BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

Draft Report for 1993/1994

ANNOTATED GUIDE TO THE FINAL REPORTS FOR BEMP, MEMP AND BREAM

Prepared for:

Indian and Northern Affairs Canada
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EXECUTIVE SUMMARY

The Beaufort Region Environmental Assessment and Monitoring Program (BREAM) was initiated in 1991 by Indian and Northern Affairs Canada, Environment Canada and the Department of Fisheries and Oceans to assist in the planning component of the Northern Oil and Gas Action Program (NOGAP). BREAM combined and built on the efforts of two earlier projects—the Beaufort Environmental Monitoring Program (BEMP; 1983-1987) and the Mackenzie Environmental Monitoring Program (MEMP; 1985-1987). Like its predecessors, BREAM was a process that ensured that environmental research and monitoring was fully integrated with industry's plans for hydrocarbon exploration and development in the region, and helped to identify areas where further information gained through research and monitoring was needed to assess the impacts of such development.

As 1993/94 was the last year of funding for BREAM under NOGAP and in the absence of any near-term oil and gas development proposals for the Beaufort Sea and Mackenzie Delta and Valley, this year of BREAM marked the fourth and final phase of the program and the end of the BEMP/MEMP/BREAM series. Over the last decade, considerable effort by government, industry and northerners has been directed at designing and implementing an environmental research and monitoring program for the region. In recognition of the importance of this work in the assessment of future oil and gas initiatives for the Beaufort/Mackenzie region and in maximizing the usefulness of the BEMP/MEMP/BREAM project and its products, this report provides an historical account of the work accomplished under each of these programs, focussing on their iterative and adaptive nature.

This document serves as a guide to the annual reports prepared for BEMP, MEMP and BREAM. It includes six sections that follow the evolution of the process in relation to the environmental issues and concerns inherited by each of the programs, Changes made to the development scenarios over the past 10 years, and the Identification of research and monitoring needs associated with future hydrocarbon development in the Beaufort/Mackenzie region.

1. History of the BEMP/MEMP/BREAM Process

Over the past decade (1983-1993), a number of significant events occurred that ultimately influenced the direction of the BEMP/MEMP/BREAM process. This section of the report describes the history of the process, and the factors and policy decisions that drove and shaped its direction. It also discusses the fundamental concepts embodied in the process, and how information gained through BEMP, MEMP and BREAM has been, is being and can be used in new initiatives for the region.

2. Development Scenarios

Based on the best current understanding of industry's short-and long-term plans for hydrocarbon development and transportation in the Beaufort Sea/Mackenzie Delta and Valley region, development scenarios were prepared for BEMP, MEMP and BREAM. These scenarios described the likely nature and scope of future development activities in the region and, thus, helped in identifying those specific activities that were expected to cause some impact on the biophysical environment. The development scenarios prepared for BEMP and MEMP focussed solely on those activities associated with routine aspects of exploration, production and transportation of oil and gas, and explicitly excluded environmental emergencies. However, a number of oil spill scenarios were subsequently developed for BREAM to provide the framework for evaluation research and monitoring related to what was referred to for this project as “catastrophic” oil spills (i.e., very large zone of potential impact).

Over the past 10 years of the project, the development scenarios evolved as industry responded to changing market conditions, energy policies and socio-economic and environmental factors. This section of the report highlights the significant changes that were made to these scenarios since 1983 and provides a summary of the scenarios developed to help address the issues of catastrophic/major spill events.

3. Routine Aspects of Development

This section provides a review of the suite of issues related to routine aspects of hydrocarbon development that were evaluated through BEMP, MEMP and BREAM, and describes how each of these concerns have been alleviated and focussed by these programs. In addition, it also identifies any new issues that the programs inherited, and identifies whether these have been addressed through research and monitoring or have yet to be resolved.

4. Catastrophic Oil Spills

While an important area of potential concern related to any hydrocarbon development, catastrophic oil spills were not considered in BEMP and MEMP because of their infrequent and unpredictable occurrence and the associated difficulty in assigning research and monitoring priorities to such low-risk events. However, in light of a number of events (e.g., *Exxon* Valdez oil spill, EIRB reviews of the Isserk and Kulluk drilling proposals, establishment of the Beaufort Sea Steering Committee), BREAM was compelled to deal with major oil spills, not only in terms of setting research and monitoring priorities but also from an environmental assessment perspective.

During the 1992/93 BREAM program, nine oil spill hypotheses were evaluated at the interdisciplinary workshop held that year. These hypotheses considered the potential impacts of four hypothetical events:

- an offshore island platform blowout of crude oil in summer on marine mammals, birds, fish and semi-aquatic mammals and the harvest of these resources;
- a river barge spill of diesel fuel near Swimming Point on Richards Island during summer on fish and birds and their harvest;
- an under ice spill of crude oil at a pipeline river crossing near Norman Wells during spring on birds and their harvest; and
- a pipeline spill of crude oil just upriver of Fort Simpson during summer on terrestrial and semi-aquatic mammals and their harvest.

This section of the report summarizes how the issues addressed in each of the nine hypotheses were assessed, and the research and monitoring programs recommended to help resolve information gaps related to these concerns.

5. Community-Based Concerns

Participation by community representatives provided opportunities to incorporate community concerns into the identification of issues and the development of impact hypotheses, as well as to utilize community-based information in the evaluation of hypothesis linkages. Groups that participated in BEMP, MEMP and/or BREAM included the Inuvialuit Game Council, the Great Bear Development Impact Zone (Oil) Society, the Dene Nation, the Sahtu, the Mackenzie Delta Regional Council, the Gwich'in, the Porcupine Caribou Management Board, the Fisheries Joint Management Commission, the Fort Liard Band, and the Deh Cho.

This section of the report discusses participation of northerners in the BEMP, MEMP and BREAM programs, as well as how traditional knowledge of the physical environment and ecology of the region was incorporated into the process.

6. Research and Monitoring Recommendations

The fundamental role of BEMP, MEMP and BREAM was to identify the most important research and monitoring priorities related to future hydrocarbon development in the region. Through evaluation of the numerous BEMP, MEMP and BREAM impact hypotheses, several information deficiencies were identified and research and monitoring programs recommended to address these gaps. With time, many of these issues were resolved through research and monitoring activities and new issues arose as a result of changes in the development scenarios. This section of this report summarizes the recommendations made during each year of BEMP, MEMP and BREAM and reviews their status.

SOMMAIRE

1.0 INTRODUCTION

The Beaufort Region Environmental Assessment and Monitoring Program (BREAM) was initiated in 1991 by Indian and Northern Affairs Canada, Environment Canada and the Department of Fisheries and Oceans to assist in the planning component of the Northern Oil and Gas Action Program (NOGAP). Its objectives have been to establish research and monitoring priorities related to future oil and gas development and transportation in the Beaufort Sea, Mackenzie Delta and Mackenzie Valley, and to assist in the assessment of the potential impacts of these future developments on the environment, its resources and resource use by notheners. BREAM combined and built on the efforts of two earlier projects -the Beaufort Environmental Monitoring Program (BEMP; 1983-1987) and the Mackenzie Environmental Monitoring Program (MEMP; 1985"1987). Like its predecessors, BREAM was a process that ensures that environmental research and monitoring is fully integrated with industry's plans for hydrocarbon exploration and development in the region, and helped to identify areas where further information gained through research and monitoring is needed to assess the impacts of such development.

