Accommodating persons on single status at base facilities in Tuktoyaktuk will not be phased out, but as industry moves into the production phase, an increasing proportion of the people in shore base roles may actually reside in the community.

In the case of possible permanent camps such as at McKinley Bay or along the Yukon coast, the industry proposes to locate and design onshore facilities so as to minimize adverse environmental effects and interference with traditional harvesting activities. Access from communities would be controlled and industry personnel would be discouraged from visiting communities while at the camps if this is the wish of the communities.

Industry recognizes the importance of traditional harvesting activities to native people and would, insofar as possible, avoid locating its facilities or carrying out activities in places where there is a risk of decreasing the productivity of harvested lands. Consultations with native organizations, hunters and trappers will take place before specific route alignments are selected for roads and pipelines. Furthermore, industry will continue to monitor the effects of ship traffic on whales with a view to minimizing adverse effects. Harvesting by camp personnel will be banned, and control of tourist and commercial hunting and fishing industries will be encouraged. Country foods have already been purchased and made available at base camps. Industry could assist in expanding or developing markets for these and other commercial resource harvest products. Industry will support government and native organizations efforts to control over-hunting which may occur in association with increased access to remote areas.

The industry has closely followed government's work on land use planning, and is prepared to assist in the land use planning process by identifying its long-term land requirements, and by discussing possible conflicting land uses and solutions with all parties.

# CHAPTER 3

# THE NORTHWEST PASSAGE REGION

Arctic Class 10 tankers, transporting oil from the Beaufort region, would travel on a route eastward into Amundsen Gulf, through Prince of Wales Strait, Viscount Melville Sound, Barrow Strait, Lancaster Sound and then southward through Baffin Bay and Davis Strait. This route or corridor is called the Northwest Passage-Baffin Bay-Davis Strait route (Figure 3-1). One alternative branch to this route is possible in some years to the west of Banks Island and through M'Clure Strait, thus bypassing Prince of Wales Strait. Another alternative which may be possible, particularly for smaller vessels, is through Fury and Hecla Strait. This alternative would bypass Lancaster Sound.

## 3.1 THE SETTING

The main features of the setting in the Northwest Passage region are its bathymetry, ice conditions, marine wildlife and the people and communities located along the route.

The ice climate and the bathymetry are primary constraints to the passage of Arctic tankers. The bathymetry defines possible navigable corridors, while the ice climate determines the vessel class, power and time necessary to travel a particular route. Other operational or routing constraints include those which may be necessary to minimize impacts to the wildlife and the people who harvest it.

### 3.1.1 BATHYMETRY

Arctic tankers require corridors with depths greater than 18 to 20 m and wide enough to allow, within environmental constraints, the exploitation of most favourable ice conditions.

The availability of hydrographic data within the primary corridor, and the alternatives, however, varies greatly. Hydrographic surveys to modern standards will be required to determine bottom conditions and to delineate shoals.

The status of, and requirements for, hydrographic surveys are basically as follows.

Beaufort Shelf: A 10 mile wide corridor is currently being surveyed and is scheduled for completion in 1983. Sub-surface pingo-like features are being mapped.

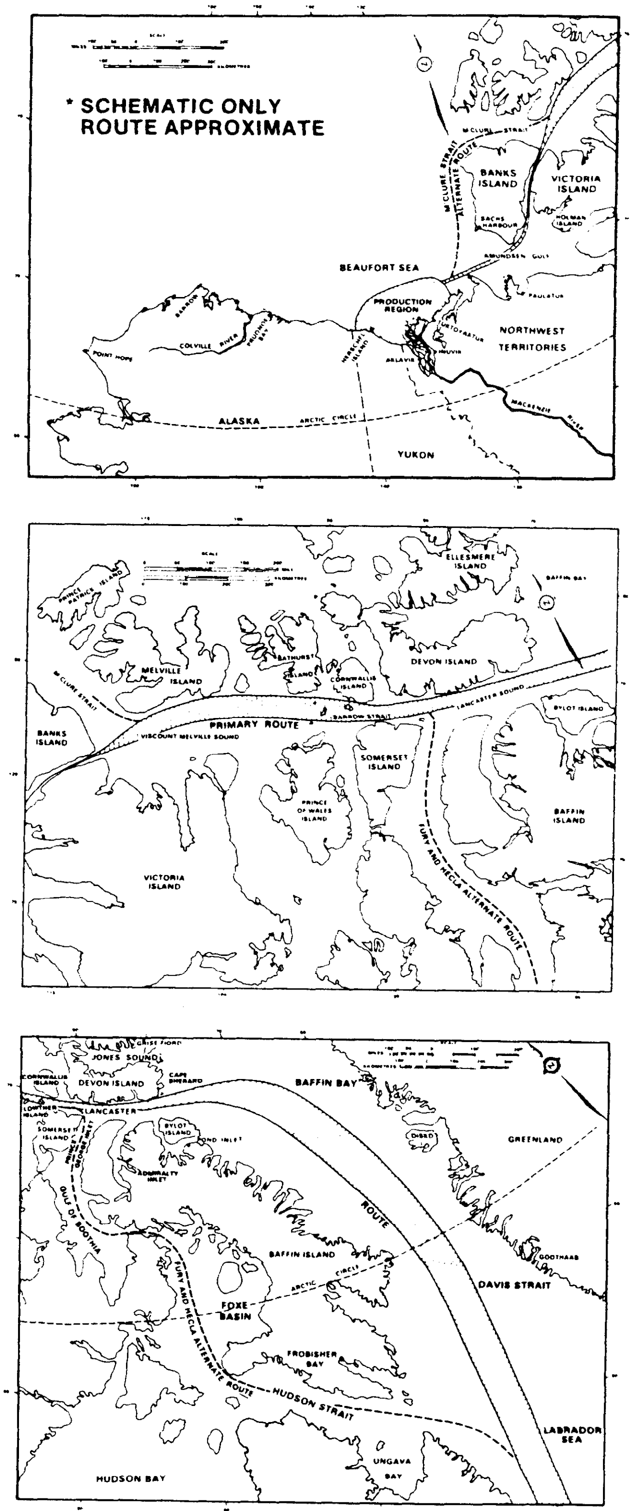



**FIGURE 3-1** *The eastern tanker route and its possible alternate branches through M'Clure Strait and Fury and Hecla Strait. The alternate route west of Banks Island and through M'Clure Strait would add 150 km to the total route and in most years Arctic tankers would encounter high concentrations of multi-year ice in M'Clure Strait. At present, an alternate route through Fury and Hecla Strait, though no farther, is not viable because of sparse soundings and possibly insufficient water depths.*

Amundsen Gulf: This area has been surveyed to modern standards.

Prince of Wales Strait: The only surveys to date have been reconnaissance soundings through the ice. Surveys to modern standards are required.

Viscount Melville Sound: The sound is generally deep, but surveys have been limited to partial soundings along the northern side and sparse soundings elsewhere. Surveys to modern standards will be required for both the northern route and the southern and central routes. The latter will be used when little ice is present, which occurs in some years.

Barrow Strait and Lancaster Sound: The quality of data is good with relatively high sounding densities in this area.

Baffin Bay and Davis Strait: No future surveys required because of sufficient water depths.

M'Clure Strait Alternative: The offshore waters of the Strait have been partially sounded and are generally deep. Surveys to modern standards will be required for the shallower waters off the west coast of Banks Island.

Fury and Hecla Alternative: Only limited information is available on water depths. This alternative is currently not considered acceptable because of limited soundings, indications of insufficient water depth, and some difficult passages for larger ships.

### 3.1.2 ICE

Ice conditions through the primary shipping corridor are summarized in Figure 3-2. The worst ice conditions exist from the north end of Prince of Wales Strait through Viscount Melville Sound, where the highest concentrations of multi-year ice and the least open water are usually found. Icebergs occur from the east end of Lancaster Sound and along the route through Baffin Bay and Davis Strait (Plate 3-1).

In late winter and spring, the sea ice in most years will be landfast from the west end of Amundsen Gulf to the east end of Barrow Strait. The lowest concentrations of multi-year ice generally exist along the northern portions of Viscount Melville Sound, Barrow Strait and Lancaster Sound.

Outside of these generalizations, ice conditions are highly variable in all seasons. Arctic tankers will employ a sophisticated navigation and ice reconnaissance system to enable them to comply with corridor constraints and at the same time take advantage of most favourable ice conditions. Ship traffic will also likely operate under the direction of a federal control authority.

### 3.1.3 MARINE LIFE

The variety and abundance of marine plant life is generally greater in eastern parts of the Northwest Passage than in the Beaufort Sea with luxuriant stands of kelp and other marine plants occurring in some locations. These nearshore plant communities are similar to those found on the east coast of Canada except that they occur at greater depths. There is a barren zone along the shoreline resulting from sea-bottom scour by ice that may extend to water depths of 15 metres.

Benthic organisms, which include barnacles, anemones, mussels and sea urchins, are also far more abundant in the deep waters of the eastern Northwest Passage, than in the Beaufort Sea (Plate 3-2). Similarly, zooplankton are more abundant in eastern waters, especially in the upper 50 metres. These two groups of organisms form a major part of the diet of fish and birds.

The Northwest Passage and western Baffin Bay support only about 30 species of fish compared to 43 species in the Beaufort Sea. Char and the widespread Arctic cod provide limited food fisheries. Also in contrast to the Beaufort region is the relative absence of fish, particularly anadromous fish, in the nearshore barren zone of the Northwest Passage.

Davis Strait supports the most diverse fish fauna in the Canadian Arctic, where about 90 species are known, mostly originating from the north Atlantic. There are important commercial fisheries for Atlantic cod, Atlantic salmon and northern deepwater prawn.

Barrow Strait and Lancaster Sound in the Northwest Passage are the sites of major nesting, moulting and staging areas for about 32 species of waterbirds (Figure 3-3). This includes the true seabirds, which use land only for nesting. The most abundant of the seabirds include the black-legged kittiwake, black guillemot and dovekie. Much of the eastern North American population of thick-billed murres and northern fulmars also nest here (Plate 3-3). There are also 16 species of shorebirds that nest only on land near the passage, but use nearshore waters for staging during migration.

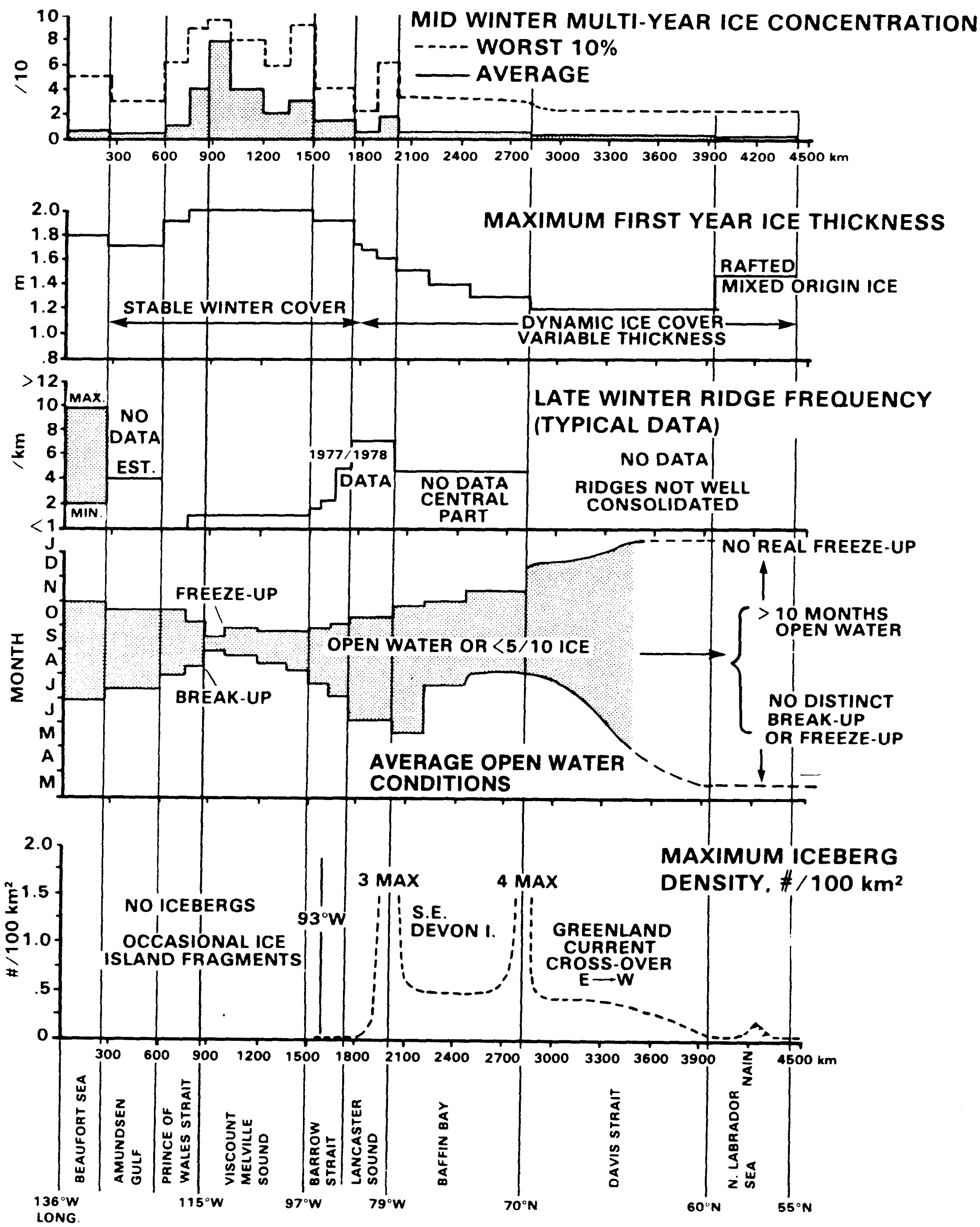



**FIGURE 3-2** *Ice conditions from the Beaufort Sea through the North Labrador Sea. The worst ice conditions are experienced in Viscount Melville Sound and the northern exit of Prince of Wales Strait.*

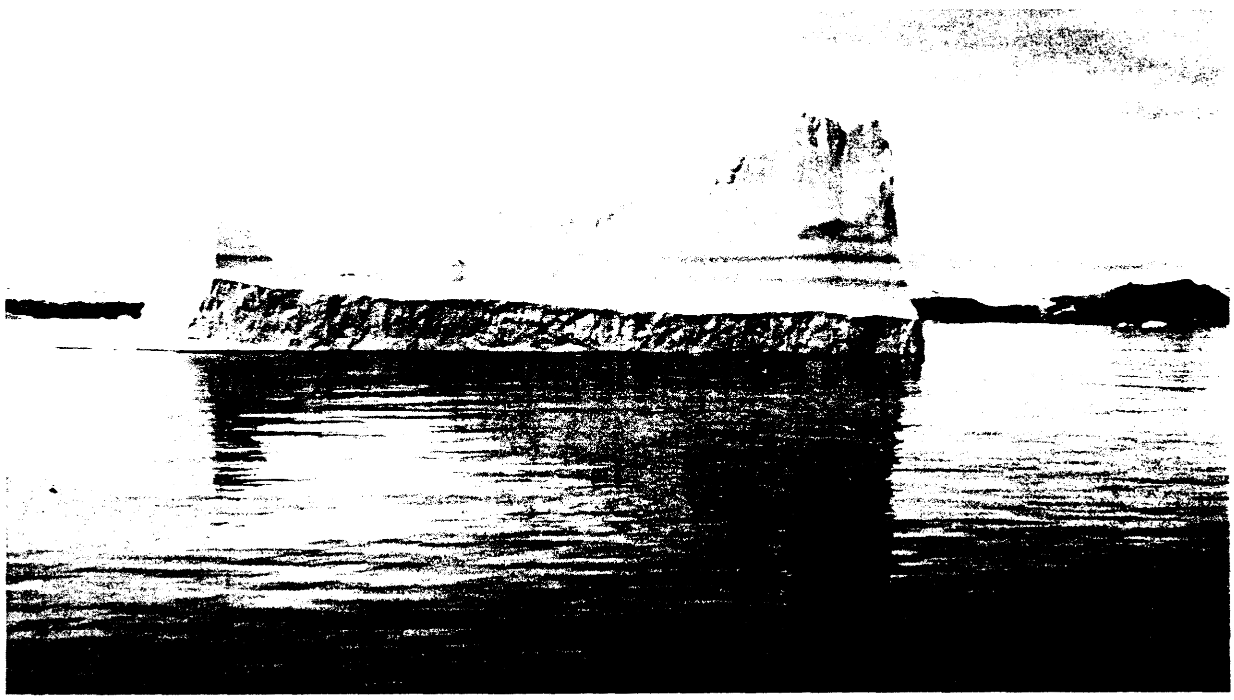


**PLATE 3-1** *An iceberg in northern Baffin Bay, September, 1968; one of many which calve from Greenland glaciers.*

**PLATE 3-2** *Most stable surfaces below the barren zone support an abundance of marine animals. This underwater photo taken at Cape Hatt near Pond Inlet shows a clump of attached anemones as well as some coralline algae (lower left) and shrimp (lower centre). (Courtesy, W.E. Cross, LGL Ltd.).*

Some very large waterbird nesting colonies occur in the Northwest Passage region; for example, an estimated 30 million dovekies nest along the coast of Greenland. Snow geese, brant, oldsquaws and eiders also commonly nest along the shipping corridor, or on islands adjacent to it. However, none of the true seabirds, and comparatively few gulls or waterfowl, nest in Viscount Melville Sound or Prince of Wales Strait, probably because ice persists there well into July in most years.

Large numbers of dovekies, northern fulmars, thick-billed murres, eiders and various other waterbirds overwinter along the southwest coast of Greenland. Some of these species, and the rare ivory gull (Plate 3-4), also winter offshore in Davis Strait. An estimated 5 to 10 thousand black guillemots winter in offshore areas further north in the High Arctic and Baffin Bay.

Fifteen of the 22 species of marine mammals occurring along the eastern shipping corridor are whales found mainly in Davis Strait in the summer. Only three species, the bowhead, beluga, and narwhal are relatively well documented. Of species inhabiting Parry Channel, ringed seals and polar bears (Plate 3-5) are the main year-round residents. Both species are widely distributed in coastal areas and rarely occur in large groups.

The eastern Arctic population of the endangered bowhead whale frequents the area along the shipping corridor. Most of these animals probably winter in

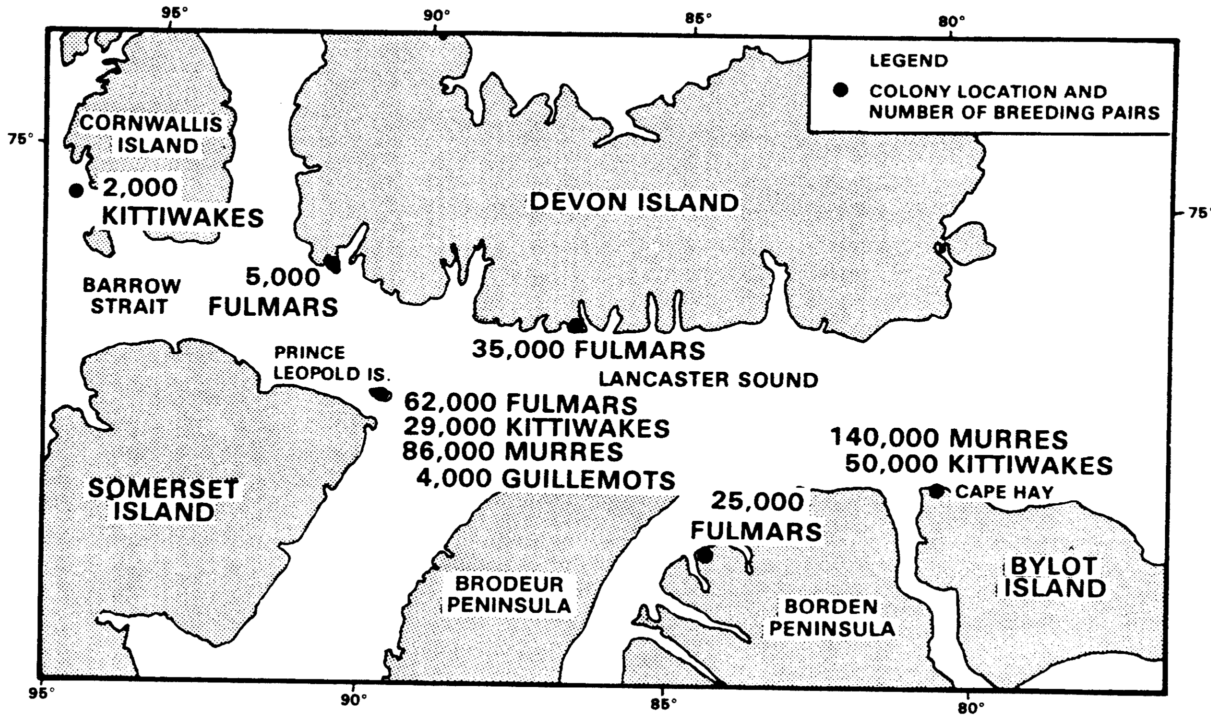



**FIGURE 3-3** *Locations of major nesting colonies and estimated numbers of breeding pairs of seabirds in Parry Channel.*

**PLATE 3-3** *Part of a thick-billed murre colony on the cliff face of a small island located along the shipping corridor. (Courtesy, G. Greene, ESL Ltd.).*

**PLATE 3-4** *The ivory gull, classed as a rare species, does not nest along the eastern shipping corridor. Small numbers of this species shown here are present along the coasts and in offshore waters of eastern Lancaster Sound and Baffin Bay throughout the summer. (Courtesy, M. Bradstreet, LGL Ltd.).*

the loose pack ice and near the pack ice edge in southern Baffin Bay and in Davis Strait. They spend their summers mainly in Prince Regent Inlet, Admiralty Inlet and Eclipse Sound (Figure 3-4). Large groups of beluga whales and narwhals also occur in Parry Channel and Prince Regent Inlet during migrations to and from their overwintering areas in Davis Strait and Hudson Strait (Plate 3-6).

### 3.1.4 SPECIAL AREAS

Three regions adjacent to the shipping route are legally protected areas in Canada (Figure 3-5). These are the Auyuittuq National Park on eastern Baffin Island, the Banks Island Federal Migratory Bird Sanctuary No. 2 and the Bylot Island Federal Bird Sanctuary. Several additional areas along the eastern corridor have official recognition, but at present have no legal status. These include the proposed National Park on northern Banks Island, four Natural Sites of Canadian Significance, and 22 International Biological Program ecological sites.

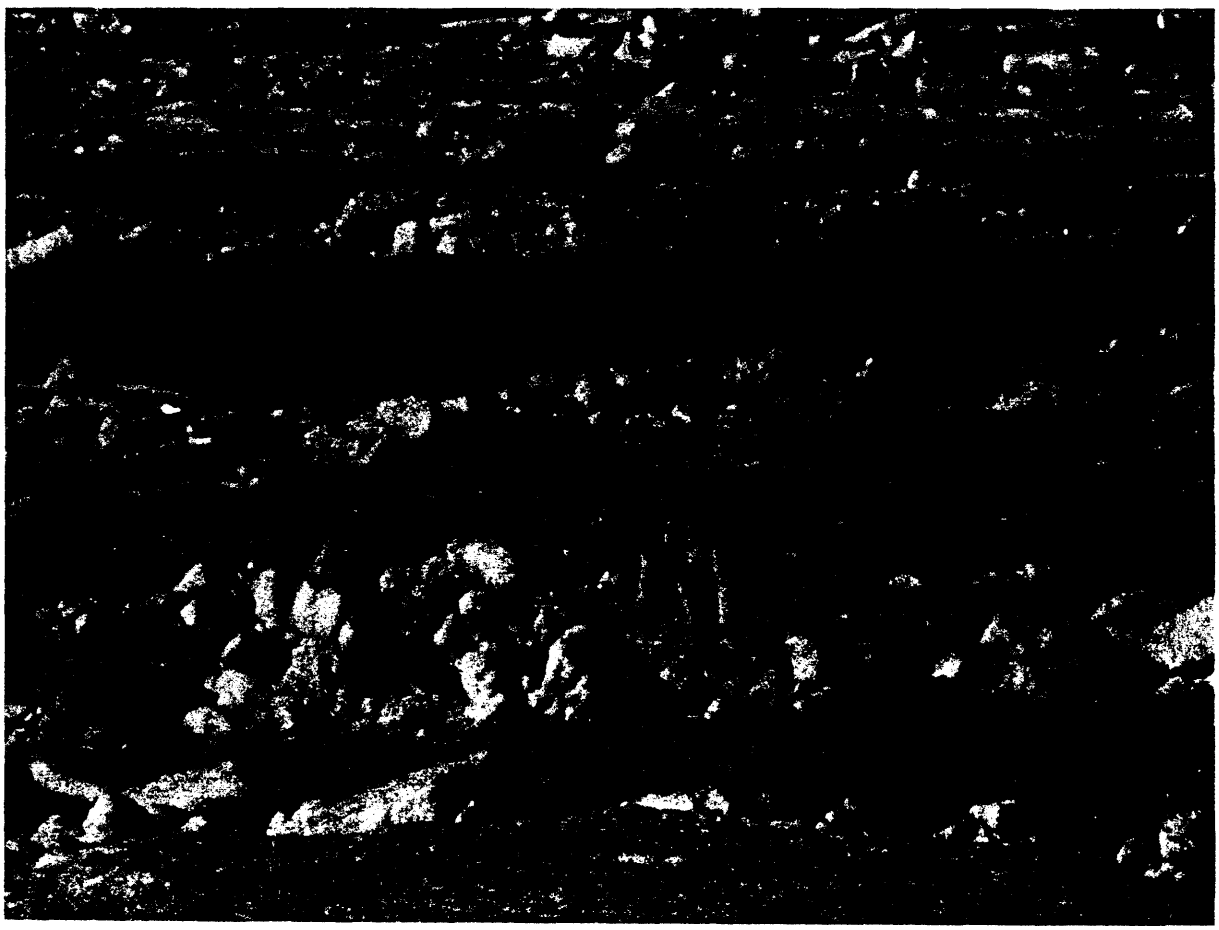


**PLATE 3-5** *Polar bears are widely distributed throughout Parry Channel and are common near the coast of eastern Baffin Island. They also occupy moving pack ice in Davis Strait and Baffin Bay. (Courtesy, M. Bradstreet, LGL Ltd.).*

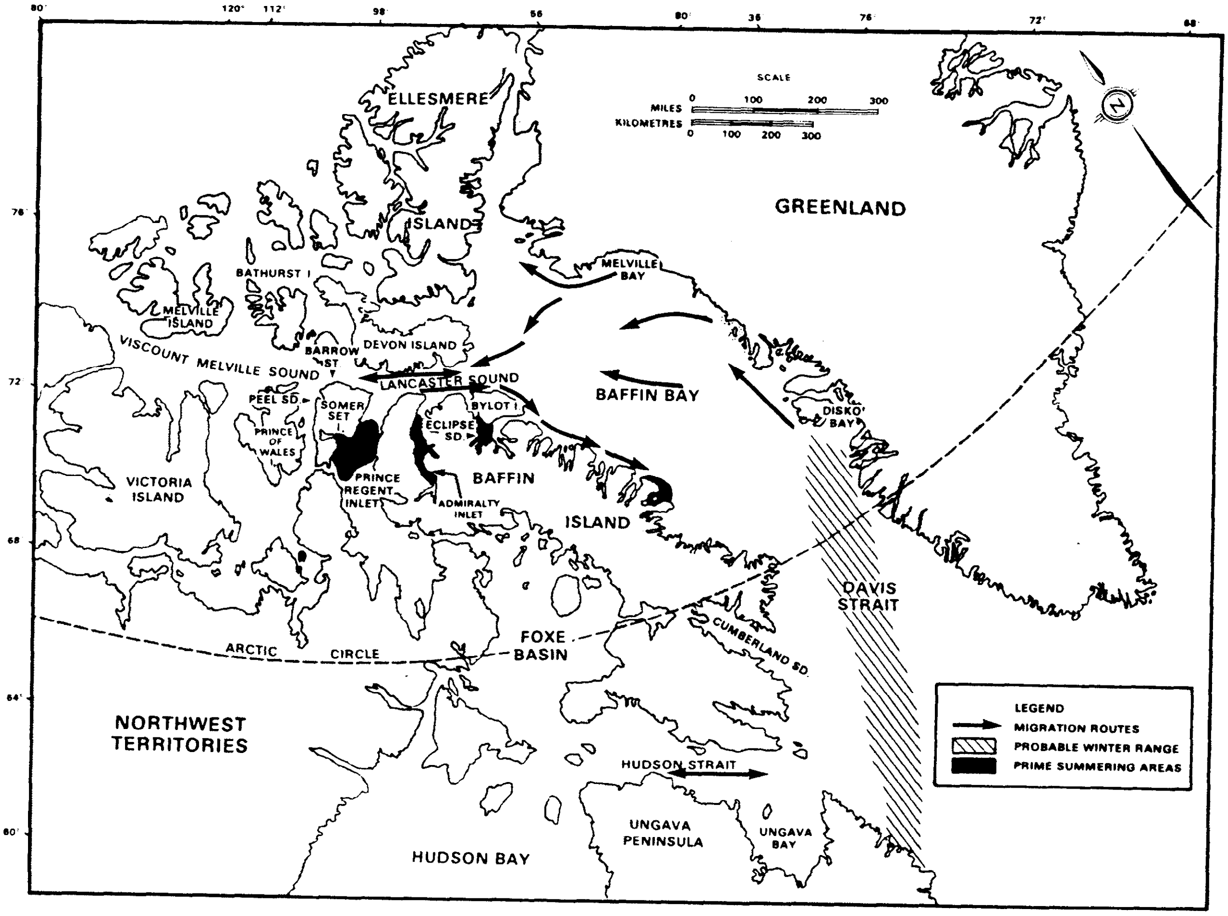



**FIGURE 3-4** *Bowhead whale migration routes, probable winter range and known summer coastal concentration areas in Parry Channel, Baffin Bay and Davis Strait.*

**PLATE 3-6** *White whales, such as those shown here, move into shallow estuaries along the south side of Barrow Strait and in Prince Regent Inlet from mid July to mid August. (Courtesy, Petro-Canada).*

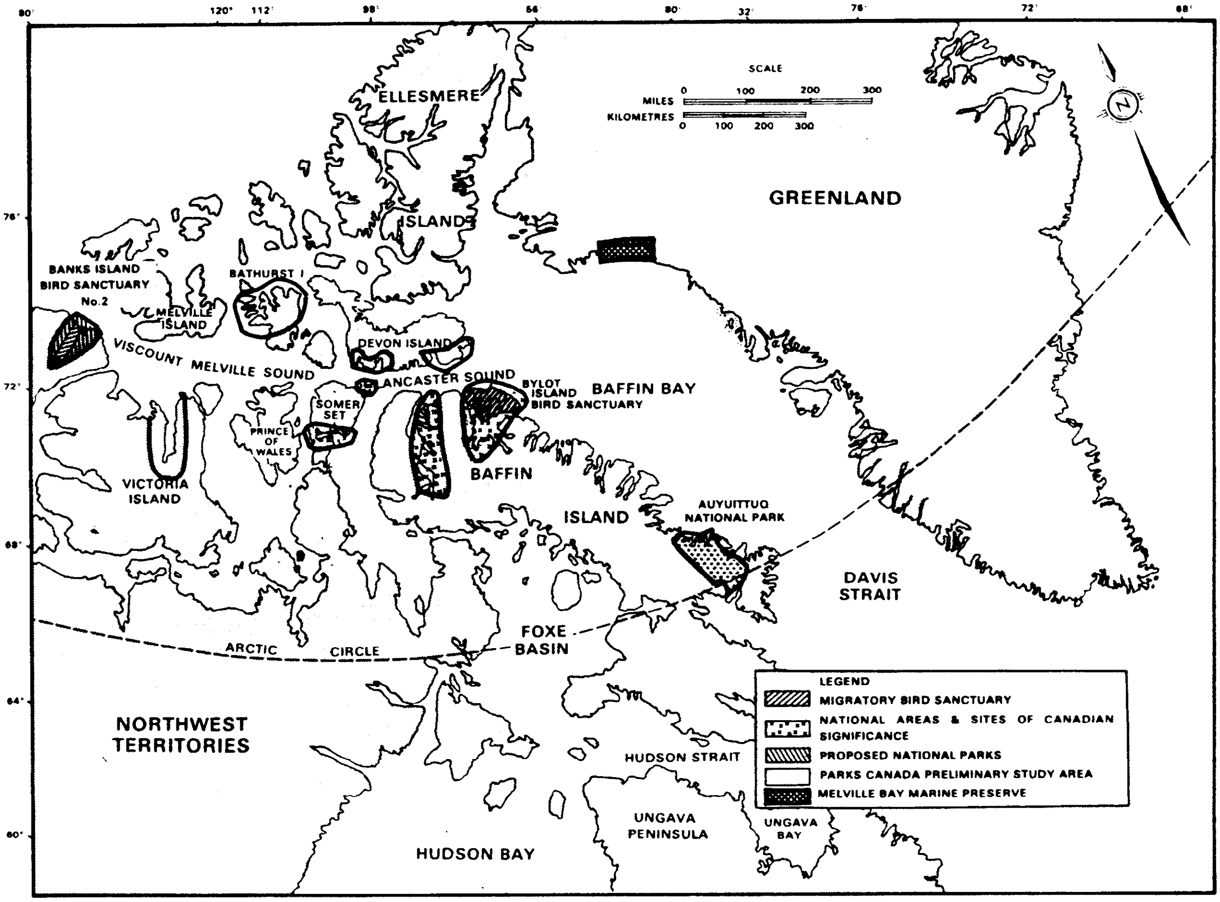



**FIGURE 3-5** *Special areas along the eastern shipping corridor.*

Most of these special areas are adjacent to Lancaster Sound. The sound itself is recognized internationally as an important ecological area. UNESCO recommended that all of Lancaster Sound become a World Heritage Area.

## 3.2 IMPACTS OF YEAR-ROUND SHIPPING IN THE NORTHWEST PASSAGE REGION

This section discusses the main possible effects of transporting oil in icebreaking tankers through the eastern shipping corridor. Possible effects related to this year-round transport of petroleum to southern markets fall into two general categories: those involving normal operations of tankers along the shipping route, and those involving tanker accidents and major oil spills. Section 3.2.1 examines the projected environmental impacts of normal operations, while Section 3.2.2 briefly reviews concerns related to possible oil spills. Possible implications of year-round shipping on the people of the region are highlighted in Section 3.2.3. The terms used to describe possible impacts are those employed throughout the assessment sections of the Environmental Impact Statement and are defined in Appendix 3 of this volume.

### 3.2.1 ENVIRONMENTAL IMPACTS OF NORMAL TANKER OPERATIONS

The first icebreaking tanker is projected to be required by the end of 1985 or early 1986, after which time the size of the fleet would gradually increase. There could be between 6 to 9 tankers needed by 1990 and between 16 and 26 needed by the year 2000. The lower numbers would apply to the intermediate development rate and the higher numbers to the less likely, but nevertheless technically achievable development rate described in Chapter 1.

There is concern that icebreaking tankers in the Northwest Passage may create impassable artificial leads, cause the landfast ice to become unstable, and alter the timing and patterns of local ice break-up. A major concern is the generation of underwater noise, and the effects it may have on seals and whales. Other concerns are about possible effects of the discharge of treated sewage, atmospheric emissions, and ice reconnaissance activities on birds and mammals along the route.

#### 3.2.1.1 Icebreaker Tracks as Barriers

Tracks made through ice have been observed from Canadian Coast Guard icebreakers and from the MV CANMAR KIGORIAK. Icebreakers passing through loose pack ice usually leave an open water track that extends 1 to 2 km behind the vessel. However, open water occurs naturally in loose pack ice so that icebreaking under these conditions is expected to have little effect on marine life. Of more concern is icebreaking through close pack and fast ice, where open water is not normally present.

Ship track experiments using KIGORIAK have been conducted in the winter and spring of 1981-82 in conjunction with the Hunters and Trappers associations of Beaufort Sea communities. Observers from the Eastern Arctic were present during the June, 1982 test period. The main purpose of the work was to determine how quickly the ice in the track consolidated and what problems might be encountered in crossing the ship track. During all test periods between early December and early June, the participants experienced little difficulty in crossing the track on foot, on skidoo, or on a skidoo with a laden komatik (Plate 3-7). On the basis of these studies, terrestrial mammals, such as Peary caribou and muskox, are not expected to encounter difficulties crossing ship tracks.

#### 3.2.1.2 Effects of Icebreaking on the Fast Ice Edge in Lancaster Sound

The prospect of year-round tanker traffic in the Northwest Passage raises concerns about possible alterations of the landfast ice in Barrow Strait and resulting effects on local climate and wildlife. In particular, there is concern about the landfast ice edge which forms each year in late winter across Lancaster Sound or Barrow Strait. It is thought that regular icebreaking tanker traffic through the landfast ice edge could delay its formation, cause its median location to be further west when it does form, and lead to its earlier break-up.

The position of the landfast ice edge in Barrow Strait-Lancaster Sound varies greatly from year to year. In April of 1976, for example, the landfast ice edge was in Barrow Strait, while in February of 1979, the landfast ice edge was at the eastern end of Lancaster Sound, representing a natural east-west variation of approximately 400 kilometres. There is the possibility that in the winter of any year the landfast ice edge may stabilize further west due to icebreaking tankers than would occur naturally. However, it is felt that the natural range of ice edge locations will probably far exceed changes caused by winter and spring icebreaking.