As 1993/94 was the last year of funding for BREAM under NOGAP and in the absence of any northern oil and gas development proposals for the Beaufort Sea and Mackenzie Delta and Valley, this phase of BREAM marked the fourth and final year of the program and the end of the BEMP/MEMP/BREAM series. Over the last decade, considerable effort by government, industry and northerners has been directed at designing and implementing an environmental research and monitoring program for the region (see Appendix A). In recognition of the importance of this work in the assessment of future oil and gas initiatives for the Beaufort/Mackenzie region and in maximizing the usefulness of the BEMP/MEMP/BREAM project and its products, it was considered important that the final report of the BREAM program provide an historical account of the work accomplished under each of these programs, focussing on their iterative and adaptive nature. While the annual reports of BEMP, MEMP and BREAM summarize the findings of each year of work, it is important to recognize that these programs were not simply a repetitive process followed year after year independently of one another but were responsive to the dynamic nature of information needs for decision-making.

This document serves as a guide to the annual reports prepared for BEMP, MEMP and BREAM from 1983 to 1993, and follows the evolution of each of the programs in relation to the environmental issues and concerns inherited by the programs and changes to the development scenarios over the past 10 years. Section 2 of the report describes the history of the BEMP/MEMP/BREAM process and the factors and policy decisions that drove the process and shaped its direction. This chapter also discusses the fundamental concepts embodied in the process, and how information gained through BEMP, MEMP and BREAM has been, is being and can be used in new initiatives. Section 3 examines changes that were made to the hydrocarbon development scenarios since 1983, while Sections 4, 5 and 6 highlight those environmental issues and concerns (both scientific and community-based) that have been alleviated and focussed by each program, those addressed through recommended research and monitoring programs, and those that have not yet been resolved. Section 7 of the report reviews the research and monitoring recommendations made during each of the project workshops of BEMP, MEMP and BREAM.

2.0 HISTORY OF THE BEMP/MEMP/BREAM PROCESS

The start of the Beaufort Environmental Monitoring Program (BEMP) in 1983 reflected a growing interest in hydrocarbon development in the Canadian Beaufort Sea, and the increasing public and scientific concern with respect to the potential environmental Impacts of such development. This chapter reviews the history of oil and gas development in the Beaufort Sea, Mackenzie Delta and Mackenzie Valley regions, as well as the events, factors and policy decisions that initiated the development and influenced the direction of BEMP, MEMP and BREAM, Reference materials for this review Include Berger (1977), the Mackenzie River Basin Committee (1981), Dome Petroleum Limited (1982), Dome Petroleum et al. (1982), Esso Resources Canada Limited (1982), FEARO (1984), INAC and Environment Canada (1984, 1985, 1986, 1987), INAC et al. (1986, 1993), INAC (1988, 1991, 1992), Owens Environmental Services (1989), Beaufort Sea Steering Committee (1991), INAC et al. (1993), and Interprovincial Pipe Line Ltd. (n.d.).

2.1 HYDROCARBON EXPLORATION AND PRODUCTION IN THE MACKENZIE VALLEY AND BEAUFORT SEA

Oil and gas development in the Mackenzie Valley began with the discovery of oil at Norman Wells by Imperial Oil limited in 1919 and the subsequent construction of a topping plant in 1921. Hydrocarbon development continued to be focused on Norman Wells until the 1950s when the first geophysical surveys were undertaken in the Mackenzie Delta.

In 1961, Gulf Canada completed the first exploratory drilling in the Mackenzie Delta. This was followed by on-land drilling for oil and gas at the Reindeer site on Richards Island by a consortium comprising British American (BA), Shell and Imperial Oil. With the discovery of oil and gas at Prudhoe Bay in 1968, exploration activity intensified throughout the Western Arctic, particularly in the Mackenzie Delta and Canadian Beaufort Sea. In 1970, Imperial Oil reported the first discovery of oil in the Mackenzie Delta at Atkinson Point.

During this same period, increasing world oil prices and demands for oil resulted in a boom in the oil industry in Alberta, which also helped to stimulate exploration and oil development in the Canadian Beaufort Sea and the Mackenzie Valley regions. Drilling the early 1970s, Imperial Oil Limited (which later was renamed Esso Resources

Canada Limited) established operating bases at Tuktoyaktuk and Richards Island to support onshore and offshore activities. Similar bases were eventually established by Dome Petroleum and Gulf Canada Resources at Tuktoyaktuk.

In the early 1970s, exploration activity moved from primarily onshore sites to a number of sites in shallow coastal waters. Imperial Oil Limited constructed the first offshore man-made drilling island in 1972. In 1973, Imperial Oil and Sun Oil (which later was renamed to Suncor) constructed additional offshore drilling islands (the Adgo and Immerk sites). Oil was subsequently discovered at the Adgo site in the same year. In 1976, Dome Petroleum, through its subsidiary Canadian Marine Drilling Ltd. (Canmar), brought a fleet of three ice reinforced drillships and icebreakers to the Beaufort Sea to support its oil and gas exploration program. The fleet permitted Dome Petroleum to explore for oil and gas formations in deeper water along the edge of the shear ice zone. Several oil and gas discoveries were reported by the major exploration companies throughout the late 1970s (e.g., Netserk, Garry, Isungnak. Isserk). In 1979, Dome Petroleum sent a fourth drillship to the Canadian Beaufort Sea. Construction also began on a harbor in McKinley Bay to support the fleet.

During the same period, two competing proposals emerged for the transport of natural gas from northern Canada and Alaska to southern markets in Canada and the United States. This may have been stimulated by the commencement of operation of the Alyeska Pipeline, as well as by ongoing discoveries of natural gas in the Mackenzie Delta and Beaufort Sea. The Arctic Gas Pipeline called for the construction of a pipeline along the Mackenzie Valley, as well as the construction of a lateral pipeline from Prudhoe Bay across the North Slope to the Mackenzie Delta. Foothills Pipelines also proposed the construction of a gas pipeline along the Mackenzie Valley. Both of these pipeline options were to have eventually been linked to pipeline systems in northern Alberta and British Columbia. In response to these proposals, the Mackenzie Valley Pipeline Inquiry (commonly referred to as the Berger Inquiry) began preliminary hearings across the western Northwest Territories and the Yukon Territory in 1974. Formal hearings began in March 1975 and concluded in November 1976. In April 1977, the Inquiry issued its recommendations to the Minister of Indian and Northern Affairs that the proposed pipeline across the North Slope not be approved, and that the construction of the Mackenzie Valley pipeline be delayed 10 years.

Settlement of native land claims also had a major influence on hydrocarbon development in the Beaufort Region during the 1970s. Through the actions of the Committee on Original Peoples Entitlement (COPE), the Inuvialuit Lands Rights Settlement Agreement in Principle was signed in 1978. This agreement led to completion of the Western Arctic Claim Settlement and the Report of the Task Force on Northern Conservation in 1984. These agreements culminated in the signing of the Inuvialuit Final Agreement (IFA) in 1988. The Final Agreement set aside a 906,430 square kilometre area, referred to as the Inuvialuit Settlement Region (ISR), which would be managed and regulated by the IFA. Within the ISR, the Inuvialuit were given title to 35,000 square kilometres of land. The final agreement also required the formation of a range of regulatory and advisory agencies such as the Wildlife Management Advisory Committee (WMAC), the Fisheries Joint Management Commission (FJMC), Hunters and Trappers Committees (HTCs), the Environmental Impact Screening Committee (EISC), and the Environmental Impact Review Board (EIRB).

Based on plans by Esso Resources Canada to increase oil production in the Norman Wells field, a detailed impact assessment was completed in 1979 for a proposed small-diameter buried pipeline from Norman Wells to Zama Lakes in northwestern Alberta. An application to construct the pipeline was submitted to the National Energy Board (NEB) in 1980. In 1981, Interprovincial Pipe Line (NWT) ltd. was granted approval by the NEB to construct and operate the pipeline. Construction of the pipeline commenced in 1983, with completion by 1985. A number of engineering, environmental and socio-economic studies were completed in conjunction with the design and construction of the system.

By the early 1980s, a number of drilling islands had been constructed in deep water areas within the Beaufort Sea, including the first concrete caisson island at Tarsiut. By 1982, 22 artificial islands had been constructed to support 23 exploratory wells. In addition, 15 deep offshore wells had been completed by drill ships, with four oil discoveries.

In the same year, the Beaufort Sea-Mackenzie Delta Environmental Impact Statement (EIS) was submitted by Dome Petroleum, Esso Resources and Gulf Canada Resources to the Federal Environmental Assessment and Review Office (FEARO). The EIS described the need for hydrocarbon development due to predicted Shortages, the probable development scenarios, transportation options for oil production in the Beaufort Sea, the biophysical and social environments, and the potential impacts of development on the environment, its resources and people. The report of the Environmental Assessment Panel for the Beaufort Sea Hydrocarbon Production and Transportation Proposal was subsequently released in July 1984. The report recommended that a number of social and economic measures be implemented to minimize adverse social effects and maximize benefits to northern people, and that growth of hydrocarbon development and transportation infrastructure be phased to allow intensive research and monitoring, and technology improvements.

Oil and gas exploration continued throughout the remainder of the 1980s. In 1983, Gulf Canada Limited began use of the Kulluk drilling platform in the Beaufort Sea, which allowed them to operate an offshore drilling platform earlier and later in the year than conventional ice-reinforced drill ships. Other exploration drilling continued in offshore and onshore areas throughout the 1980s with a number of additional oil and gas discoveries being reported. Perhaps the most significant of these was the discovery of the Amauligak oil field by Gulf. Concurrent with these discoveries, a cooperative funding program by the federal government and industry, referred to as the Northern Oil and Gas Action Program (NOGAP) was initiated in February 1984 to fund important research for oil and gas technology and the environment.

Despite these discoveries, it became apparent in the mid to late 1980s that the high expectations of the region had not been met. Unlike the Alaskan North Slope, where a small number of large prolific fields exist, the Mackenzie Delta/Beaufort region is characterized by a large number of smaller, widely-scattered reserves due to the highly structured and fractured sedimentary strata. As a result, production from these fields would be more difficult and expensive, requiring more extensive gathering systems than those used in Alaska. Coincidental with these conclusions, world oil prices and oil demand began to decline rapidly in the mid 1980s, thereby affecting the impetus, as well as the available financing to undertake hydrocarbon exploration and drilling in the western Canadian Arctic. Government restraint also resulted in the downscaling, freezing or termination of certain research initiatives. NOGAP funds were frozen during the 1988/89 and 1989/90 fiscal years. By the late 1980s, a number of petroleum companies were undergoing financial difficulties and restructuring. Perhaps the most significant change relevant to the Beaufort region was the dissolution of Dome Petroleum and the purchase of its assets by Amoco Canada.

The negative consequences of declining demand for oil was partially offset by increased needs for natural gas. In August 1989, the National Energy Board granted licenses to Esso Resources Canada, Shell Canada and Gulf Canada Resources to export approximately 9.2 trillion cubic feet of natural gas from the Mackenzie Delta region. In response to the renewed interest in exporting of natural gas from the Mackenzie Delta-Beaufort region and the construction of a pipeline along the Mackenzie Valley to transport natural gas to southern markets, Phase II of NOGAP was approved in January 1990. This phase of the program made available $10 million to fund essential research on technology and the environment related to northern oil and gas development.

In March 1989, the Exxon Valdez ran aground in Prince William Sound, resulting in the release of an estimated 11.2 million gallons of crude oil. The spill was the largest in the history of the United States. World-wide publicity on the impacts of the 011 spill on the ecosystem, and the criminal conviction of Exxon had repercussions on hydrocarbon exploration, development and transportation throughout North America, particularly in the Beaufort Sea region. Concerns about the environmental effects of hydrocarbon development in the Beaufort Sea were further increased as a result of a shallow gas blowout at Immerk during 1989.

In 1990, Esso Resources Canada applied to the Canadian Oil and Gas Administration (COG LA) and the EIRB for the Isserk drilling program. Shortly after the Esso application, Gulf Canada Resources applied for the 1991-1993 Kulluk drilling program. Amoco Canada also began preparation of an application for additional drilling adjacent to the Amauligak field. Following the completion of the hearing for the Kulluk drilling program, however, Amoco decided to not apply for drilling approval. Esso was subsequently granted approval for drilling on the condition that Esso provide a financial guarantee to cleanup any oil spills and provide compensation. Gulf was refused approval until financial guarantees could be provided and issues could be resolved relating to worst-case scenarios, operating seasons, oil spill contingency plans, Inuvialuit involvement, compensation, habitat restoration, and impact assessment methodologies. The Beaufort Sea Steering Committee was formed shortly after the Esso and Gulf hearings to address these issues.

During the early 1990s, exploration in the Mackenzie Valley and the Delta-Beaufort regions was restricted to Norman Wells, Colville Lake and the Mackenzie Delta/Beaufort Sea. With the exception of ongoing oil production from the Norman Wells area, most of this work was completed largely to address contractual commitments. While the exploration phase was expected to continue through the 1990s, there was some interest by petroleum companies to develop oil and gas reserves in the Mackenzie Delta-Beaufort region over the long term. The 1989 decision by the NEB to permit export of natural gas from the Mackenzie Delta was an important step needed to proceed with a request to construct a natural gas pipeline along the Mackenzie Valley. In 1991, a Statement of Principles was signed by the three major producers (Esso, Gulf and Shell) and the three main pipeline companies (Foothills, Interprovincial Pipe Lines and Polar Gas) to attempt to establish a joint venture for a Mackenzie Valley pipeline. The development of a gas pipeline would obviously provide a major stimulus to future exploration and delineation drilling in the Mackenzie and Beaufort regions.