Nevertheless, the consequences of ice edges being located generally further west were examined relative to year-to-year ice cover variations in the Lancaster Sound and northern Baffin Bay region. With respect to the regional climate, any additional open water which might be caused by icebreaking would likely be insignificant compared with the vast changes in year-to-year ice cover in the region and the natural variability in open water. The ice edge is least stable during spring, in contrast to the fall when prevailing winds help maintain its integrity as it advances eastward. Therefore in spring there could occur a set of circumstances - winds, currents, crack patterns and icebreaking - which could precipitate a cascade-like removal of ice in a short time. However this could happen without icebreaking by tankers, making the effects of icebreaking indistinguishable from natural ice removal.

#### 3.2.1.3 Effects on Biological Resources

This section and Table 3-1 summarizes possible impacts of normal tanker activities on the main biological resources in the various geographical areas along the eastern shipping corridor. The terms used to describe possible impacts are those employed throughout the assessment parts of the Environmental Impact Statement and are defined in the appendix to this volume.

Amundsen Gulf

Icebreaker operations in Amundsen Gulf are most likely to affect ringed and bearded seals, white whales, bowhead whales and birds.

Ringed and bearded seals may be temporarily disturbed by the tanker and swim to avoid it and ringed seal pups in birth lairs along the ship track may be crushed. Ringed seal birth lairs, in which pup rearing takes place over a six week period from late March to May, are relatively numerous as most of Amundsen Gulf is covered by first year ice in winter. However, the highest densities of birth lairs occur in bays and along the coasts outside the tanker corridor. Thus, the effects of icebreaking on ringed seals in the gulf would probably be MINOR, while the effects on bearded seals will likely be NEGLIGIBLE.

White whales may be disturbed by tanker noise during spring and late summer, although serious effects are not expected and possible impacts should be NEGLIGIBLE.

**PLATE 3-7** *Research has shown that it is possible to cross a ship track left by an icebreaking vessel within a few minutes to hours under all conditions tested in the Beaufort Sea. Similar studies will be carried out in the Eastern Arctic as new ships become available in the area.*

**TABLE 3-1**

**SUMMARY OF POSSIBLE IMPACTS OF YEAR-ROUND SHIPPING THROUGH THE PRIMARY EASTERN SHIPPING CORRIDOR, BY THE GEOGRAPHIC AREA AND BY SEASON**

| | Amundsen Gulf | | | Prince of Wales Strait | | |
|---|---|---|---|---|---|---|
| **Species** | **Type of Impact**[1] | **Season**[2] | **Level of Impact** | **Type of Impact** | **Season** | **Level of Impact** |
| White whale | N, D | Sp, S | NEGLIGIBLE | — | — | — |
| Narwhal | — | — | — | — | — | — |
| Bowhead whale | N, D | Sp, S | NEGLIGIBLE - MINOR | — | — | — |
| Ringed seal | N, D | Sp, S | MINOR | N, D, M | W, Sp | MODERATE |
| Bearded seal | N, D, M(?) | Sp, S, F | NEGLIGIBLE | N, D, M(?) | Sp, S, F | NEGLIGIBLE |
| Birds (all species) | D, A | Sp, S, F | NEGLIGIBLE | D, A | Sp, S, F | NEGLIGIBLE |

| | Viscount Melville Sd. | | | Barrow Strait | | |
|---|---|---|---|---|---|---|
| **Species** | **Type of Impact**[1] | **Season**[2] | **Level of Impact** | **Type of Impact** | **Season** | **Level of Impact** |
| White whale | — | — | — | N, D | Sp, S, F | NEGLIGIBLE |
| Narwhal | — | — | — | N, D | Sp, F | NEGLIGIBLE |
| Bowhead whale | — | — | — | N, D | Sp, F | NEGLIGIBLE |
| Ringed seal | N, D, M | W, Sp | MINOR | N, D, M | W, Sp | MODERATE |
| Bearded seal | N, D, M(?) | Sp, S, F | NEGLIGIBLE | N, D, M(?) | SP, S, F | NEGLIGIBLE |
| Birds (all species) | D, A | Sp, S, F | NEGLIGIBLE | D,A | Sp, S, F | NEGLIGIBLE |

| | Lancaster Sound Area | | | Baffin Bay/Davis Strait | | |
|---|---|---|---|---|---|---|
| **Species** | **Type of Impact**[1] | **Season**[2] | **Level of Impact** | **Type of Impact** | **Season** | **Level of Impact** |
| White whale | N, D | Sp, F | NEGLIGIBLE | N, D | W, Sp | NEGLIGIBLE - MINOR |
| Narwhal | N, D | Sp, F | NEGLIGIBLE - MINOR | N, D | W, SP | NEGLIGIBLE - MODERATE |
| Fin whale | — | — | — | N, D | S | MINOR |
| Sei whale | — | — | — | N, D | S | NEGLIGIBLE |
| Minke whale | — | — | — | N, D | S | MINOR |
| Blue whale | — | — | — | N, D | S | NEGLIGIBLE |
| Humpback whale | — | — | — | N, D | S | NEGLIGIBLE |
| Bowhead whale | N, D | Sp, F | NEGLIGIBLE - MINOR | N, D | W, Sp | NEGLIGIBLE - MINOR |
| Walrus | N, D | Sp, S, F | NEGLIGIBLE | N, D | W, Sp | MINOR |
| Harbour seal | — | — | — | — | — | NEGLIGIBLE |
| Harp seal | D | S | NEGLIGIBLE | D | S | NEGLIGIBLE |
| Hooded seal | — | — | — | D | Sp | NEGLIGIBLE |
| Ringed seal | N, D, M | W, Sp | MINOR - MODERATE | N, D, M | W, Sp | MINOR - MODERATE |
| Bearded seal | N, D, M (?) | Sp, S, F | NEGLIGIBLE | N, D, M(?) | W, Sp | MINOR |
| Birds (all species) | D, A | Sp, S, F | NEGLIGIBLE | D, A | Sp, S, F, W | NEGLIGIBLE |

[1]N = Effects of noise, D = Disturbance, M = Mortality, A = effects on food availability
[2]Season of greatest impact. Sp = Spring, S = Summer, F = Fall, W = Winter
— Indicates species not present or no impact
(?) Indicates greater uncertainty but impacts potentially at the level

Tanker noise may interfere with communications between bowheads in Amundsen Gulf during spring and summer, however, during the early years when there would be few tankers travelling, impacts are likely to be NEGLIGIBLE although they could rise to MINOR by the year 2000.

Possible impacts on birds are also expected to be NEGLIGIBLE. Ice reconnaissance activities and associated disturbances would not occur near any coastal nesting colonies, but some birds staging in the Amundsen Gulf polynya during spring may be temporarily disturbed by reconnaissance aircraft. This effect will be minimized by adherence to flight altitude restrictions whenever possible.

Prince of Wales Strait

Icebreaking in Prince of Wales Strait could have a measurable effect only on ringed seals. No other biological effects are expected as whales do not normally occur in Prince of Wales Strait, and birds are few. Because the strait is usually covered by first year fast ice, ringed seal birth lairs are probably numerous. The projected passage of up to two tankers per day through Prince of Wales Strait by the year 2000 could result in the loss of 7 to 10% of the ringed seal habitat. If this occurs, impacts could approach the MODERATE rating. This degree of impact, were it to occur, could be reduced by re-routing ships to the west of Banks Island and through M'Clure Strait where the ice does not become landfast. Over the last 10 years, there have been four winters when it may have been easier to travel through the M'Clure Strait alternate route.

Viscount Melville Sound

Whales do not usually occur in Viscount Melville Sound and densities of adult ringed seals and birth lairs are believed to be low. Nevertheless, the impacts of icebreaking on seals could be MINOR because about 3% of the first year ice habitat could be lost to breeding seals. Densities of birds are low, and the only known coastal nesting colonies have only a few pairs of glaucous gulls. The proportion of the epontic community in Viscount Melville Sound that could be affected by icebreaking would be regionally insignificant. Possible impacts of tanker operations in this area on whales, birds, fish and lower trophic levels are expected to be NEGLIGIBLE.

Barrow Strait

There is concern that icebreaking activities in Barrow Strait may reduce the usable habitat for wintering and pupping ringed seals, and also result in the loss of pups when tankers break ice in breeding areas. Barrow Strait supports moderate to high densities of both overwintering adult seals and birth lairs. Between 2 and 4% of this habitat could be lost to breeding seals,leading to perhaps MODERATE impacts. However, if some habituation and adaptation occurs then impacts might only be MINOR.

White whales are the most abundant whale species in Barrow Strait. While in the strait, they swim mainly in shallow coastal waters where tanker noise would not interfere with either their echolocation or communication. However, they could be affected briefly during their migration from southern Devon Island to summering areas along and south of Barrow Strait. Nevertheless, impacts on white whales in Barrow Strait are expected to be NEGLIGIBLE. Most narwhals and bowheads do not migrate as far west as Barrow Strait, and those that do, summer in adjacent channels where they would not be affected by vessel noise. Consequently, impacts on these species in Barrow Strait should also be NEGLIGIBLE.

Lancaster Sound

The ice in Lancaster Sound is not usually landfast during winter, and may not support the high densities of breeding ringed seals typical of fast ice areas. However, densities may approach those typical of the Baffin Bay pack ice. On this basis, it is likely that the possible impacts on the resident population would be MINOR, although this rating could rise to MODERATE, especially in years when the ice in Lancaster Sound becomes landfast.

White whales migrate through Lancaster Sound along the coast of Devon Island, and would not be affected by high noise levels produced by tankers while icebreaking. Consequently, possible impacts on this species would be NEGLIGIBLE. Both narwhals and bowheads migrate through Lancaster Sound, and at least part of the migration occurs in offshore waters near the proposed shipping corridor. They then move into summering areas in bays and inlets south of Lancaster Sound where they would not be affected by tanker activities. Possible impacts on these species when they are in Lancaster Sound are likely to range from NEGLIGIBLE to perhaps MINOR, because they are only present for a brief period in areas traversed by tankers.

There are several large seabird colonies along the shores of Lancaster Sound. Certain offshore areas, particularly at the ice edge across Lancaster Sound, may be used by large numbers of birds in spring. Birds at the nesting colonies and at the ice edge could be disturbed by ice reconnaissance aircraft, while birds at the ice edge would probably flush during the passage of a tanker. However, adherence of aircraft to altitude and routing restrictions would ensure that impacts to birds would be NEGLIGIBLE.

Baffin Bay and Davis Strait

Baffin Bay and Davis Strait support a larger number of marine species in both summer and winter than do other portions of the eastern shipping route. Several species of odontocete and baleen whales summer along the fishing banks off west Greenland, and white whales, narwhals and bowheads all winter in this region. Ringed seals, bearded seals, walruses and probably hooded seals are present in Baffin Bay and Davis Strait all year, whereas harp seals are present in spring, summer and fall.

Historically, bowheads are known to winter within the loose pack ice edge zone from Disko Island to northern Labrador. Recent surveys have found them south of Disko Island and in Hudson Strait. It is possible that the bowheads that winter in Hudson Strait summer in the eastern Arctic or in Hudson Bay and Foxe Basin. Therefore, it is likely that most bowheads could be exposed to ship noise in winter only when they are within the loose pack ice edge zone where they winter. In spring bowheads move north through the Baffin Bay pack ice and along the west coast of Greenland. Animals along the coast would not be exposed to ship noise, whereas those migrating north in the offshore region likely would be. Although there is a lack of information on winter ambient noise in Baffin Bay and Davis Strait and on the possible effects of increased masking caused by shipping noise, it is likely that shipping noise would only affect bowheads over relatively short ranges while they are within the loose pack ice edge zone. In summer, ambient noise levels are such that shipping noise effects would only be significant at relatively short ranges compared to the area under consideration. Effects could range from NEGLIGIBLE to MINOR depending on the proportion of the bowhead population that migrates offshore.

Narwhals winter throughout the heavy pack ice of Davis Strait and Baffin Bay. Thus, a portion of the population would be exposed to ship noise and disturbance on every passage during the 6 to 7 month period of ice cover. Impacts in the vicinity of the shipping corridor could range from NEGLIGIBLE to MODERATE.

White whales winter in the loose pack ice off the coast of Greenland. There is a limited potential for masking white whale communication and disturbance in some years when the loose pack zone coincides with the shipping corridor. The degree of possible impact could range from NEGLIGIBLE to MINOR.

Several other species of odontocete and baleen whales summer off western Greenland. During summer, the tankers would be travelling at relatively low power settings, and ship noise above 1 kHz would attenuate to ambient levels within a few kilometres of the ship. Therefore, impacts on odontocete species, which mainly use frequencies above 1 kHz, should be NEGLIGIBLE. Baleen whales communicate at lower frequencies, but even at 100 Hz, tanker noise would reach average ambient noise levels within about 30 km of the vessel. Possible impacts on these other baleen whales (fin and minke whales) are therefore expected to be MINOR.

Bearded seals are widely dispersed during winter in pack ice areas including the shipping corridor, and possible impacts of vessel noise on this species would likely be MINOR. Impacts on ringed seals could be MINOR to MODERATE. Although walruses winter in coastal areas where they would not be affected by tanker activities, others winter in loose pack ice areas where possible impacts may be MINOR. Impacts on harp and hooded seals should generally be NEGLIGIBLE.

Major seabird colonies exist along the shores of both Baffin Bay and Davis Strait. However, the tanker corridor and the routes of ice reconnaissance aircraft would be far offshore and are unlikely to affect birds at colonies. Densities of birds in offshore areas are low, so short-term disturbances in these areas by aircraft would be unlikely to affect regional populations. Thus the impacts on birds in the Baffin Bay-Davis Strait area are expected to be NEGLIGIBLE.

### 3.2.2 TANKER ACCIDENTS AND OIL SPILLS

To determine possible impacts from oil spills along the eastern shipping corridor, accident risks are a first consideration. In Volume 6, hypothetical tanker accidents and their consequences have been described, however, there is no implied certainty that these or similar accidents will actually occur. One can, by reviewing the history of tanker accidents, determine and categorize the causes, the frequency, and occurrence of each type, and devise measures to reduce the possibility of similar accidents in the future. This is the approach the proponents have taken in the design of a new generation of tankers that would be used to transport oil from the Beaufort Sea through to southern markets.

#### 3.2.2.1 Accident Risk

Numerous studies and analyses of past tanker accidents have demonstrated that at least 75% of the accidents have been due to human operating errors. Most accidents involved groundings at night with a loaded tanker and took place in restricted waters only a few miles from land. Visibility was generally good. The overwhelming majority of groundings occurred as a result of navigational and steering errors. Most collisions, on the other hand, occurred during periods of poor visibility. The colliding ships' crews were usually aware of each others presence well before the collision took place, with sufficient time to avoid an incident by taking evasive action. The most common collision scenario involves two ships in a head-on encounter, proceeding at fairly substantial speeds in poor visibility and maneuvering directly into a collision. Although most tanker spills result from collisions and groundings, structural failures caused by weather, explosions, fires and general breakdowns have contributed their share.

In almost all of these cases the problem listed above can be related to a human failure. For the most part, these failures can be linked to the management policy of the ship's owner. The proportion of accidents with oil company-owned vessels compared to those with independently-owned vessels has been very low; about one in seven. The quality of management and crew is the deciding factor. Poor management, poor crew selection and training, and poor vessel safety have been the main causes of accidents, along with a lack of control on an international or national basis, to correct the problem.

In consideration of the above, the proponents have estimated that an Arctic tanker, designed, equipped and operated in the fashion proposed in Volume 6, will transport oil with a spill risk 120 to 160 times less than that of a conventional industry-owned tanker operating in more temperate waters. Much of this reduction in spill risk comes from the ship's double hull design which is strengthened for heavy icebreaking, providing much greater protection in the event of collision or grounding. This extra hull strength and a system of stress monitoring devices would reduce the possibility of structural failures to a very low level. This, combined with superior training and enlightened crew management practices, will result in an extremely small risk of a major spill occurring.

### 3.2.2.2 Impact of Oil Spills

Though the probability of oil spills along tanker routes is very low, the proponents recognize that the possibility of a spill nevertheless exists. The effects of oil spills and the duration of damage depend on many factors. These include the type and volume of oil spilled, oceanographic and meteorological conditions, time of year, success of oil spill countermeasures, ice conditions, and type of habitat or environment oiled. This makes it difficult to predict the impact of future spills, although a range of effects can be anticipated. Assessment of possible oil spill effects is further complicated by a deficiency of case histories and laboratory data available for Arctic regions. Hence, the exact nature of oil impacts on Arctic biological communities cannot be fully predicted. Animals may or may not be present at or in the vicinity of a major oil spill, and if present, may or may not be at particularly crucial, sensitive, or vulnerable stages of their life cycles. However, general projections of possible impacts of oil on Arctic marine plants and animals can be made.

### 3.2.2.3 Oil Spill Case Study

In Volume 6, which covers the subject of accidental spills, five scenarios of hypothetical tanker accidents are described for locations along the eastern shipping corridor. The scenario for Lancaster Sound is reviewed in the following paragraphs, mainly because of the biological significance of the Sound. In reviewing this or other scenarios, it should be noted that the hypothetical incidents assume that no oil spill countermeasures have been used. The application of such measures, for example, pumping oil from a damaged compartment to an undamaged compartment, would tend to reduce the level of impact which may occur. The scenarios are useful for estimating possible effects of real oil spills and for describing possible countermeasure strategies, but it should be recognized that the events in a real accident at the same location and time would likely be different. Likewise, for a real accident, on site evaluation, combined with computer modelling of the motion of the oil slick, using up-to-the-minute wind and current data, would be used to more accurately determine where the oil may move.

In the scenario described here, 43,000 cubic metres (270,000 bbls) of oil are assumed to be spilled offshore in eastern Lancaster Sound in late August. Over the following three weeks the slick is projected to affect an offshore area of about 6,000 km$^2$, and to eventually contaminate about 200 km of shoreline and 220 km$^2$ of nearshore seabed (Figure 3-6). Table 3-2 summarizes the projected effects of this hypothetical event on the fauna of Lancaster Sound, without the application of oil spill measures.

Although it is not possible to predict what proportion of the fauna of nearshore areas will be affected, the proportion could be high. Recovery would probably be slow and the overall impact on these organisms could be MAJOR for several years in those areas affected. However, walruses and bearded seals, the only mammals dependent on nearshore and bottom organisms in Lancaster Sound, are not abundant there. Oldsquaws, king and common eiders also feed on nearshore organisms, but only use the areas affected in some years. Thus impacts of the loss of nearshore and bottom fauna on higher life forms are expected to be MINOR.

Impacts on marine mammals are predicted to range between NEGLIGIBLE and MINOR with the exception of the impacts on polar bears due to the fouling of fur. Impacts could be MODERATE for polar bears because they could die if badly oiled. However, it is likely that this impact could be mitigated by removing bears from oiled areas.