Although large reserves of natural gas had been discovered in the Mackenzie Delta, production of these fields was not viewed as being economic at this time, given the extent of surplus gas supplies in Alberta, British Columbia and Saskatchewan. Low world oil prices, in combination with insufficient, proven oil reserves in the Beaufort Sea -Mackenzie Delta region are presently a limiting factor in the production of oil from the region. By the 1993/1994 fiscal year, NOGAP funding ended, presumably reflecting the low interest of the petroleum industry and associated government programs in the development of hydrocarbon resources from the Mackenzie Valley-Beaufort Sea region.

2.2 THE GENESIS AND EVOLUTION OF THE BEAUFORT ENVIRONMENTAL MONITORING PROGRAM (BEMP)

During the 1970s, particularly the mid to late 1970s, the extent and scope of environmental research in the Canadian Beaufort Sea and the Mackenzie Delta increased sharply. This trend continued throughout the early 1980s, in part driven by the completion of the Beaufort Sea-Mackenzie Delta Environmental Impact Statement.

Following the submission of the Beaufort-Mackenzie Delta EIS, there was a growing realization in government and industry that although valuable research had been completed prior and leading up to the EIS, there needed to be a process for focusing research funding on those environmental issues, components or processes that were most likely to be significantly affected by the cumulative effects of oil and gas development in the Beaufort Sea and Mackenzie Delta, for which:

- existing baseline information was inadequate or lacking; and/or
- responses to specific impact mechanisms were unknown or poorly understood.

As noted in the Introduction to the first BEMP report in 1984 (INAC and Environment Canada 1984), there was considerable concern that hydrocarbon development activities in the Beaufort Sea would result in important, adverse environmental impacts, These concerns were compounded by the limited amount of experience of the petroleum industry in the offshore Arctic, and the lack of experience of the industry in the use of some of the innovative technologies proposed for the region (INAC and Environment Canada 1984).

During this period, Indian and Northern Affairs Canada and Environment Canada were the primary government agencies charged with the mandate to protect and manage the environment in the Northwest Territories and Yukon. As part of this mandate, Indian and Northern Affairs Canada and Environment Canada initiated BEMP to better integrate environmental research and monitoring with the expected exploration and development scenario for the oil and gas industry.

The long-term objective of BEMP was to provide government and industry with "the technical basis for design, operation and evaluation of a comprehensive and defensible environmental research and monitoring program to accompany hydrocarbon development activities in the Beaufort Sea Region" (INAC and Environment Canada 1984). To meet this objective, participants in the initial meetings for BEMP concluded that the program must:

1. determine the most significant environmental resources and features likely to be affected by development;
2. formulate and test impact hypotheses and predictions;
3. recommend mitigative measure and provide ongoing evaluation of their success; and
4. adapt to new information, identified data gaps and changes in the most likely scenario for hydrocarbon development (INAC and Environment Canada 1984).

2.2.1 BEMP 1983/84

The assessment process utilized in BEMP was the result of a series of workshops and technical meetings held in 1983. Because this approach was subsequently utilized throughout the remainder of the BEMP, MEMP and BREAM programs, it is important to discuss some of the events and decisions that occurred at this time. The tasks and activities of each of the initial meetings and workshops are summarized in Table 2-1 (adapted from Table 1-1, INAC and Environment Canada 1984). The study area for BEMP is shown in Figure 2-1.

During the first BEMP workshop (16 to 20 May 1983), C.S. Holling's (1978) approach to Adaptive Environmental Assessment and Management was utilized to facilitate the identification of important research and monitoring needs. This approach involved six major tasks:

1. identification of Valued Ecosystem Components (VECs);
2. identification of development activities;
3. identification of the spatial extent and resolution of the model;
4. identification of temporal scales and resolutions for the model;
5. identification of impact hypotheses to relate development activities to specific VECs; and
6. preliminary screening of impact hypotheses for validity, relevance and credibility.

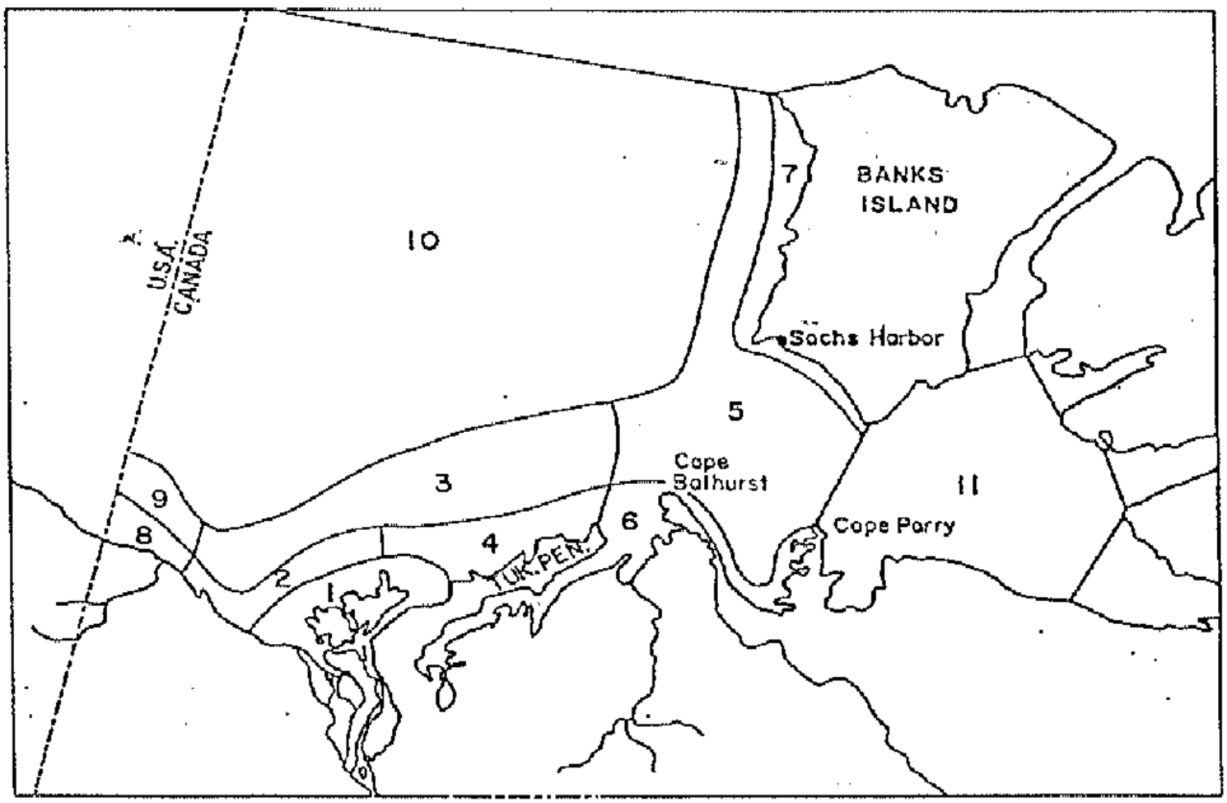
Valued Ecosystem Components

The identification of VECs was a critical step in the development of the BEMP process because it focussed the discussion of impact hypotheses and research/monitoring needs to those resources and biophysical processes of greatest concern relative to hydrocarbon development in the region; and it defined the quantities for which the simulation models would provide predictions over time (INAC and Environment Canada 1984). Prior to the first BEMP workshop, a preliminary list of potential VECs was prepared based on information in the Beaufort

Table 2-1
Activities during the Initial Year of BEMP (1983/84)
(taken from INAC and Environment Canada 1984)

TASK	MODELLING	MEETINGS	REPORTING/ DOCUMENTATION
Identification of VECs	Model building task	- scoping - workshop 1	- report documenting the VECs prepared for presentation at workshop 1
Identification of Development Activities	Model building task	- scoping - workshop 1 - ongoing	- reports on each new development scenario are prepared as scenario is revised
Identification of Spatial Extent and Resolution	Model building task	- scoping - workshop 1 - technical meetings	- workshop 1 report model description
Identification of Temporal Horizon and Resolution	Model building task	- scoping - workshops 1 - technical meetings	- workshop 1 report model description
Identification of Impact Hypotheses	Model structure is composed of linked impact hypotheses	- workshops - technical meetings	- preliminary flow-charts and statements if impact hypotheses were prepared prior to workshop 2, based on the model building programming and analysis and discussions in technical meetings
Screening of Impact Hypotheses	Quantification of the links eliminates unrealistic or ill-specified hypotheses	- technical meetings	
Evaluation of Impact Hypotheses		- workshop 2	- final report
Definition of Research/Monitoring		- workshop 2	- final report

Figure 2-1
The BEMP Study Area
(taken from INAC and Environment Canada 1984)



Sea-Mackenzie Delta EIS and submissions to the Beaufort Sea Assessment Panel. During the workshop, there was lively and heated debate on the definition of a VEC and the identification of VECs, and this list was modified. During subsequent technical meetings, the list underwent further revisions and was eventually finalized to include the following:

RESOURCE TYPE	VALUED ECOSYSTEM COMPONENTS
Marine Mammals	population, harvest and available habitat for white whale, bowhead whale, ringed seal, bearded seal, polar bear
Birds	population, harvest and available habitat for common eider, king eider, diving ducks (oldsquaw, scoters, scaups), thick-billed murre
Fish	population, harvest and available habitat for lake whitefish, broad cisco, least cisco, arctic cisco, arctic char
Physical Environment	air quality

A number of potential VECs were proposed during technical meetings or by various participants during the first BEMP workshop, but were not included in the final list of VECs. Among these were:

- **thick-billed murre:** the colony at Cape Parry was identified as a VEC but was not considered further as possible impacts on this colony were viewed as highly site-specific;
- **snow goose:** this species was excluded as a VEC since its use of the marine environment is extremely limited;
- **red-throated loon:** there was a lack of agreement by workshop participants on inclusion of this species as a VEC; and
- **the coastal zone, the Bathurst polynya and landfast ice:** these types of areas, like water and sediment quality, were considered to constitute part of

the habitat of existing VECs addressed by BEMP, and are not in themselves VECs (INAC and Environment Canada 1985).

Over the next four years of BEMP, the list of VECs did not change significantly even though the impact hypotheses were modified or new impact hypotheses were developed to reflect changes in the probable development scenarios (see Section 2.2.2). The robust nature of the list of VECs during the overall BEMP program is indicative of how successful the initial selection process was in identifying the important resources and environmental features of the region in relation to future hydrocarbon development.

Development Activities

The identification of the nature, extent and duration of potential development activities in the region was a necessary step towards beginning to define the causal chain or impact hypothesis linking specific development activities to a particular VEC or group of VECs. During the first BEMP workshop, four major types of activities were considered:

1. exploration activities and drilling associated with discovery and delineation of oil reservoirs;

2. construction of islands and oil production facilities and the drilling of production wells;

3. subsea pipelines and onshore gathering systems; and

4. transportation of produced hydrocarbons within the Beaufort Region by tankers.

The evolution of the development scenarios formulated for BEMP, MEMP and BREAM is discussed later in Section 3 of this report.

Identification and Screening of Impact Hypotheses

Simulation models were used as a tool during the initial workshop to force workshop participants to think in interdisciplinary, quantitative, and dynamic terms about the interactions between hydrocarbon development and the biophysical environment (INAC and Environment Canada 1984). The simulation models involved the development of complex mathematical models to describe a very large number of specific linkages between development activities and the biophysical environment. Due to the lack of quantitative data to define all possible relationships, and the sheer number of relationships considered in the simulation models, it was concluded during the initial workshop that: (1) a smaller number of impact hypotheses should be addressed during the second BEMP workshop; and (2) that the hypotheses should address conceptual, intuitive linkages, rather than predictive, mathematical relationships. The simulation model approach was, therefore, abandoned.

During the summer and fall of 1983, a number of technical meetings were held to refine the number and scope of the impact hypotheses. A total of 21 impact hypotheses were identified for assessment during the second BEMP workshop, which was held during 28 November to 2 December 1983. An additional impact hypothesis was added at the beginning of the workshop. Of these 22 impact hypotheses, 19 were fully evaluated. The remaining three impact hypotheses addressed potential social impacts of hydrocarbon development, specifically:

1. the effects of wage employment on the amount, distribution and effectiveness of subsistence harvesting,

2. the effects of development-associated increases in human populations on bird hunting (i.e., level of effort), and

3. the effects of development-associated increases in human populations on anadromous fish populations (i.e., level of effort).

Because these three hypotheses and some of their component linkages involved societal factors and impacts which were considered by the funding agencies to be outside the scope of the BEMP program, these hypotheses were not evaluated further during the BEMP program.

While most of the environmental concerns identified in the Beaufort Sea-Mackenzie Delta EIS, its support documents and submissions of intervenors during the public review were included as a linkage in one or more of these 19 impact hypotheses, some potential concerns were not specifically addressed through BEMP. These included:

1. resources or environmental processes that were not within the geographic scope of BEMP (e.g., terrestrial impacts, polar bear and arctic fox attraction to waste disposal sites; disturbance of birds that nest, stage or moult in

coastal habitats adjacent to the Beaufort Sea but generally not found in marine areas);

2. environmental processes or components that are not directly addressed by the range of VECs (e.g., the effects of ice-breaking and offshore structures on the landfast ice regime and food web interrelationships was not considered directly, but was considered through the white whales hypotheses); and

3. issues that, on the basis of scientific evidence, were perceived rather than real (e.g., effects of offshore production waste disposal, effects of underwater noise on fish).

2.2.2 BEMP 1984/85 to 1987/88

The BEMP program continued each year from 1983/84 through *1987/88.* During each year of BEMP, a review of relevant research that had been initiated during the past year was completed, and project overviews describing the purpose of these investigations and their relationship to the existing BEMP hypotheses were prepared (Table 2-2). New information from ongoing research of relevance to the BEMP hypotheses was also identified. The information overviews were subsequently used in most years to re-evaluate and update specific impact hypotheses.