Birds are the animal group that will be most affected by oil. MAJOR impacts could be expected on thick-billed murres and black-legged kittiwakes and possibly on northern fulmars. The primary reason for the projected major impacts on murres and kittiwakes is that the oil slick is expected to cover a large area adjacent to Cape Hay where about 140,000 pairs of murres and 20,000 pairs of kittiwakes nest. Only if a large proportion of the slick was prevented from arriving at Cape Hay could impacts on these species be significantly reduced. The countermeasure most likely to be effective is the use of chemical dispersants. Dispersants applied in large amounts near the

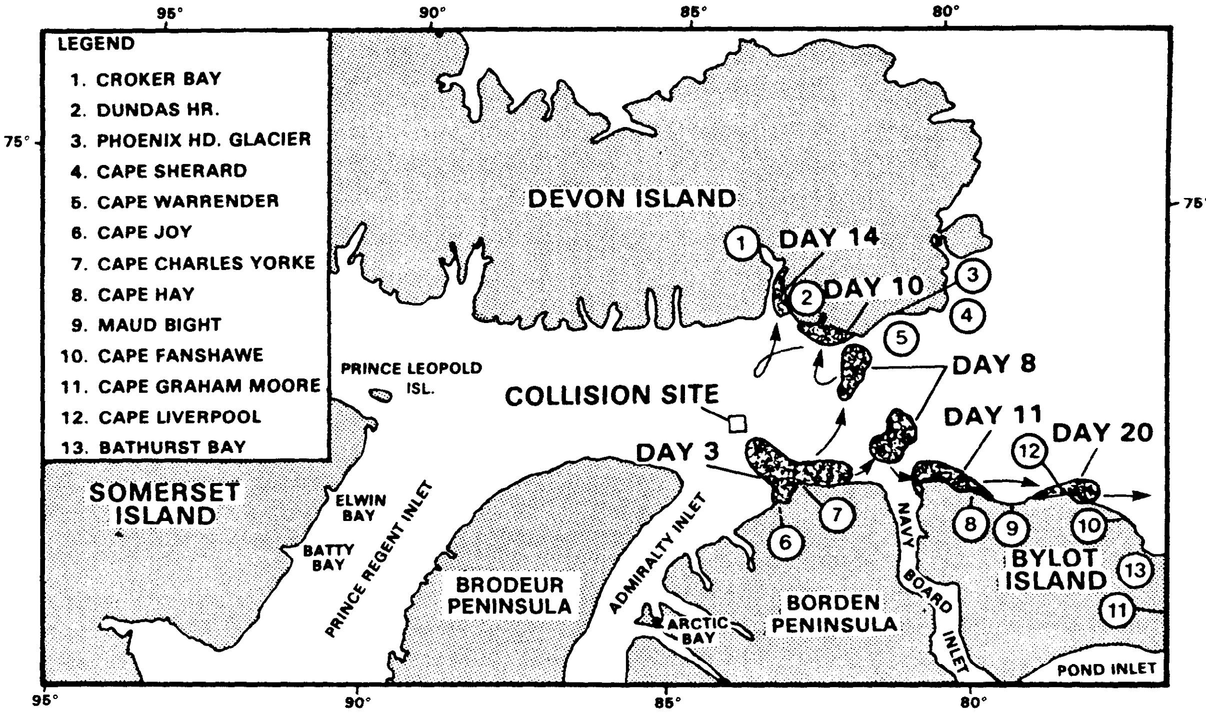



**FIGURE 3-6** *Distribution of surface oil released after a hypothetical tanker collision in Lancaster Sound assumed to occur on August 20.*

source of the spill could reduce the amount of oil on the surface of the water. This would reduce the size of the slick and the amount of oil that could reach the Cape Hay seabird colony. It could also reduce the effects on other bird species. Effect of the dispersant itself on birds, if applied at the site of the spill, would be minor. Birds would not be concentrated in offshore areas and dilution of the dispersant would be rapid. Dispersant use would be subject to approval by government.

In the case of the hypothetical tanker accident in Lancaster Sound, the first countermeasure response is to control the source of oil by pumping the remaining oil out of the damaged tanks.

The second countermeasure response is to disperse as much of the oil as possible in deep water, once government permission for the use of dispersants was obtained. Dispersal of the oil into deep water, using aerial spraying of dispersants would minimize biological impacts on seabirds from the Cape Hay colony.

A major equipment depot would likely be located at Pond Inlet. Countermeasures equipment in the form of containment barriers, skimmers, portable incinerators and igniters could then be sent to sensitive areas threatened by oil slicks. Aerial spraying of chemical dispersants would continue offshore.

The area on the Borden Peninsula threatened by oil is predominantly one of gravel beaches backed by low

**TABLE 3-2**

**ANTICIPATED DEGREE OF REGIONAL IMPACT FROM A HYPOTHETICAL OIL SPILL IN LANCASTER SOUND**

| Resource | Anticipated Degree of Regional Impact |
|---|---|
| BIRDS | |
| Red-throated loon | Moderate |
| Northern fulmar | Moderate to Major |
| Geese | Negligible |
| Oldsquaw | Minor |
| Eiders | Minor to Moderate |
| Shorebirds | Negligible to Minor |
| Glaucous gull | Minor to Moderate |
| Ivory gull | Negligible to Minor |
| Black-legged kittiwake | Major |
| Other gulls and Arctic tern | Negligible |
| Thick-billed murre | Major |
| Dovekie | Negligible |
| Black guillemot | Minor to Moderate |
| MAMMALS | |
| White whale | Negligible to Minor |
| Narwhal | Negligible |
| Bowhead | Negligible |
| Walrus | Minor |
| Harp Seal | Negligible to Minor |
| Ringed seal | Negligible to Minor |
| Bearded seal | Minor |
| Polar bear | Minor to Moderate |
| FISH | |
| Arctic cod | Negligible to Moderate |
| Other fish | Negligible to minor |
| LOWER TROPHIC LEVELS | |
| Benthos and intertidal | Major |
| Phytoplankton | Negligible |
| Zooplankton | Negligible |
| Ichthyoplankton | Minor |

eroding cliffs. Only the area between Cape Joy and Cape Charles York contains a small lagoon system that could be protected by booming or diking. The rest of the area would eventually be cleaned by wave action.

The north coast of Bylot Island is predominantly a hummocky rock foreland interspersed with low-lying deltas and barrier beach-lagoon systems. Booms could be placed to protect these lower areas since in this scenario the oil is not predicted to arrive there for a week. The Cape Hay, Maud Bight-Cape Liverpool areas and Bathurst Bay could be sealed off. Manual cleanup could take place in these areas while the exposed rocky coast would be cleaned by wave action.

The oiled shores along the south coast of Devon Island are similar to shores on the south side of the sound and the protection and cleanup could proceed in the same manner. Dundas Harbour could be used as a base camp.

### 3.2.3 THE PEOPLE

Two of the community groups described in Volume 5 - the Parry Channel communties and the Baffin Bay-Davis Strait communities - are situated along the eastern shipping corridor. The population of these communities is about 90% Inuit. The communities along Parry Channel are Resolute, Arctic Bay, Pond Inlet and Grise Fiord. The Baffin Bay-Davis Strait communities, on the east coast and along more easterly parts of Baffin Island, include Clyde, Broughton Island, Pangnirtung and Frobisher Bay (Figure 3-7).

From a socio-economic viewpoint, Parry Channel communities are similar to Beaufort communities in many respects. Within the past 20 years, the Inuit have moved from camps to permanent settlements. A large proportion of the population consists of young people. There is a continuing commitment to hunting, trapping and fishing, but modern technology is used in resource harvesting. The cost of living is high in these communities. Taking part-time or full-time wage employment is common among the people of the region. This allows them to purchase goods and services, especially expensive hunting equipment and consumer goods.

Many Inuit from Pond Inlet and Arctic Bay have experienced rotational wage employment with industrial projects such as with Panarctic Oil's exploratory drilling on Melville Island and the Nanisivik mine near Arctic Bay. The experience has been generally positive.

Inuit use the region extensively for hunting. Resolute residents use Parry Channel (in the Barrow Strait area) for both hunting and travelling to hunting areas. Other communities do not typically hunt in Parry Channel itself, but they hunt animals that migrate through the channel. In the past, some people have harvested animals in Lancaster Sound, which is a major part of Parry Channel. Marine animals that are important to the region's residents include seals, narwhals and white whales.

The resource harvesting activities of the Baffin Bay-Davis Strait communities have been studied by the Arctic Pilot Project. It was generally found that none of these activities extend much beyond the immediate coast of Baffin Island. Similarly, although Greenlanders harvest resources from the Baffin Bay and Davis Strait areas, their activities are generally confined to areas near the coast of Greenland.

The people of the Northwest Passage region are greatly concerned about how tankers may affect their natural environment and the resources that they harvest. Beyond satisfying these concerns and thereby protecting their primary interests, the people may wish to be given the opportunity to benefit from Beaufort development and the transportation of hydrocarbons by tankers through their region. In this regard the industry is now exploring means by which the residents of Parry Channel communities could benefit from Beaufort hydrocarbon development. Some possibilities under consideration include employing people on a rotational work basis at Beaufort facilities and on ships which use the Northwest Passage. Other possibilities under consideration include the provision of liquid fuels for local use and assitance with community resupply activities.

Other industry initiatives with respect to the Parry Channel communities include:

- Provision for part of the funding for the Baffin Region Inuit Association's resource harvesting study which is already underway. The study will provide additional information on Inuit harvesting levels and locations;

- Development of appropriate employment, training, business development and social programs for the Parry Channel region and other eastern Arctic areas similar to those developed for the Beaufort Sea region;

- In cooperation with government, industry will assist Parry Channel communities to research and monitor the local impact of employment and other forms of involvement with oil and gas based development;

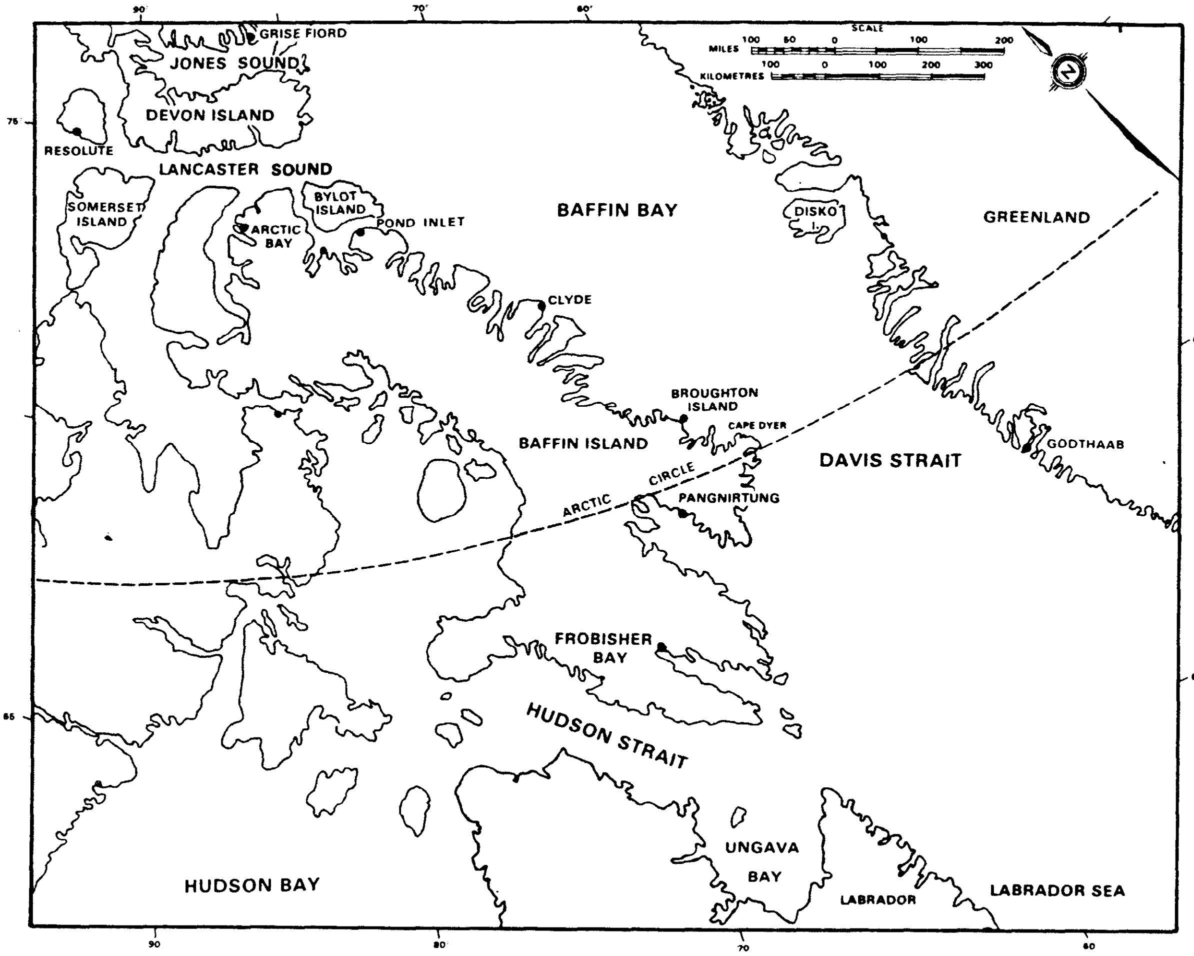



**FIGURE 3-7** *Communities near the eastern shipping corridor.*

- The industry will examine methods to compensate northerners, including Parry Channel residents, for losses of property or livelihood that occur as a result of hydrocarbon development and transportation activities; and

- The industry will ensure that eastern Arctic communities are fully informed of its plans and intentions. A regional information office has been established for the purpose at Frobisher Bay and is staffed by resident personnel fluent in Inuktitut.

All of the foregoing initiatives and others as they are identified or developed should assist in maximizing the opportunities for the people of the Eastern Arctic to participate in a meaningful way in the development of the Beaufort Sea hydrocarbon resources. The experiences gained should also be of considerable value for the time when the hydrocarbon resources of the High Arctic and Eastern Arctic begin to be developed.

# CHAPTER 4

# THE MACKENZIE VALLEY REGION

## 4.1 THE SETTING

The overland pipeline corridor is located on lands generally to the east of the Mackenzie River, except south of Fort Simpson where it crosses the river and extends south to northern Alberta (Figure 4-1).

There are several main features of the corridor relative to the construction and operation of a pipeline. The climate determines when and how construction will take place. The characteristics of the land, such as its topography, drainage, vegetation and permafrost, will determine its location, design, construction, and operation. The communities will interact with industry during all phases of approvals, construction and operation.

### 4.1.1 CLIMATE

In the Mackenzie Valley, it is generally warmer in the south than in the north. At Inuvik, the mean daily temperature in July is 13.3°C compared to 16.1°C at

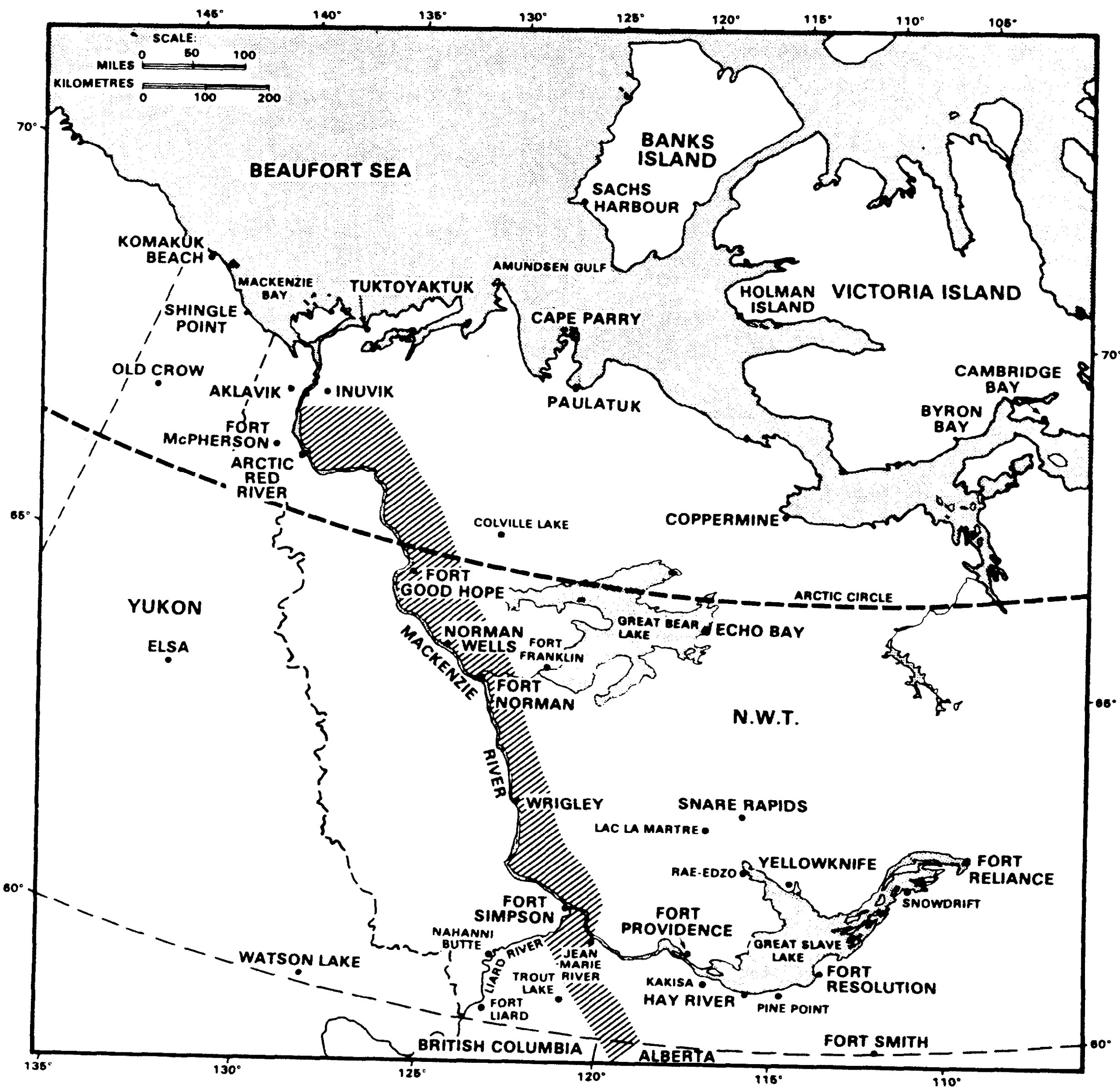



**FIGURE 4-1** *Approximate boundary of the Mackenzie Valley Corridor showing community locations.*

Fort Simpson at the southern end of the Mackenzie Valley. In January, the daily mean temperature at Inuvik is -29.3°C compared to -26.1°C at Fort Simpson. The number of frost-free days per year varies from 50 at Inuvik to 90 at Fort Simpson. The difference in latitude between Inuvik and Fort Simpson is about 6° so that in mid-winter the sun is below the horizon at Inuvik but there is 4 hours of daylight at Fort Simpson.

The wide range of yearly temperatures in the Mackenzie Valley, together with the presence of permafrost in the soil, have many implications for pipeline design, construction, and operation. For example, pipeline design would require consideration of such features as insulation, elevated sections, or cryoanchors to maintain soil stability and prevent a pipeline rupture. Pipeline construction will generally take place in winter when the terrain is frozen.

### 4.1.2 THE LAND

The terrain of the Mackenzie Valley pipeline corridor is generally flat and featureless, or gentle undulating hills, with occasional steep slopes at river crossings. Pipeline alignments will avoid mountain ranges.

Major glacial advances left a thick layer of till over the land crossed by the pipeline corridor. Silts and clays were deposited in glacially dammed lakes. Most soils are derived from till deposits. Near Fort Simpson, a large area of such deposits have been reworked by the wind and formed into dunes. Bogs and fens occur throughout the Mackenzie Valley, particularly in poorly drained depressions.

Since the mean annual temperature of the Mackenzie Valley is well below freezing much of the ground is perennially frozen. The northern part of the valley falls within the continuous permafrost zone; measured depths of permafrost range up to 100 metres and nearly all medium and fine textured soils here have permafrost within one metre of the surface (Figure 4-2). In the central part of the valley temperatures are higher and thus soils are better developed; permafrost is not continuous here but is still widespread. In the southern part of the corridor, from Fort Simpson to the Alberta border, permafrost is discontinuous, occurring mostly in poorly drained depressions. The presence of permafrost would require about one third of the pipeline to be constructed above ground on supports.

The Mackenzie River drains about 18% of Canada's land area and has numerous tributaries crossing the corridor from the east. Construction of the pipeline would require three major river crossings: the East Channel of the Mackenzie River in the Delta; the Great Bear River near Fort Norman and the Mackenzie River upstream from Fort Simpson. Important river crossings are identified in Figure 4-3.

### 4.1.3 WILDLIFE

There are at least 45 species of mammals living in the Mackenzie Valley. Of these, reindeer, caribou, moose, bear, and furbearers are of primary interest. Reindeer and caribou ranges are summarized in Figure 4-4. Moose are common in summer along the Mackenzie River north of Norman Wells (Plate 4-1). Islands in the river, bordering lowlands and tributaries are important winter range for moose (Figure 4-5). Grizzly bears inhabit the area as do a substantial population of black bears. Animals with the exception of reindeer are hunted for food but not for commercial purposes. There is an annual commercial reindeer slaughter.

A large number of furbearing animals inhabit the valley and some of these are important to the local trapping economy. The seven most economically important furbearers are: marten, muskrat, lynx, beaver, coloured fox, mink, and Arctic fox. The pipeline corridor north of Norman Wells crosses good marten habitat. Marten are the most commonly trapped species in the area. Muskrats abound in the abandoned channels and ponds of the Mackenzie River floodplain and delta. Lynx are plentiful in the boreal forest and are important to the trapping economy. The area between Norman Wells and Fort Simpson provides prime habitat for beaver. In this area, red fox, Arctic fox and mink also occur and, along with beaver, are trapped in large numbers.

In spring and autumn, the Mackenzie Valley is a major migration route for birds, both for the species that move through enroute to and from Arctic breeding areas and for birds that breed within the Mackenzie Valley (Plate 4-2). The Mackenzie River is an important staging area as early arriving species, such as geese, move through to their more northern breeding grounds.

The Mackenzie Valley, especially the delta, contains the most productive fishing waters of the western Arctic. Throughout the Valley, fish provide the staple protein for local residents while commercial and sport fisheries provide both income and recreation.

## 4.2 IMPACTS FROM PIPELINE DEVELOPMENTS IN THE MACKENZIE VALLEY

The following reviews the possible environmental and social effects of pipeline developments in the Mackenzie Valley region. Section 4.2.1 examines the projected impacts associated with normal operations.

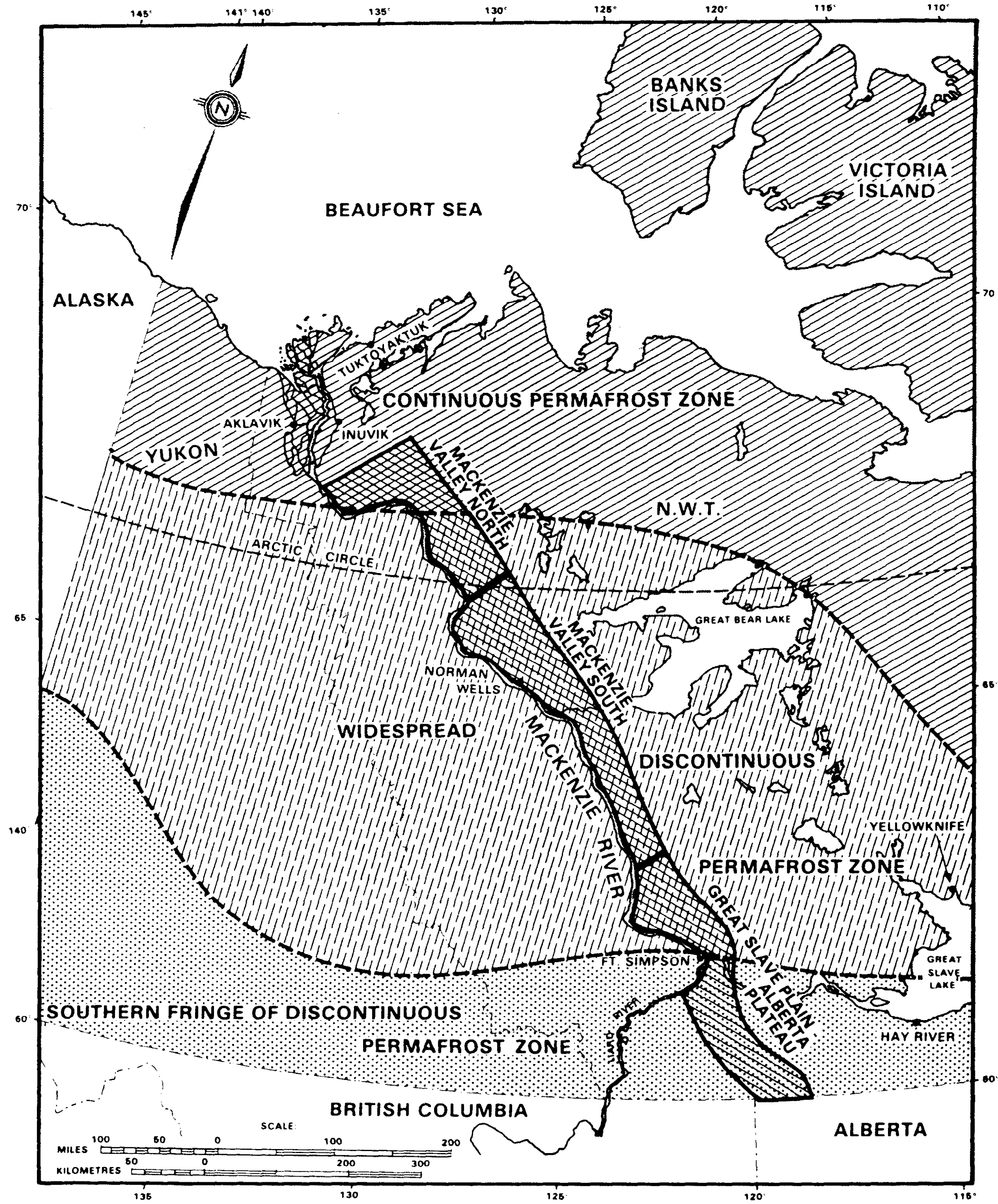



**FIGURE 4-2** *Permafrost zones in the Mackenzie Valley. In the northern continuous permafrost zone, the measured frozen ground thickness ranges from 100 metres in the north end of the corridor to 30 metres at the southerly limit of the zone. In the discontinuous permafrost zone at Norman Wells, permafrost thickness averages 50 metres thick to more than 100 m thick to the east away from the influence of the river. Three Valley terrain zones are also shown.*

Section 4.2.2 briefly reviews the concerns related to possible oil spills. Possible implications of pipeline development on the people of the region are summarized in Section 4.2.3. The terms used to describe possible impacts are those employed throughout the assessment sections of the Environmental Impact Statement and are defined in Appendix 3 of this volume.

### 4.2.1 ENVIRONMENTAL IMPACTS OF NORMAL PIPELINE RELATED ACTIVITIES

Most anticipated impacts associated with pipelines will arise from the construction of the pipelines and pump or compressor stations because of the large

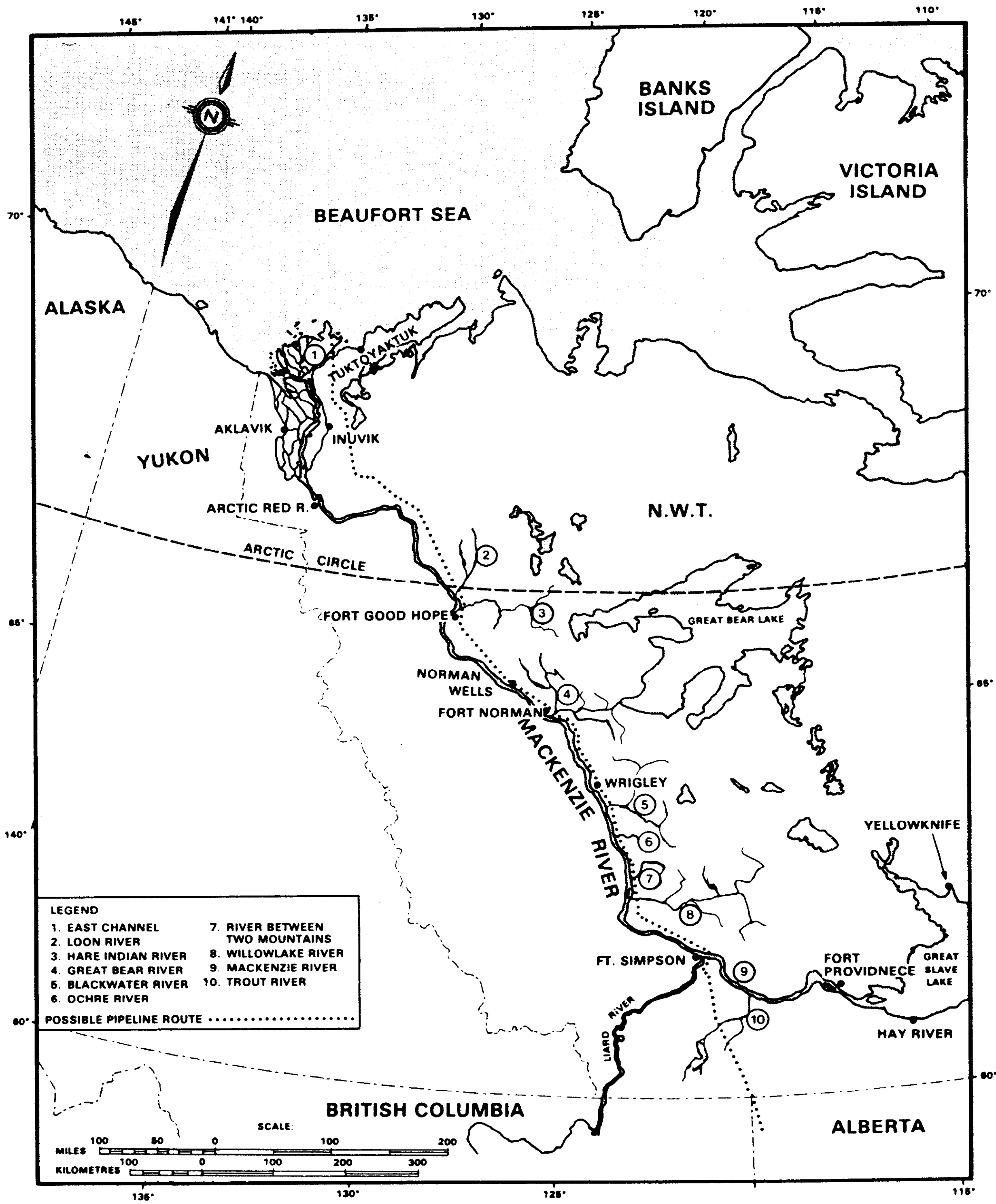



**FIGURE 4-3** *River crossings for a possible pipeline route. Major river crossings are the East Channel in the Delta, the Great Bear River near Fort Norman and the Mackenzie River upstream of Fort Simpson.*

numbers of personnel and numerous activities involved (Matrix 4-1). Once construction is complete, operations and maintenance activities are anticipated to cause fewer impacts. The impacts of additional pipelines in a pipeline corridor are not expected to be greater than those for the first pipeline, although alignment criteria may differ. The kinds of impacts which may be expected are summarized in Matrix 4-l.

### 4.2.1.1 Geology and Soils

Pipeline construction activities will require the removal of vegetation, ditching for pipeline burial and gravel to be extracted from borrow sites. In the pro-

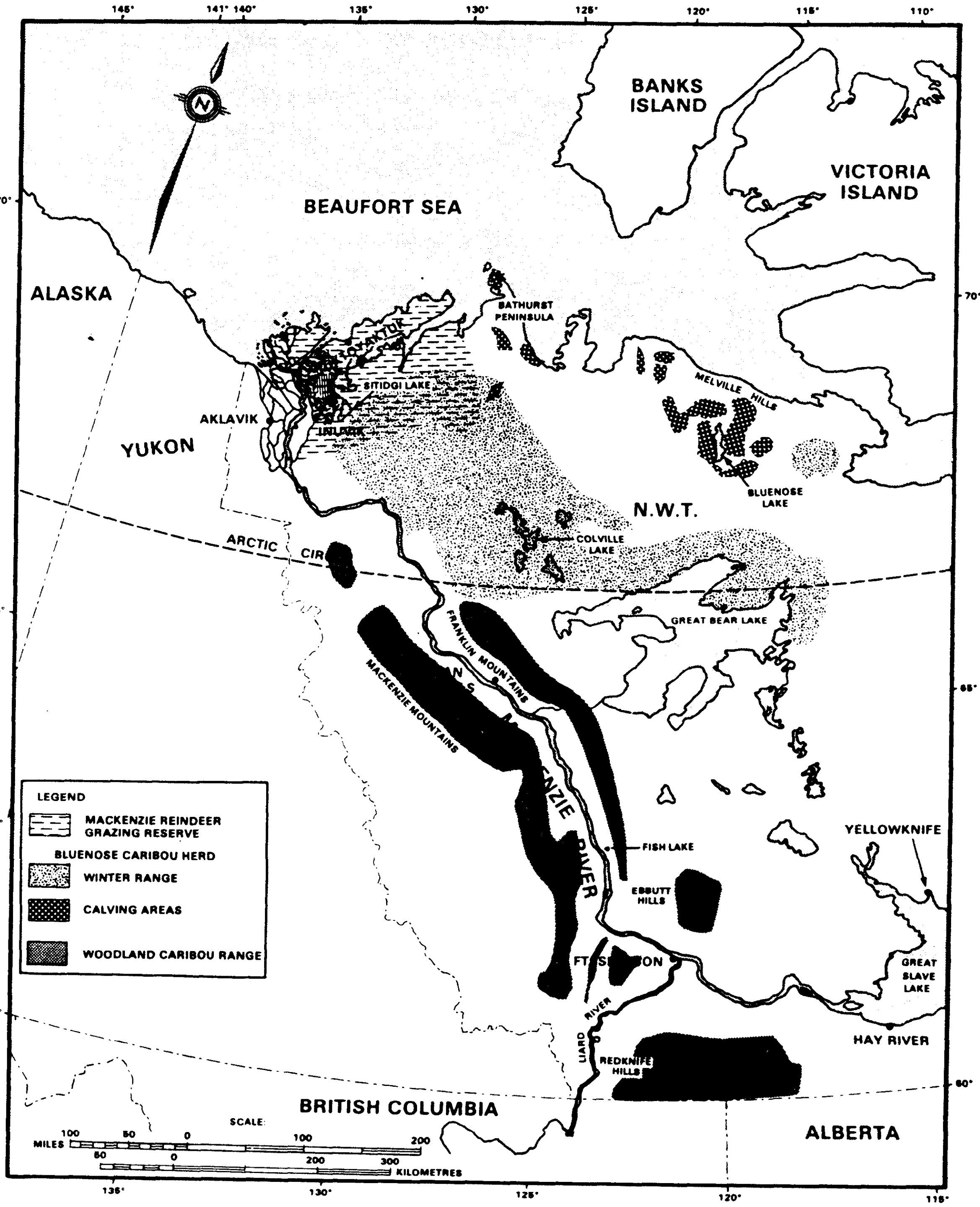



**FIGURE 4-4** *The Mackenzie Reindeer Grazing Reserve, winter range and calving areas of the Bluenose caribou herd, and woodland caribou range in the vicinity of the Mackenzie Valley corridor.*

**PLATE 4-1** *Moose range throughout the boreal forest areas along the Mackenzie Valley corridor (Courtesy, McCourt Management).*

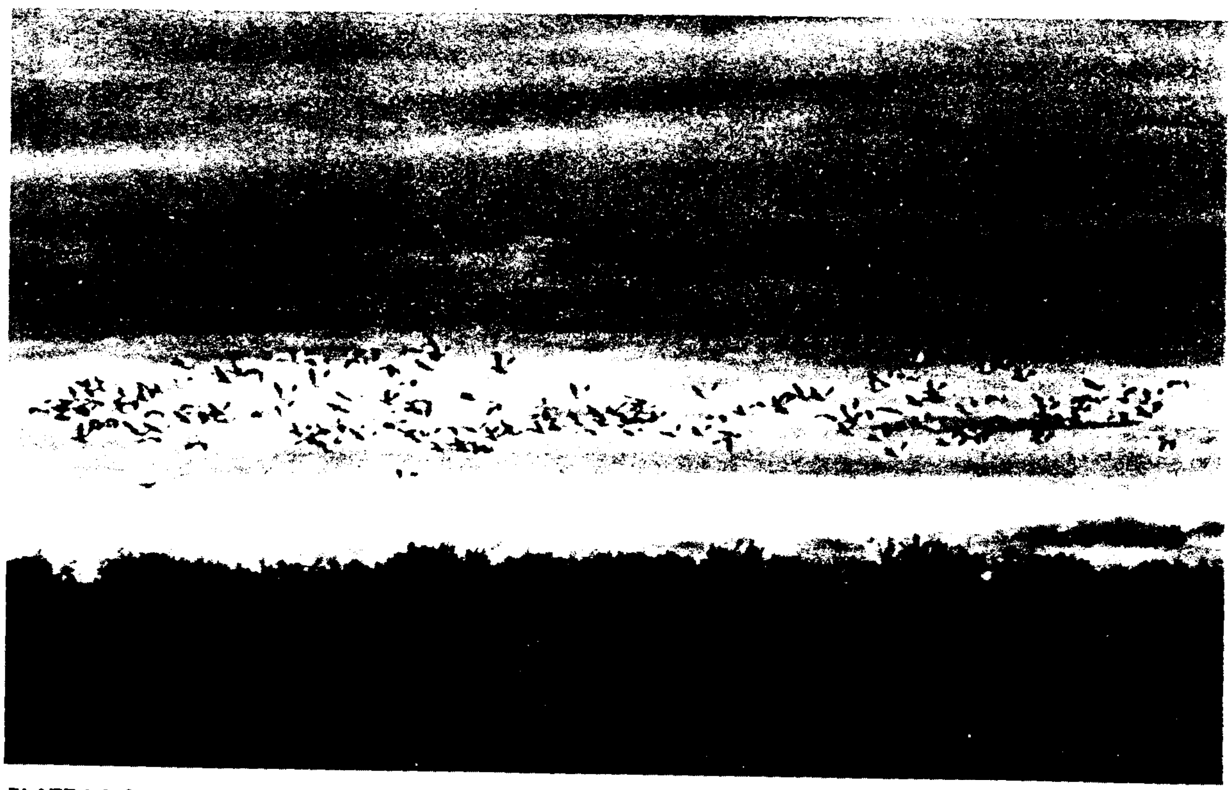


**PLATE 4-2** *Southward migration of snow geese along the Mackenzie Valley in autumn is rapid in most years with geese flying non-stop from staging areas in the Beaufort Sea region to staging areas on the Slave River delta or in northern Alberta. (Courtesy, J. Kristensen, LGL Ltd.).*