During the 1984/85 BEMP program, a workshop was held to re-evaluate each of the 19 impact hypotheses and to identify additional research and monitoring needs. A detailed evaluation of all BEMP hypotheses was considered necessary due to changes made to the development scenario to reflect (1) the possible use oil-based drilling muds during exploration and production, and (2) the possible construction of near shore structures such as jetties and causeways in shallow water areas (i.e., 2-3 m in depth or less). A new hypothesis (Hypothesis 20) was subsequently formulated to deal with the effects of oil-contaminated cuttings on anadromous fish (INAC and Environment Canada 1985). As a result of renewed interest in a Mackenzie Valley pipeline during 1984 to 1985, potential impacts associated with the construction and operation of sub-sea and above-ground pipeline systems to connect to a valley pipeline were also considered.

Table 2-2
A Summary of Activities of the BEMP Program
During the 1984/85 to 1987/88 Fiscal Years

Year	Research Review and Overviews	Technical Planning Meetings	Workshops
1984/85	All hypotheses	All hypotheses	All hypotheses
1985/86	All hypotheses; specific review for effects of oil-based muds; decision to expand Hypothesis 20 to include other fish, birds and marine mammals.	Hypotheses 1 (bowhead whales) and Hypothesis 20 (oil-based muds)	Hypothesis 1 (bowhead whales); workshop on oil-based muds cancelled
1986/87	All hypotheses	Hypotheses 1 and 21 (bowhead whales) and Hypothesis 20 (oil-based muds)	Specific workshop for Hypothesis 1 and 21 (bowhead whales)
1987/88	Overview of all information relevant to BEMP hypotheses; including update on new and ongoing research	No specific technical meetings	No workshop

Workshops were also held in 1985/86 and 1986/87 to re-evaluate specific hypotheses dealing with the impacts of human activities and underwater noise disturbances on bowhead whales (Hypothesis 1), the proposed use of oil-based muds (Hypothesis 20) and the effects of westward moving tanker traffic during the open-water season on bowhead whales (Hypothesis 21). However, re-evaluations of the remaining impact hypotheses were not considered necessary because:

1. changes in the most probable development scenario (see Chapter 3 of this report) resulted in a substantial reduction in the likelihood and significance of certain impacts to specific VECs. For example, the BEMP 1984/85 workshop concluded that impacts of production wastewater on arctic cisco or broad whitefish were extremely Unlikely due to the small amounts of effluent that were expected (Hypothesis 16).

2. results of new research indicated that concerns for impacts had been overstated. For example, a study of the effects of ice-breaker traffic on ice stability (Danielewicz et at. 1983) indicated that icebreaker tracks quickly refroze and stabilized. As a result, it was concluded during the 1984/85 BEMP program that icebreaker tracks are unlikely to hamper hunter travel over the landfast ice during the period when polar bears are harvested (BEMP Hypothesis 8); and/or

3. no new information had become available that required a re-evaluation of impacts to specific VECs.

Bowhead Whales

Throughout BEMP, there was considerable interest in the potential effects of ship traffic, seismic exploration and active offshore structures on bowhead whales (I.e., BEMP Hypothesis 1). Considerable discussion was directed at the potential for the partial or complete exclusion of bowhead whales from areas of high zooplankton densities as a result of the cumulative effects of high-frequency underwater noise. Part of the driving force behind this interest was the resumption of a limited harvest of bowhead whales by the Alaskan Inupiat, and an expressed desire by the Inuvialuit to also conduct a limited hunt in the Canadian Beaufort Sea. During the 1985/86 BEMP program, a workshop was held in February 1986 to specifically re-evaluate BEMP Hypothesis 1 and incorporate new information from ongoing studies. Participants agreed that the hypothesis and its linkages remained valid. It was recommended that research and monitoring continue to document the annual patterns of whale distribution in the southeast Beaufort Sea and provide information on the relationship between bowhead whales distribution and food availability.

Hypothesis 1 was further evaluated at the 1986/87 workshop, where there was considerable discussion regarding the testability of the hypothesis and whether ongoing research could provide sufficient information to adequately address this impact (see Section 4.1 of this report). A new impact hypothesis (Hypothesis 21) was also developed to address the potential effects of the westward movement of oil tankers through the Canadian and American Beaufort Sea and minor oil spills on the western arctic population of bowhead whales and the harvest of this population by the Alaskan Inupiat. This hypothesis was developed in response to an application by Gulf Canada Resources for an Extended

Production Testing Project for the Amauligak field involving westward transport of oil by shuttle tanker.

Oil-based Drilling Muds

As noted above, the development scenario was modified in 1984/85 to reflect the probable use of oil-based drilling muds during exploration and production. A workshop on the effects of oil-based drilling muds was scheduled as part of the 1985/86 BEMP program but was cancelled due to unanticipated government spending constraints. However, a review of recent research on oil-based drilling fluids was completed, and Hypothesis 20 was revised to reflect the potential effects of oil-based muds on a broader range of species (INAC and Environment Canada 1986). This hypothesis was subsequently evaluated during a workshop held in March 1987.

As a result of reduced interest in oil development in the Canadian Beaufort Sea during the mid 1980s, government and industry funding and support for BEMP declined. No further initiatives were undertaken as part of BEMP after the 1987/88 fiscal year.

2.3 THE MACKENZIE ENVIRONMENTAL MONITORING PROGRAM (MEMP)

In early 1985, Indian and Northern Affairs and Environment Canada initiated a companion program to BEMP to assess the potential effects of hydrocarbon development on terrestrial and freshwater environment in the Mackenzie Valley. Like BEMP, the Mackenzie Environmental Monitoring Program (MEMP) was directed primarily at integrating research and monitoring needs with the most probable scenarios for hydrocarbon development in the Mackenzie Valley. MEMP was to:

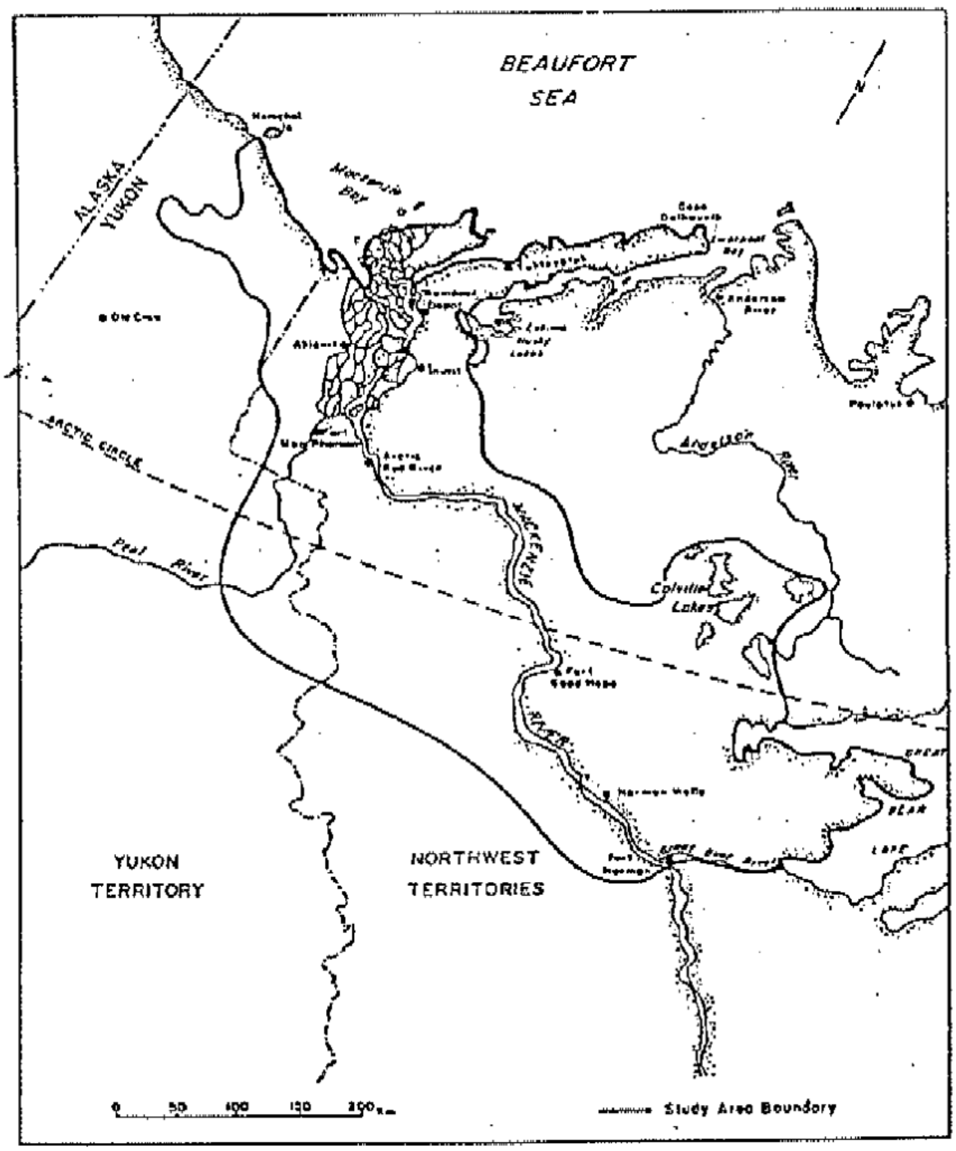
1. address significant potential impacts associated with hydrocarbon development and transportation-related activities;
2. be based on the best current understanding of the most likely industrial development scenarios for the Valley, and it ecological processes;
3. have the capability to respond to changing industrial development scenarios and new information regarding ecological processes in the Mackenzie Valley;

4. be applicable and practical; and

5. be supported with a full scientific and technical justification (INAC et al. 1986).

The study area for MEMP is shown in Figure 2-2. The eastern and western boundaries were considered to be somewhat flexible, particularly in the Colville Lakes areas in the east, and the Peel drainage and the Dempster Highway in the west. The planning horizon for MEMP was 20 years, reflecting the uncertainty about the scale and pace of hydrocarbon development in the region at that time.

Figure 2-2
Proposed Boundaries of the MEMP Study Area
(taken from INAC et al. 1986)



MEMP involved the conduct of two workshops and technical meetings to formulate and evaluate impact hypotheses, The first workshop (26-30 March 1985) focussed on the identification and summarization of information used to develop conceptual impact hypotheses describing the effects of oil and gas activity on people (primarily harvesting activities and employment) and environmental resources. This workshop was followed by technical meetings in June and September 1985 to resolve outstanding concerns related to resource harvesting activities and potential effects of hydrocarbon development. The second workshop (4-8 November 1985) provided a forum for the first evaluation of 25 MEMP impact hypotheses and identification of research and monitoring needs for the region.

As with BEMP, the world-wide decline in oil prices and the associated decline in interest in oil and gas exploration and production in the Mackenzie Valley resulted in a decline in government and industry funding and support for the MEMP program. No further initiatives for MEMP were undertaken after 1986/87, when a review of relevant research and monitoring was completed.

2.4 EMERGENCE OF THE BEAUFORT ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM (BREAM)

The Beaufort Region Environmental Assessment and Monitoring Program (BREAM) was initiated in 1991 by Indian and Northern Affairs Canada, Environment Canada, and the Department of Fisheries and Oceans. BREAM combined and built upon the results of BEMP and MEMP and, like these predecessors, provided a multi-stakeholder process that promoted the integration of environmental research and monitoring with current changes in the likely exploration and development scenarios for the Mackenzie Valley, Mackenzie Delta and Beaufort Sea regions. It also helped identify priority areas where research and monitoring efforts could best be used to better assess the effects of proposed developments on the environment.

A number of important events prior to 1991 influenced the scope and focus of BREAM. The Exxon Valdez oil spill in March 1989 and the shallow gas blowout at Immerk contributed to a heightened awareness of the environmental effects of oil spills on marine ecosystems, and the potential for accidental releases or blowouts to occur. During the EIRB hearings for Esso's Isserk drilling program and Gulf Canada's Kuiluk drilling program, concerns were expressed by government agencies, as well as aboriginal groups and other intervenors regarding the potential for catastrophic oil spills, oil spill cleanup and contingency programs, habitat restoration capabilities, compensation mechanisms and financial guarantees. Concerns were also expressed by aboriginal organizations and other residents that the exploration programs did not provide adequate opportunities for local involvement and benefits. Review of these issues by the Beaufort Sea Task Force (1991) further defined these issues with respect to future hydrocarbon development.

Advancements in native self-government and growing recognition of the value of traditional environmental knowledge during the 1980s and early 1990s also strongly influenced BREAM. The completion of the Inuvialuit Final Agreement in 1988, and ongoing negotiations for the Gwich'in Final Agreement and the Sahtu Final Agreement influenced the range of issues considered by BREAM, the study region boundaries and the involvement of northern residents in the process.

Events outside of the Northwest Territories also strongly influenced the direction and scope of BREAM. During 1989 and 1990, several proposals were put forward for the construction or upgrading of large pulp and paper facilities and hardwood logging throughout northern Alberta (e.g., Alberta Pacific, Daishowa, Proctor and Gamble). In particular, hearings for the Alberta Pacific project focussed the attention of government agencies and residents in the Northwest Territories on the potential for contamination of northern rivers as a result of pulp and paper production, oil production, municipal waste and agricultural expansion. By this time, a growing number of international studies suggested that increased levels of carbon dioxide in the earth's atmosphere were resulting in subtle changes in the earth's temperature (I.e., global warming), and the federal government made it a policy that the possible effects of global warming were to be included as part of all project assessments. Several studies suggested that arctic and subarctic areas could be significantly affected by the combined effects of global warming, increases in sea levels, melting of permafrost, and increased shoreline erosion. Concerns were also expressed about "holes in the ozone layer" and the effects of increased solar radiation on plant productivity and animal and human health.