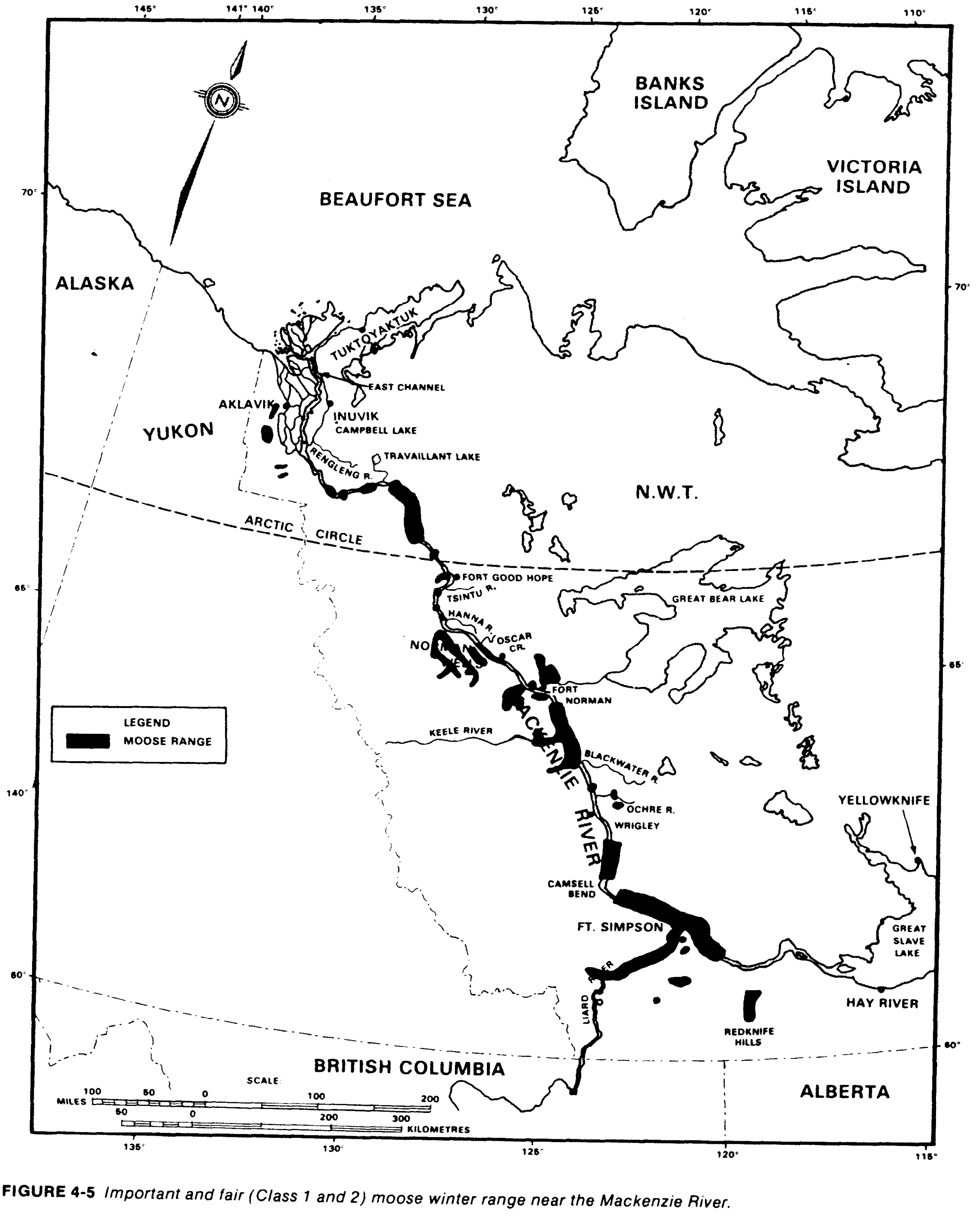



**FIGURE 4-5** *Important and fair (Class 1 and 2) moose winter range near the Mackenzie River.*

**MATRIX 4-1**

POTENTIAL ENVIRONMENTAL IMPACTS RESULTING FROM DEVELOPMENT OF AN OIL PIPELINE IN THE MACKENZIE VALLEY

| | | GEOLOGY AND SOILS | | | | HYDROLOGY AND WATER QUALITY | | | AIR | | VEGETATION | | | MAMMALS | | | | | | | | BIRDS | | | | | AQUATIC RESOURCES | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SOIL CHEMISTRY | SURFACE STABILITY | SLOPE STABILITY | GENERAL TERRAIN | WATER QUALITY | SURFACE WATER | GROUNDWATER | AIR QUALITY | MICROCLIMATE | RIPARIAN | CONIFEROUS FOREST | TUNDRA | REINDEER | BARREN GROUND CARIBOU | MOOSE | GRIZZLY BEAR | BLACK BEAR | AQUATIC FURBEARERS | TERRESTRIAL FURBEARERS | GENERAL MAMMAL CONCERNS | RAPTORS | GEESE/SWANS | DUCKS | OTHER | GENERAL/AVIAN CONCERNS | LOWER TROPHIC LEVELS | FISH |
| PIPELINE PRECONSTRUCTION AND CONSTRUCTION | RIGHT-OF-WAY PREPARATION | | L-s | L-s | L-s | L-s | L-s | L-s | | | L-s | L-s | L-s | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ● | ◊ | ◊ | ○ | | ○ | ◊ |
| | BLASTING | | | | | L-s | L-s | | | | | | | | | | | | | | ○ | ○ | ○ | ○ | ○ | | ○ | ◊ |
| | PIPELINE DITCHING, INSTALL. & BACKFILLING | | L-s | L-s | L-s | L-s | L-s | | L-s | | L-s | L-s | L-s | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | ◊ | | | | | | ○ | ○ |
| | PIPELINE TESTING AND FLUID DISPOSAL | L-s | L-s | L-s | L-s | L-s | L-s | | | | L-s | L-s | L-s | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ◊ |
| | STREAM CROSSINGS | | L-s | L-s | L-s | L-s | L-s | | | | L-s | L-s | L-s | ○ | ○ | ◊ | ○ | ○ | ◊ | ○ | | | | | | | ◊ | ◊ |
| | ELEVATED PIPELINE | | L-s | L-s | L-s | | | | | | L-s | | L-s | ◊ | ◊ | ◊ | ○ | ○ | ○ | ○ | ◊ | | | | | | | |
| | BURIED PIPELINE | | L-s | L-s | L-s | | L-s | L-s | | | L-s | L-s | L-s | ◊ | ◊ | ◊ | ○ | ○ | ○ | ◊ | ◊ | | | | | | | |
| | PUMP STATIONS | | L-s | L-s | L-s | | | | | | L-l | L-l | L-l | | | | | | | | ◊ | ● | ● | | | ● | | |
| SUPPORT FACILITIES PRECONSTRUCTION AND CONSTRUCTION | SITE PREPARATION | | L-s | L-s | L-s | L-s | L-s | L-s | | | L-l | L-l | L-l | | | | | | | | ◊ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | GRANULAR BORROW | | L-s | L-s | | L-s | L-s | | | | | L-m | L-m | | | | | | | | ◊ | ◊ | ◊ | ◊ | | ◊ | ○ | ○ |
| | WHARVES AND BARGE TRAFFIC | | | | | | | | | | | | | | | | | | | | | | ◊ | ◊ | | | ○ | ○ |
| | TEMPORARY ACCESS ROADS | | L-s | L-s | L-s | L-s | L-s | | | | L-s | L-s | L-s | ◊ | ◊ | ● | ◊ | ◊ | ◊ | ◊ | | | | | | ○ | ○ | ○ |
| | PERMANENT ACCESS ROADS | | L-s | L-s | L-s | L-s | L-s | L-s | | | L-l | L-l | L-l | | | | | | | | ◊ | ◊ | ◊ | ◊ | | ◊ | ○ | ○ |
| | STAGING SITES AND STOCKPILES | | | | | | | | | | | | | | | | | | | | ◊ | ◊ | ◊ | ◊ | ◊ | | | |
| | CONSTRUCTION CAMPS | | | | | | | | | | | | | ◊ | ◊ | ◊ | ● | ◊ | ○ | ◊ | | ◊ | ◊ | ◊ | | | ○ | ○ |
| | AIRCRAFT AND AIRSTRIPS | | | | | | | | | | | | | ◊ | ◊ | ◊ | ◊ | ◊ | ○ | ○ | | ● | ● | ◊ | | | | |
| | WASTE DISPOSAL | | | | | | | | | | | | | ○ | ○ | ○ | ● | ○ | ○ | ◊ | | | | | ○ | ○ | ◊ | ◊ |
| | OFF-DUTY ACTIVITIES BY PIPELINE PERSONNEL | | | | | | | | | | | | | | | | | | | | ◊ | | | | | ◊ | | ○ |
| OPERATION MAINTENANCE AND ABANDONMENT | PIPELINE SURVEILLANCE | | | | | | | | | | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | | | ○ | | |
| | PERMANENT ROADS AND WHARVES | | | | | L-s | L-s | | | | | | | | | | | | | | ◊ | | | | | ◊ | | |
| | OTHER PERMANENT SUPPORT FACILITIES | | | | | | | | | | | | | | | | | | | | ◊ | | | | | ◊ | | ○ |
| | PUMP STATIONS | L | | | | | | | L | L | L | L | L | | | | | | | | ○ | | | | | ○ | | ○ |
| | FIRE HAZARD | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | ABANDONMENT | | L-s | L-s | L-s | | | | | | L-s | L-s | L-s | | | | | | | | ○ | | | | | | | |
| | RECLAMATION | | L-s | L-s | L-s | | | | | | L-s | L-s | L-s | | | | | | | | ○ | | | | | ○ | ○ | ◊ |

LEVEL OF POTENTIAL IMPACT

BIOTIC
○ : NEGLIGIBLE
◊ : MINOR
● : MODERATE
■ : MAJOR

PHYSICAL
L : LOCALIZED
R : REGIONAL
m : MEDIUM-TERM
l : LONG-TERM
s : SHORT-TERM

BLANKS INDICATE NON-APPLICABILITY OR ADDRESSED ELSEWHERE

cess, the surface soil will be disrupted, drainage altered and the land recontoured in places. As a result, hydraulic erosion might occur, and where there is permafrost, there may be thaw settlement and increased problems with slope failures and erosion. Thaw settlement might also result in local ponding on rights-of-way.

Drainage alterations and hydraulic erosion of surface soils are most likely to occur on sloping terrain of the pipeline right-of-way and at access roads, borrow pits, and airstrips. These effects can be minimized with appropriate drainage and erosion control measures. The overall impact on geological and soil materials due to drainage alterations and erosion from pipeline construction and from additional parallel pipelines is expected to be LOCALIZED and SHORT TERM.

Slope instabilities will be greatest along sections of the pipeline route with rugged topography, such as in the central Mackenzie Valley, where cuts and grading ~~will be required, and~~ in river bottoms where deep excavations may be needed to bury the pipe below the depth of streambed scour. If a pipeline rupture occurred due to a slope failure, emergency repairs would be necessary, and could result in additional terrain damage. The overall impact of additional parallel pipeline routes could aggravate stability problems on slopes, but effects are likely to be LOCALIZED and SHORT-TERM.

#### 4.2.1.2 Hydrology and Water Quality

Stream flow and water quality, in some instances, will be unavoidably affected by pipeline construction and operation. Ditching, the construction of stream crossings, and permanent access roads may cause drainage alterations and siltation. Appropriate drainage and erosion controls will minimize these effects. The overall impacts of one or more pipelines on drainage alterations are expected to be LOCALIZED and SHORT-TERM.

#### 4.2.1.3 Atmospheric Environment

The construction and operation of the pipeline will produce local noise, air emissions and ice fog at times. In an atmospheric inversion, plant emissions as well as ice fog may be trapped near the ground. The duration and extent of this condition will depend on the duration of cold weather, prevailing winds, and the strength of the inversion. Compressor stations will be designed to have exhaust stack velocities so that emissions and ice fog are expected to be at elevations where air currents will provide better dispersion. The overall impact of additional parallel pipelines and their pumps or compressor stations on air quality is expected to be LOCALIZED.

#### 4.2.1.4 Vegetation

Vegetation will be removed or destroyed on all permanent facility sites including permanent roads, pump station sites, and permanent camps for the life of the pipeline. The resultant impact on vegetation is considered LOCALIZED due to the small area involved. All temporary facility locations and the pipeline right-of-way will be revegetated shortly after construction in an area is completed. However, in forested areas, trees and tall shrubs will be kept from growing in the right-of-way for the life of the pipeline. The overall impact of additional parallel pipelines on vegetation in the Mackenzie Valley is rated as LOCALIZED.

Revegetation may not be as successful where pipeline construction activities disturb the soil rooting zone. The removal of the natural vegetation and surface organic layer may initiate local hydraulic erosion, slope failure, and thermal erosion. However, the possible effects on vegetation will be LOCALIZED. The construction and operation of additional pipelines may increase soil disturbance and instability, however the overall impact is likely to be LOCALIZED and SHORT-TERM.

#### 4.2.1.5 Mammals

Many species of mammals are found in the Mackenzie Valley for at least part of the year. Possible impacts on these species from the numerous pipeline-related activities are summarized in the following paragraphs. The impact descriptions are based on the impact catagories: habitat alteration, disruption of movements, disturbance, and direct mortality.

Reindeer

Reindeer and pipeline activities may interact within the western portion of the Mackenzie Reindeer Grazing Reserve. The reindeer herd may also encounter the pipeline corridor on Richards Island because of a possible expansion of the grazing area. Untended movements of the reindeer herd may be initially disrupted by the elevated pipeline although they will probably adapt quickly to its presence. The Nelchina and Central Arctic caribou herds in Alaska do not appear to have been affected by an elevated oil pipeline across their range (Plate 4-3). Also, herders will likely choose the best crossing areas for the herd.

Other possible barriers to reindeer movements include the open pipeline ditch, strung pipe and intensive construction activity along sections of the pipeline route. These possible barriers will be short in length and duration and unlikely to affect the welfare of the reindeer herd. In addition, herd movements can be controlled to avoid construction areas.

Disturbance from human activity, land-based vehicles, aircraft, and blasting will be largely confined to the pipeline right-of-way and will be intensive only during the short construction period. A result could be the local displacement of reindeer, which is not expected to adversely affect the reindeer herd because they are accustomed to human activity, snow machines, and aircraft during herding. Also, construction locations could be avoided by advanced planning of herd movements.

Habitat lost to the pipeline right-of-way, facility sites, borrow sites, and roads will be insignificant compared to the available range. Additional access for people provided by the right-of-way and temporary permanent roads, combined with the human population influx to the Mackenzie Delta as a result of development, may increase reindeer poaching. It may be necessary to intensify herd patrols to prevent poaching. In general, construction and operation of the pipeline is expected to have a MINOR impact on the reindeer herd.

The Bluenose Caribou Herd

The pipeline corridor traverses the western extremity of the winter range of the Bluenose herd. It is therefore unlikely that large numbers of Bluenose caribou will encounter the pipeline. The few caribou which may winter over the pipeline route will be exposed to

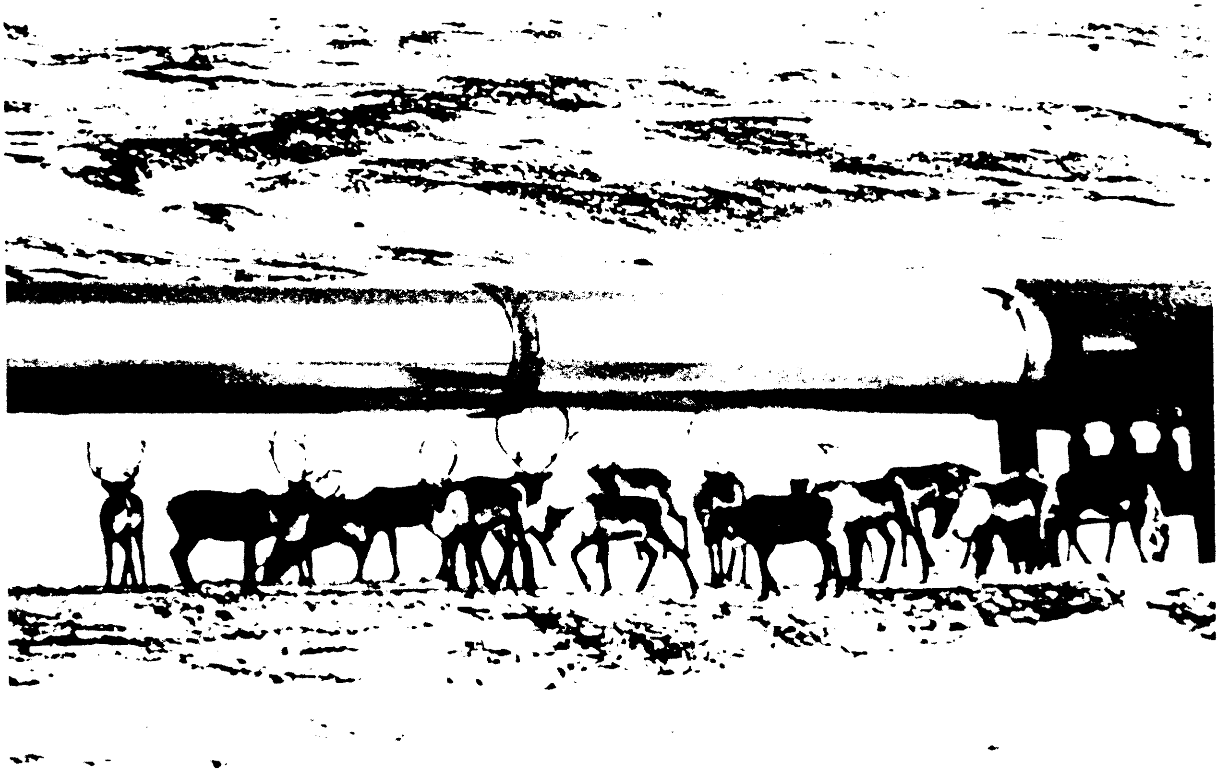


**PLATE 4-3** *Barren ground caribou in Alaska have been found to use the Alyeska Pipeline right-of-way as a travel corridor and foraging area. (Courtesy, Alyeska Pipeline Service Company).*

aircraft traffic, land-based vehicles, stationary machinery, human activity and possibly blasting. These disturbances, which will be greatest during the relatively short construction period, will locally displace caribou. Habitat lost to the right-of-way, facility sites, borrow sites, and roads, will be insignificant.

The pipeline, at the western edge of the range of the Bluenose herd, will be sufficiently elevated to allow caribou to move under the pipeline so that no physical barrier would exist. Access provided by the pipeline right-of-way and temporary and permanent roads may result in some increased hunting of the Bluenose herd. However, the impact on the herd is expected to be MINOR because of the small number of caribou which use the area.

### Woodland Caribou

Woodland caribou are only rarely likely to encounter the pipeline corridor in the Mackenzie Valley because of the lack of suitable habitat. Interactions are most likely to occur along the section of the pipeline corridor south of Fort Simpson between the Redknife Hills and Bistcho Lake areas. In this area, some habitat will be occupied by facility sites and the pipeline right-of-way. Existing rights-of-way and clearings will be used wherever possible, thereby minimizing habitat loss. It is assumed that habitat alteration as a result of fires will be prevented. Thus, no significant impacts on caribou populations are expected to result from habitat alteration. Within woodland caribou range, most of the pipeline will be buried and is therefore of little concern as a potential barrier. Elevated sections will be either circumvented or crossed under, as caribou of the Nelchina and Central Arctic herds cross under the Alyeska Pipeline.

Pipeline construction within caribou range may expose some caribou to disturbances from aircraft, land vehicles, blasting, and personnel. However, caribou populations are dispersed so that disturbances at isolated locations would affect very few animals. Moreover, restrictions governing aircraft flights and other mitigative measures to be applied during construction and operation are expected to maintain sensory disturbance effects on the woodland caribou population at a NEGLIGIBLE level.

Increased access, even though kept to a minimum, may result in increased hunting of woodland caribou in the Redknife Hills and Bistcho Lake areas. Since there are relatively few caribou in this area, increased access is expected to have only a MINOR effect on the population.

Very few, if any, caribou are expected to be involved with hazardous substances or collisions. Regulations governing movements of vehicles, fencing of facility sites, procedures governing backfilling of excavated trenches and other mitigation measures will minimize the chances for caribou to be killed. Overall, adverse effects on the caribou population are expected to be MINOR.

### Moose

Moose habitat exists along almost the entire pipeline corridor and its main effect will be to temporarily produce new vegetation favored by moose. However, the total area of moose habitat which could be altered will be insignificant.

Possible temporary barriers to movements would include slash piles along the right-of-way, sections of open ditch, and strung pipe. However, none of these are expected to delay or prevent moose movements to such an extent that the animals would be harmed.

Moose are generally not considered to be particularly susceptible to sensory disturbances. A few moose may be killed as a result of vehicle collisions. Adoption of mitigative measures, together with route selection to avoid most of the important winter range for moose in the Mackenzie Valley, will ensure that these impacts on moose will be NEGLIGIBLE.

However, increased access and more people may result in local increased hunting of moose. Currently, moose near most Mackenzie Valley communities already appear to be overharvested. Without wildlife management practices, the impact from increased hunting pressure on moose could be locally MODERATE.

### Deer

White-tailed deer and mule deer may be subject to limited habitat loss, disturbance, and barriers to movement. As is the case with other ungulates, these effects will be very local. The net effect of development on deer populations is likely to be less than on moose and caribou populations, because of their low density and lack of migratory movements. Overall, effects of development on deer will be NEGLIGIBLE.

### Grizzly Bear

Interactions between grizzly bears and construction and operation of the pipeline will occur mainly along the northernmost section of the pipeline route. Habitat loss will be insignificant and all known den sites will be avoided. Disturbances from aircraft, machinery, and human activity may cause some local displacement and stress reactions, but these will not likely have significant effects on the population. The main concerns are with problem bears attracted to facilities and those hunted for sport. Despite mitigative measures for handling wastes and problem bears, it is likely that some bears will be killed during the construction phase. However, winter construction should minimize these interactions.

During the operations phase there will be few facilities within grizzly bear habitat. Nevertheless, some bears may be encountered during surveillance, monitoring, and maintenance activities. Improved access and the increased human population in the Mackenzie Delta region may increase hunting pressure on grizzly bears and result in some illegal harvest. The overall effect will probably be MODERATE on grizzly bears in the Mackenzie Delta area and MINOR in the Mackenzie Valley.

### Black Bear

Black bears are widely dispersed throughout forested areas adjacent to the pipeline corridor, making it unlikely that many will interact with the pipeline facilities. The general effects of interactions will be similar to the effects on grizzly bears. Because of the widely dispersed distribution of bears and their relatively high reproductive potential, impacts on the black bear population are expected to be MINOR.

### Aquatic Furbearers

Beaver, muskrat and mink are widely distributed and will not be affected much by habitat alteration. Some local areas of short-term habitat loss will occur as vegetation is removed and drainage or water levels are altered. Beaver are adapted to feed on early stages of vegetation growth and can control drainage and water levels upon which they depend, so possible adverse effects should be short-lived. They are also relatively insensitive to sensory disturbances. Increased access is also a concern, albeit a minor one, in areas where no access now exists. Beaver are susceptible to overharvesting and there is the potential for local depletions along the pipeline corridor. The net effect on beaver is expected to be MINOR.

The possible effects of the project on muskrat will be similar to those on beaver. However, because of the wide distribution of muskrats and their very high reproductive potential, development is likely to have only a MINOR effect on the muskrat population. The effects of development on mink will be similar to those on beaver and muskrat and are expected to have a MINOR effect on the population.

Arctic fox, which only inhabit the northernmost portion of the pipeline corridor, are widely dispersed but not particularly abundant. Interactions with pipeline construction and operation activities will therefore likely be infrequent. Since few den sites occur in the area, chances of destruction of den sites are low. Some foxes may be attracted to construction camps and may be killed if they appear rabid. The possibility that foxes may become dependent on camp garbage or handouts and be unable to fend for themselves when the camp is abandoned is remote because of methods of garbage disposal and regulations against feeding of wildlife. The increased human population during the construction period may result in some increased hunting and trapping of Arctic fox but is unlikely to significantly affect the regional population. Any adverse effects of pipeline construction and operation on the Arctic fox population are expected to be MINOR.

Red Fox are also widely dispersed and few interactions will occur. As with Arctic fox, the most important impacts could involve destruction of den sites, attraction to camps, and some increased hunting and trapping. These effects on the red fox population are expected to be MINOR.

Lynx are expected to be little affected by habitat loss and disturbance. Improved access for hunters may result in local scarcities of lynx if their population cycle is at a low point. If this does occur, the population will recover rapidly when the snowshoe hare population rises. Lynx reproduce rapidly with an adequate food supply. The overall effect on the lynx population is expected to be MINOR.

Marten are widely dispersed and have relatively small home ranges. Marten are not particularly susceptible to disturbance, perhaps because their relatively small size enables them to easily find security in escape cover. A very small fraction of marten habitat would be altered. The impact of the greatest concern is with improved access and possible overharvesting. However, overharvesting is likely to happen in only a few areas so that the effect on the population is expected to be MINOR.

Wolves are relatively insensitive to habitat alteration. They often follow transportation rights-of-way when hunting. Their food supply may be depleted in local areas by the over-harvesting of caribou and moose where access is improved. Since these effects on ungulates are expected to be minor, the effect on the wolf population is also expected to be minor. Improved access and more people may increase the harvest of wolves. However, wolves reproduce rapidly, thus the net result of all effects on the wolf population is likely to be MINOR.

Other furbearing mammals in the Mackenzie Valley corridor, such as weasels, squirrel, wolverine, fisher, otter and coyote, are generally widely dispersed. As a result, only very small fractions of the populations of these mammals are likely to be affected by pipeline development. Habitat alteration and disturbance will therefore have NEGLIGIBLE impacts. Increased access may result in local depletion of those species susceptible to over-harvesting. The effect on regional populations may therefore be MINOR.

Other Terrestrial Mammals

Populations of other mammals, such as shrews, small rodents and hares, are widely dispersed. Impacts are therefore expected to be MINOR since only insignificant proportions of their populations would interact with pipeline development.

#### 4.2.1.6 Birds

More than 170 species of birds occur in the Mackenzie Valley region each year. A few, such as willow ptarmigan and common raven, are year-round residents. Most others migrate northward into the Valley in spring, and some continue to more northerly breeding grounds while many others remain to nest. A return migration southward begins for some as early as late June and continues through the fall into October. The Mackenzie Valley region has continental importance for birds as a migration corridor and as a relatively undisturbed area for breeding, nesting, raising young, and moulting. Also, the Mackenzie Delta is of continental importance, particularly for waterfowl and shorebirds.

Waterfowl are the main concern in the Mackenzie Valley because of their vulnerability when concentrated in flocks at certain seasons. Raptors are also of concern because of the low numbers of some species and their sensitivity to disturbance. Impacts on waterfowl and raptors can arise as a result of disturbances caused by noise from aircraft and vehicles, human presence, long term habitat loss or modification, increased hunting pressure, and the possibility of oil spills. The most effective mitigative measures to protect both raptors and waterfowl would be to locate the right-of-way and facilities remote from known raptor nests and to avoid river habitats important to swans and geese during the spring migration. Other mitigative measures include: winter scheduling of construction when most birds are absent; strict enforcement of regulations; and an effective oil spill prevention and contingency cleanup program. Given the general sensitivity of raptors to disturbances and the low population levels of some species, the overall impacts to raptors are generally considered MINOR but could approach MODERATE in local areas. Overall impacts to waterfowl are generally expected to be NEGLIGIBLE but could approach MINOR in some local areas.

### 4.2.1.7 Fish

Pipeline construction and operations activities may impact on fisheries resources in several different ways. The following discusses impacts on fish as related to sediment introductions, habitat modifications, fish kills, increased recreational fishing, water requirements, and reductions of food organisms.

Sedimentation

All development activities resulting in disturbance of stream bottoms substrates, banks, or watersheds, will tend to increase the total sediment loads in waterbodies. In most streams, sedimentation occurs naturally but additional sediment introductions will have effects depending on when they are introduced, for how long, and in what concentrations.

Even with an aggressive program of inspection, reclamation, and revegetation, failures of stream banks, slopes, and erosion control measures may occasionally add suspended sediments to some waterways throughout the life of the pipeline development. In general, most sediment will be introduced where there are acute erosion problems, which means that any effects will usually be both LOCAL and SHORT-TERM. Unless sedimentation becomes generalized or chronic at a single location, recovery of both fish and their food organisms will be rapid. Although a few localized reductions in fish populations are probable, the overall effects on all sediment introductions on fish populations in the region are likely to be MINOR.

Habitat Modification

Stream crossings, access roads, stream training structures, spills of toxic materials, sediment introductions, and other environmental modifications that may accompany development will alter or diminish some fish habitat. Although a few of these modifications will have beneficial effects, the majority will reduce habitat quality.

Most fish habitats which could be disturbed by Mackenzie Valley pipeline development serve mainly as summer feeding locations, but in a cumulative sense, all pipeline-related disturbances would affect only a very small percentage of the total available feeding habitat. As a rule, large fish will readily seek alternate habitat if unsuitable conditions are encountered. Of greater concern are habitats for spawning, rearing, and overwintering which may be scarce. If pipeline development depletes certain habitat which is already scarce, then regional populations could be adversely affected.

To reduce the possibility of disturbing sensitive upstream fish habitats, the number of stream and lake crossings will be minimized and most Mackenzie tributary streams will be crossed near their mouths. Of the spawning, rearing, and overwintering areas identified in the region to date, few occur directly on the general pipeline alignment. Although most of the streams crossed by the alignment serve as migratory routes for fish moving to and from sensitive habitats, it is unlikely that pipeline development will interfere with these migrations, and any modifications will be short-term, likely lasting less than one year. Given the small amount of habitat likely to be affected, the even smaller amount of sensitive habitat involved, and the brief duration of most habitat modifications, the cumulative effect of pipeline activities on fish habitat will be NEGLIGIBLE.

Fish Kills

In addition to the possible effects of sediments on eggs and juvenile fish, fish could be killed by the operation of machinery, spills of toxic materials, blasting in streams, entrapment, and blockage of passage to and from critical habitats. Were all these disturbances to occur at a single location, their collective effect would undoubtedly reduce local populations; however, a single disturbance is more likely to occur at an isolated location within the pipeline corridor. This being the case, possible reductions in fish populations would be short-term. With the exception of a major crude oil spill, the duration of effect would be brief, and recovery would be expected in a single generation. Even with several simultaneously occurring disturbances, effects would be reflected in short-term local declines in fish populations. The effects are consequently rated as MINOR.

Increased Recreational Fishing

More people and increased access to remote areas will result in increased recreational fishing. Lake trout populations grow slowly and have low recruitment rates, and thus could decline with increased fishing pressure unless stringent measures are employed to control angling. Grayling, though more tolerant of angling pressure than lake trout, may also decline. However, grayling have a widespread regional distribution so that overall population levels are not expected to be affected. Other species in the region are less vulnerable to angling pressure.

No all-weather road will be constructed beside the pipeline right-of-way. Hence the total number of areas made accessible to anglers by the pipeline is expected to be small. Cumulative effects attributable to increased angling pressure are expected to be NEGLIGIBLE.

Water Requirements

Projected water requirements for the four year pipeline construction period total 43,000,000 $m^3$, including the water requirements of personnel, hydrostatic testing, winter road construction, and other incidental uses. Thereafter, water requirements will drop to only that needed for the operation and maintenance of facilities and support of personnel. Most water will be required during winter months for hydrostatic testing and road construction. Water availability may become a problem when required at locations distant from the Mackenzie River.

Water withdrawals from overwintering habitat for fish can cause fish to die by dewatering their habitat and reducing dissolved oxygen concentrations. This concern does not apply to the Mackenzie River mainstem where there is an abundant year-round water supply. However, in its smaller tributaries, there is often only enough water to meet the needs of overwintering fish. Some of these streams may also serve as spawning areas for fall-spawning species. Assuming that proper consideration is given to overwintering fish and that water requirements can be met without endangering local fish populations, the effect of water withdrawals will be NEGLIGIBLE.

Reduction of Food-Organisms

Sedimentation, nutrient enrichment, and spills of toxic fluids can alter the productivity of lower trophic levels. With the exception of accidental oil spills, however, such disturbance effects on lower trophic levels would generally occur in the immediate vicinity of development facilities. All such disturbances will alter local community structure, which may affect the feeding distribution of local fish populations. Because they can quickly recolonize a previously disturbed water body from nearby unaffected waters, lower trophic levels recover rapidly from disturbance, often in a single generation.

In the Mackenzie Valley, communities of lower trophic level organisms are ubiquitous, so it is unlikely that a brief disturbance will affect any unique feature of their distribution. Given the rapid recovery rate of the lower trophic levels and the limited effects on their widespread distribution, overall effects are expected to be MINOR.

### 4.2.2 PIPELINE ACCIDENTS AND OIL SPILLS

The transport of oil by pipeline along the Mackenzie Valley is not without the risk of an oil spill, but, the factors to be incorporated into the design, construction and operation of the line, minimize the risk. Leak detection and control systems will automatically shut down the system and isolate a leak; thereby, limiting the quantity of oil which could be released.

#### 4.2.2.1 Prevention

Factors have been incorporated in the design of the overland pipeline to ensure the integrity of the line, and as such, prevent the occurrence of leaks. These factors include the elevation of the line in permafrost areas, the installation of cryoanchors in permafrost areas particularly sensitive to temperature increase, the use of Arctic construction techniques, corrosion protection systems, and the installation of the line below the level of ice and water scour at river crossings.

Leak detection systems will form an integral part of the pipeline operations and control system and have the capability to detect and identify the location of a leak which is in the order of 0.25 to 0.5% of pipeline flow. Upon detection of a leak, the pipeline would automatically shut down, and the operator immediately alerted. The section of pipeline where the leak occurs would be closed by appropriate remote controlled valves installed in the line for this purpose. With the aid of computer based leak detection systems, the operator could be alerted to minor leaks in the pipeline and provide shut down of the system before 50 to 100 $m^3$ have escaped.

#### 4.2.2.2 Spill Clean-up and Effects

If a rupture of the pipeline were to occur, for example, on an elevated portion of the line over permafrost terrain, the maximum amount of oil spilled cannot exceed 8,000 $m^3$. By providing closer valve spacing, such as in environmentally sensitive areas, the quantity of oil spilled would be reduced. If the pipeline rupture occurred during summer, trenching and berming would be undertaken to contain the oil. Thereafter, it would be pumped into temporary storage bladders prior to reinjection to the pipeline or disposal in an approved manner. The area of the spill would be fenced in some locations to prevent intrusion of large animals. Restoration of the affected area would be undertaken.

Should a rupture occur during winter, the oil will penetrate snow but will not seep into the frozen soil. The spill site will be cleaned by burning the oil, or by removing the bulk of the oil with mechanized equipment, followed by manual removal of any residual material.

If a spill from the pipeline occurred at a river crossing on the Mackenzie River during summer, mechanical containment and recovery equipment would be deployed to recover the oil. The collected oil would be burned and impacted shoreline would be cleaned using manual techniques. During winter, oil moving downstream would be diverted and collected by cutting slots in the ice angled toward shore. Oil collect-ing in the slot ends would be removed by skimming and pumping. Combustion of the oil in the slot ends could also be undertaken.

The impacts of oil spills on terrestrial vegetation would naturally be limited to the areas contacted or covered by oil. For example, mortality of all plant tissue results from contact with sprayed oil. Lichens and mosses would be killed quickly, followed by the death of black spruce. Natural regrowth of some species may be initiated within a few weeks, however, several growing seasons would be required for seedling establishment of vascular plants. On the other hand, a point source spill would affect vegetation to varying degrees. Mosses, lichens and small conifers and deciduous species would be killed; however, mature black spruce trees may not be significantly affected.

Major oil spills in freshwater rivers or lakes could cause considerable harm to furbearing animals such as beaver, muskrat and mink, and all aquatic birds coming in contact with the oil.

An oil spill can affect freshwater aquatic organisms in a number of ways such as by interfering with respiration facilities of aquatic organisms; coating and destroying primary producer and benthic organisms; (the food sources of higher trophic levels); coating spawning habitat of fish; being ingested by fish and other aquatic organisms and thus taint flesh or cause mortality through toxic effects; or deoxygenating water resulting in indirect fish mortality.

The impact of a spill in flowing water will be reduced, however, by rapid dilution in the Mackenzie River, the evaporation of lighter fractions, the high sediment loads characteristic of the river during the open water period, the self-cleaning capacity of streams, and, of course, the oil spill clean-up measures.

### 4.2.3 THE PEOPLE

Excluding the Mackenzie Delta settlements, communities in the Mackenzie Valley and in the Great Slave Lake area (Plate 4-4) have a total population of about 24,000, which is slightly more than half of the total population of the Northwest Territories. Of this population, approximately 40% or about 10,000 people, lives in or near Yellowknife, the capital of the Northwest Territories. Fort Simpson, with an estimated population of 1,100, is the largest settlement in the corridor along the Mackenzie River.

Apart from the populations of some predominantly non-native communities, especially Yellowknife and Hay River, the majority of the people in the region are Dene or Metis. In prehistoric and early historic times, the Dene were semi-nomadic people like the Inuit of the Arctic. Since their first contact with the European explorers and fur traders in the late 18th century, their way of life has changed in much the same way as that of the Inuit. They were drawn into the fur trade in the early to mid 1800's. Missions also have a long history in the region. The period following World War II saw the growth of government services, the construction of roads and enlarged permanent communities, industrial activity based on mining and oil and gas exploration, political development, and population growth. Recently, territorial political leaders have made increasingly stronger demands for a greater degree of self-government, resource revenue sharing and some measure of control over major development projects.

The construction of an oil pipeline, perhaps followed by a gas pipeline, along the Mackenzie corridor, would have important effects, on most of the communities of the Mackenzie Valley and Great Slave Lake region. These effects would be especially marked at the larger and more commercial communities - Yellowknife, Hay River, Fort Simpson, and Norman Wells.

Transportation operations and pipeline construction could employ much of the regional labour force, although neither activity would offer most workers more than seasonal employment since the bulk of pipeline construction would last no more than three to four years. Following the initial surge of construction there would, however, be several years of lower level activity involving the construction of facilities such as compressor stations. Operations and maintenance would provide further employment opportunities. Altogether, qualified Mackenzie Valley residents could expect many years of continuing work arising out of pipeline and Beaufort-Delta developments.

While the oil pipeline construction force requirements would be short-term, they would be large. Winter construction would require some 7,000 people in 1984-85, over 13,000 in 1985-86, and about 9,000 in 1986-87. Summer activity would, at the most, employ up to 3,000 personnel during pipeline construction. Continuing activity, following 1987, and involving operations and maintenance and the construction of compressor stations, would employ up to 700 people in some years, although the typical number would be lower.

Much of the pipeline labour force would be employed along rights-of-way and housed in camps well away from communities. There would be little interaction between the camps and communities. Inuvik, Fort Good Hope, Norman Wells, Fort Norman, Wrigley, Fort Simpson and Jean Marie River, would be at varying distances from pipeline construction and

**PLATE 4-4** *Two Mackenzie Valley communities that lie near the proposed pipeline right-of-way. Above, Fort Good Hope. Below, Wrigley, near which the Mackenzie Highway terminates. (Courtesy, Outcrop).*

related activities. Larger communities such as Inuvik and Fort Simpson would play key roles in both construction and in operations and maintenance. There is a potential for some interference with local harvesting, although this would be kept to a minimum. It is also possible that many part-time and even some full-time trappers would take jobs in pipeline construction. Because both peak construction and trapping occur in winter, there could be some localized decline in trapping activity for a few years. However, neither a major nor a long-term decline in trapping is inevitable because of the pipeline.

Most impacts resulting from pipeline construction would be short-term. Communities along or adjacent to the pipeline right-of-way would experience an upsurge in employment and business for three to four years during pipeline construction. Once construction was completed, activities would take place on a much reduced scale. Long-term employment and business development associated with operation and maintenance would be at a much lower level, although at a level which would still be significant in local terms.

Pipeline construction would result in a large increase in truck, tug-barge and air transportation activities in the Mackenzie Valley. Air transport would be used primarily for the movement of construction personnel. The volume of material that would have to be transported during construction would require a doubling of existing river tonnages. Even though there is much excess capacity in the river system currently, provision would likely have to be made for some expansion if the intermediate production rate is achieved. Care would have to be taken to ensure that vital supply services to communities were not interrupted.

The nature of the pipeline is such that several issues would require further definition and research. Questions related to sources of borrow materials to meet both pipeline construction and community needs, and locations of access roads and pump stations, would require further analysis. Futhermore, it would be useful to develop workable mechanisms which would provide for effective regional and local participation in employment and business, while ensuring that skills and services which were essential to meeting local needs were not unduly stressed.

# APPENDIX 1
# PROCESS - PROPONENTS

Oil and gas exploration in the Beaufort Sea-Mackenzie Delta region of Canada has been successfully undertaken during the past two decades at a cost of over two billion dollars. Confirmation has now occurred of substantial gas reserves onshore and of major oil potential offshore. In order to meet Canada's energy needs, the next phase of hydrocarbon development in the region is to provide oil and gas to southern markets.

The production phase of oil development is required by the Federal Government to undergo an environmental and socio-economic review process of which preparation of an Environmental Impact Statement (EIS) is an integral part. In July 1980, the Minister of the Department of Indian Affairs and Northern Development, the principal coordinating and planning body for the north, announced that the proposals for oil and gas development would be referred to the Federal Environmental Assessment Review Office (FEARO) of the Department of the Environment. The purpose of the review is to facilitate a formal public assessment of the possible environmental and socio-economic effects of the development throughout its planning and implementation phases.

Soon after this announcement, the three major companies active in the region, Dome Petroleum Limited, Esso Resources Canada Limited and Gulf Canada Resources Inc., jointly initiated the Environmental Impact Statement. This EIS is already being supported by several oil companies with interests in the area and more are expected to join during the course of the review process. Meanwhile, the Beaufort Sea Environmental Assessment Panel appointed by the Minister of the Environment was established, and guidelines for the preparation of an Environmental Impact Statement were drafted by the Panel. In February, 1982, after a series of public meetings on the draft guidelines with northern communities, the Panel issued the Guidelines in their final form.

In accordance with the terms of reference of the Beaufort Sea Environmental Assessment Panel, the EIS has been distributed to the public and government agencies for review. After an appropriate review period, established by the Panel, public meetings will be held. Based on the results of this review process, the Panel will prepare its report with recommendations for submission to the Minister of the Environment. Through this process, the EIS will play an important role in assisting the people of the regions and the various governments in determining the direction of future development activities in the north.

During the two years of preparation of the EIS, the proponents have continued many scientific research programs, special studies and most important of all, community consultation and liaison activities. Concurrently, this seven-volume statement was prepared, each volume responding to specific information needs, as suggested by its title:

- Volume 1 Summary
- Volume 2 Development Systems
- Volume 3A Beaufort Sea-Mackenzie Delta Setting
- Volume 3B Northwest Passage Setting
- Volume 3C Mackenzie Valley Setting
- Volume 4 Biological and Physical Effects
- Volume 5 Socio-Economic Effects
- Volume 6 Accidental Spills
- Volume 7 Research and Monitoring

Identifying possible effects is a vital part of impact assessment and development planning. The exercise began by examining development plans based on the industry's best estimates of technical requirements. The plans and the engineering aspects take into consideration environmental and social factors. This process is constantly evolving, and will continue throughout the implementation stage.

In accordance with the EIS Guidelines, the development plans and the possible associated effects to the year 2000 are presented. However, due to the high degree of uncertainty associated with long-term predictions, the EIS focuses more on short-term (5-year) development plans and less on long-term plans. It is anticipated that the long-term plan would be subject to change influenced by factors such as government policy, community impacts, environmental monitoring results and other considerations.

Three principal regions were considered in the EIS: the Beaufort Sea-Mackenzie Delta, where production development will take place, and the Northwest Passage and Mackenzie Valley, which are potential transportation corridors.

Another important component of the EIS is ongoing research and monitoring programs. Some existing programs will be carried on into the future and new programs will be introduced. Research and monitoring are deemed important to address concerns and issues which require further examination, such as the need for ice monitoring, the development and testing of oil spill countermeasures and the progressive development of new island construction technology. Because development in the region is incremental, environmental impacts can be effectively monitored and mitigated, if needed.

The proponents are the companies who have exploration permits covering areas of the Beaufort Sea floor and adjacent land, or both in the region. At this time, approximately 50 companies hold permits in the region. As indicated earlier, Dome. Esso and Gulf have undertaken to prepare this EIS, on behalf of all permit-holders in the region, although three other companies are participating on a financial basis at this time, and more are expected to join before the beginning of the hearing phase.

**Dome Petroleum Limited** has been active in the Beaufort Sea region since the early 1970's. Incorporated in 1950, this Calgary based company has been engaged in the exploration and development of crude oil and natural gas, primarily in Canada. The Company operates a large natural-gas-liquids extraction, transportation, processing and wholesale marketing system in Canada and the United States. In 1976, Dome pioneered the use of ice-reinforced drillships and more recently man-made deep water caisson islands in the Beaufort Sea. Dome's drilling operations in the Beaufort Sea are conducted by a wholly owned subsidiary, Canadian Marine Drilling Ltd. (Canmar).

**Esso Resources Canada Limited** is a wholly owned subsidiary of Imperial Oil Limited. Esso Resources, with its head office in Calgary, owns and manages Imperial Oil's natural resource operations and assets. Imperial Oil is active in all phases of the petroleum industry in Canada, including the exploration for and production of crude oil and natural gas. In Canada, it is the largest producer of crude oil, the largest refiner and marketer of petroleum products and a supplier of natural gas. Esso received the first permit to construct an artificial island in shallow water at Immerk in 1972. Prior to that, Esso had been drilling primarily onshore in the lower Mackenzie since the early 1960's. Today, Esso's activities still largely concentrate on land, and in the shallow water area of the Beaufort Sea.

**Gulf Canada Resources Inc.** and its affiliated companies have been active in all phases of the oil and gas industry for over 75 years. Combined, they are the third largest producer of oil in Canada. Gulf has extensive land holdings in all the frontier areas including the Beaufort Sea, Mackenzie Delta, Arctic Islands, Labrador Sea, and the Grand Banks. The company drilled the first well in the Mackenzie Delta in 1965 and later drilled many more onshore wells. Offshore, Gulf has participated in wells with Dome and Esso and is the operator of the Tarsiut N-44 drilling program. More recently, Gulf has designed and is building a second generation drilling system to drill in the Beaufort Sea.

**Westmin**, 84% owned by Brascan Limited, has producing oil and gas acreage in Western Canada and the U.S.; exclusive coal deposits in the Edmonton area and a base-precious metals mine near Campbell River, Vancouver Island. Mineral exploration encompasses most provinces and territories, while the search for oil and gas extends to the Beaufort Sea, offshore east coast, the U.S. and the Middle East. Westmin itself does not act as operator on any of its parcels in the Beaufort. The company has a 12% interest in 290,000 acres just southeast of the Koakoak and Kopanoar wells and lesser blocks to the west and north of the Tarsiut play. Westmin recently became a financial participant in the production of the Environmental Impact Statement.

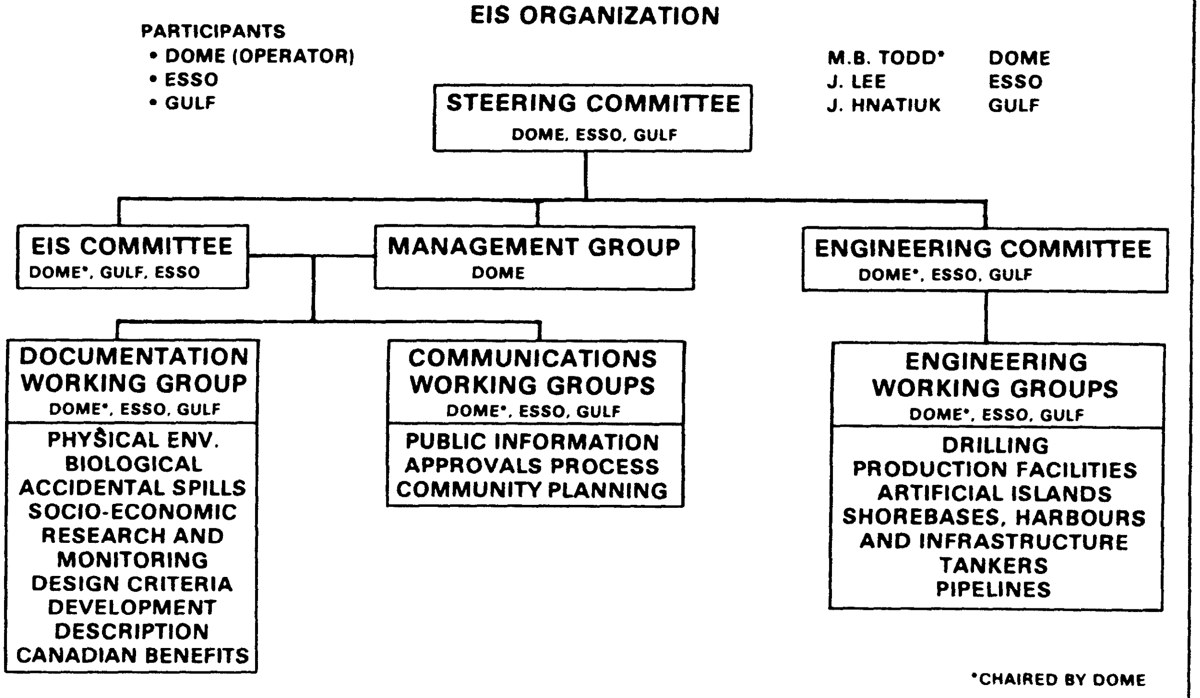
Another recent financial participant is **Bow Valley Industries Ltd.**, a Canadian-owned and controlled natural resource company engaged in the exploration for and development of oil, gas, coal and uranium worldwide. Bow Valley commenced activities in 1950 in the oil well drilling sector of Western Canada's petroleum industry and through a 78% owned drilling and manufacturing subsidiary. Bow Valley Resources Services Ltd. is today one of Canada's largest oil well drilling contractors. The company is also involved in the development and manufacture of subsea systems for the production of deep water offshore hydrocarbons. Although not directly drilling, Bow Valley is a 3% participant in the Esso farm-in the Beaufort Sea.

**Suncor Inc.** commenced operations in Canada in 1919 and has been involved in exploration and technical research activities throughout the frontiers since 1968. In addition to its conventional exploration, production, refining, petrochemical and marketing operations, Suncor is 100% owner of the first plant to produce synthetic crude oil from the Athabasca tarsands on a commercial scale. In the Beaufort Sea/Mackenzie Delta, Suncor has interests in approximately 755 thousand gross hectares, including one gas discovery and one oil and gas discovery made over the past decade. Two Beaufort Sea blocks containing 245 thousand gross hectares were optioned to Dome under an agreement requiring Dome to perform extensive seismic work on the properties in return for options to drill five wells. The seismic work has been completed and is now being interpreted. Several potentially drillable structures are indicated.

# APPPENDIX 2 INDUSTRY ORGANIZATION PRODUCING THE EIS

To produce the Environmental Impact Statement, the three companies established an organization which brought together various types of expertise ranging from senior managers to oversee the total effort, to working level scientists, engineers and oth-

FIG. 1-1
EIS ORGANIZATION




ers to supervise consultants and company staff in the preparation of the necessary documents.

The overall organization is illustrated in Figure 1-1. The project was "operated" or managed by a Management Group within Dome under the general direction of a Steering Committee, comprising senior representatives from the three companies. In addition, there was an Engineering Committee, which managed the inputs related to engineering considerations of the developments described, and an EIS Committee, which was responsible for producing the EIS documents.

Beneath this level, there were numerous Working Groups, consisting of engineers, scientists, socio-economists and others, drawn from the three companies, to provide technical input to the EIS and to manage tasks assigned to various external consultants.

The companies also established several Communications Working Groups to assist with public information programs and planning for future approvals requirements. The Public Information Working Group retained the services of Community Liaison Officers in each of the three principal regions covered by the EIS, and were instrumental in the production of the Beaufort Magazine, several short films, and other information items.

# APPENDIX 3 ENVIRONMENTAL IMPACT DEFINITIONS

The basic procedures used to determine possible environmental impacts are described in Volume 4. The definitions used to assist in assessing the degree of possible biological impact throughout the Environmental Impact Statement (excluding terrestrial vegetation sections) were modified from definitions used by industry in the Davis Strait EIS and are shown in Table 1-1. These definitions were modified to focus the biological assessment on regional populations of specific resources, rather than on local groups of individuals, and to remove any references to resource use since these impacts are discussed in the socio-economic impact assessment.

Possible physical impacts of various development components, as well as biological impacts on terrestrial vegetation were assessed according to a separate series of criteria shown in Table 1-2.

Like all such definitions, the ones used in this EIS must have the built-in flexibility to allow their use for a wide range of biophysical resources, as well as sources and durations of potential impact. As a

**TABLE 1-1**

**DEFINITIONS USED FOR DETERMINING THE DEGREE OF IMPACT ON BIOLOGICAL RESOURCES (EXCLUDING TERRESTRIAL VEGETATION) IN EACH DEVELOPMENT REGION**

A **MAJOR IMPACT** exists when a regional population or species may be affected to a sufficient degree to cause a decline in abundance and/or a change in distribution beyond which natural recruitment (reproduction and immigration from unaffected areas) would not likely return that regional population or species, or any population or species dependent upon it, to its former level within several generations.

A **MODERATE IMPACT** exists when a portion of a regional population may be affected to a sufficient degree to result in a change in abundance and/or distribution over more than one generation of that portion of the population or any population dependent upon it, but is unlikely to affect the integrity of any regional population as a whole.

A **MINOR IMPACT** exists when a specific group of individuals of a population at a localized area and over a short time period (one generation) may be affected, but other trophic levels are not likely to be affected in a manner which is considered regionally significant, or the integrity of the population itself is not significantly affected.

A **NEGLIGIBLE IMPACT** exists when the degree of the anticipated biological effects are less than minor.

**TABLE 1-2**

**DEFINITIONS USED FOR DETERMINING DEGREE OF IMPACT ON PHYSICAL RESOURCES AND VEGETATION IN EACH DEVELOPMENT REGION**

A **LOCAL IMPACT** exists when any physical or chemical changes (or alterations in vegetation patterns) are only expected to be detectable within 1 km of proposed facilities and/or linear transportation corridors.

A **REGIONAL IMPACT** exists when physical or chemical changes (or alterations in vegetation patterns) are expected to be detectable beyond 1 km of proposed facilities and/or linear transportation corridors.

A **SHORT-TERM IMPACT** is likely to persist less than 5 years from the onset of the disturbance.

A **MEDIUM-TERM IMPACT** is likely to persist from 5 to 10 years from the onset of the disturbance.

A **LONG-TERM IMPACT** is likely to persist more than 10 years from the onset of the disturbance.

result, the definitions are primarily a set of guidelines rather than a fixed and inflexible mechanism to determine degree of impact. For the purposes of establishing a clear and consistent basis for the impact assessment, it was also important to differentiate between possible local and regional effects. In view of the large geographic area considered, this EIS primarily addresses regional impacts. Possible impacts were consistently evaluated on a regional basis to place the development concept in a broader perspective. It is emphasized, however, that regional assessments still necessitated examination of the possible effects of individual development components or activities on the local environment prior to assessing their regional significance.