2.4.1 BREAM 1990/91

The first year of BREAM (1990/91) was largely a planning phase, which involved a range of activities to help decide the direction of the program over the next few years. A planning meeting was held to determine the focus and scope of BREAM relative to

BEMP and MEMP, and to the more recent work of the Beaufort Sea Steering Committee. In addition, a number of research and monitoring programs completed in the Beaufort/Mackenzie region since the last BEMP workshop in 1986 were reviewed.

2.4.2 BREAM 1991/92

During the 1991/92 BREAM program, three new technical working groups were established to deal with the broadened scope of BREAM. These were the Impact Hypothesis Technical Working Group, the Catastrophic Oil Spill Technical Working Group, and the Community based Concern Technical Working Group. Each of these groups were charged with the responsibility of determining specific issues that should be dealt with in future BREAM workshops.

During the first technical meeting of the Impact Hypothesis Working Group, each of the impact hypotheses developed for BEMP and MEMP were reviewed to determine those that would be re-evaluated as part of BREAM. Of these hypotheses, many were restructured, reworded combined or eliminated to reflect new information, changes in the scope of the project, or changes in the development scenario. Three additional hypotheses were developed to address the effects of lake water drawdown on fish, offshore activities on the bowhead whale harvest, and dredging in Husky Lakes on fish. The result of this review was 32 BREAM hypotheses, some of which were Identified for a detailed evaluation, while others were considered valid but not necessary to evaluated at the time (Table 2-3). This work culminated with a workshop to fully evaluate the eight hypotheses selected for evaluation, to conduct a preliminary assessment of each of the 32 hypotheses, and to identify future research and monitoring requirements for the Beaufort/Mackenzie region.

Table 2-3
BREAM Impact Hypotheses, Screening Decisions and Future Actions (taken from INAC 1992)

BREAM #	OLD#	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION AND ACTION
BREAM R1	BEMP 1	Bowhead Whale	Ship traffic, seismic programs, and active offshore platforms/artificial islands will cause a reduction In the western arctic population of bowhead whales.	Valid - Detailed evaluation in workshop due to new information and re-interpretation of existing information
BREAM R2	BEMP 2 MEMP 19	White Whale Harvest	(a) offshore structures will reduce the white whale harvest; (b) frequent icebreaker traffic In the landfast ice will increase harvest; and (c) open-water ship traffic In the Mackenzie Estuary will alter while whale distribution and lead to changes in harvest levels.	Valid - Brief evaluation in workshop in relation to site-specific conflicts, climate change on landfast ice, and Beluga Protection Plan; combine hypotheses; add link related to barge traffic
BREAM R3	BEMP 3	Ringed and Bearded Seal	Marine vessel activities, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of ringed and bearded seal populations In the Beaufort Sea.	Valid but untestable - No need to re-evaluate at this time; current development scenario does not warrant additional work;
BREAM R4	BEMP 4	Ringed Seal	Increased frequency of Ice breaker traffic through the landfast ice will reduce ringed seal pup production and population levels.	Valid but untestable and insignificant - Wording changed to remove reference to Amundsen Gulf; no further work required
BREAM R5	BEMP 5	Bearded Seal	Icebreaker traffic in the transition (shear) zone will reduce bearded seal pup production.	Valid but untestable - No action required
---	BEMP 6	Ringed Seal and Polar Bear	Icebreaker traffic In Amundsen Gulf will affect the ringed seal and polar bear populations,	Invalid - No action required. Eliminated given current development 'Scenario
BREAM R6	BEMP 7	Polar Bear Harvest	The presence of active facilities will result in increased polar boar mortality and reduced harvest levels.	Valid·- Add linkage related to attraction of seals and bears to open water in lee of offshore structures as well as to reduced harvest levels (hypothesis wording altered to reflect the latter); some new information but no need to evaluate in workshop

Table 2-3 (cont'd)

BREAM#	OLD#	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION AND ACTION
BREAM R7	BEMP 8	Polar Bear Harvest	Offshore hydrocarbon development activities will reduce the harvest of polar bears.	Valid·- No further work recommended given current development scenario
BREAM R8	BEMP 9	Polar Bear Harvest	Chronic (episodic) oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of polar bears and reduced harvest levels.	Valid - Add linkage related to reduced harvest levels (hypothesis wording altered to reflect this change); adequate Information exists, no need to evaluate In workshop; Polar Bear Oil Spill Response Plan should be revisited before major development takes place
BREAM R9	BEMP10 MEMP10	Waterbirds	Chronic (episodic) oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will reduce the abundance of certain species of waterbirds.	Valid - hypotheses consolidation: new information available but no additional work required
---	BEMP 11	Eiders and Diving Ducks	Oil slicks in open water areas around offshore structures during periods of ice cover will cause increased mortality of eiders and diving ducks.	Valid - No action required; previously combined with BEMP10
BREAM Rl0	BEMP 12 MEMP 7	Waterfowl	Disturbance associated with hydrocarbon development In or near staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.	Valid - Hypotheses consolidated: linkages reworded to include effect or compressor noise: adequate Information exists

Table 2-3 (cont'd)

BREAM#	OLD#	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION AND ACTION
BREAM R11	BEMP 13	Fish Harvest	Shorebases and shallow-water production facilities will release (a) hydrocarbons and (b) heavy metals at sufficient levels such that fish harvest will be reduced through tainting and heavy metal accumulation.	Valid - Linkages 1 and 3 of Hypothesis 13A reworded to include contaminants derived from air emissions; wording changed in linkage 4 of hypothesis 13B to remove reference to human health; active area of research but no need to re-evaluate at present time
---	BEMP 14	Broad Whitefish	Nearshore structures will disrupt the nearshore band of warm brackish water and reduce the broad whitefish population.	Invalid - No action required; eliminated due to current development scenario
---	BEMP 15	Arctic Cisco	Nearshore structures will disrupt the nearshore band of warm brackish water and reduce the arctic cisco population.	Invalid - No action required; eliminated duo to current development scenario
BREAM R12	BEMP 16	Arctic Cisco and Broad Whitefish	The construction of shorebases and development of shallow-water production fields will result In a decrease in the populations of arctic cisco and broad whitefish.	Valid - Detailed evaluation in workshop due to new information and concerns related to shorebases; wording changed in linkages and figure boxes to include references to pipeline landfall, brackish water, and effects on fish movement
---	BEMP 17	Broad Whitefish and Arctic cisco	Marine water intakes will reduce populations of broad whitefish and arctic cisco	Invalid - invalid with respect to marine water intakes (hypothesis wording altered to reflect this); eliminated due to current development scenario
BREAM R13	---	Broad Whitefish and Arctic cisco	Freshwater intakes will reduce populations of broad whitefish and arctic cisco.	Valid but mitigable - Detailed evaluation required at workshop: new BREAM hypothesis developed to address effects of lake water drawdown

Table 2-3 (cont'd)

BREAM#	OLD#	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION AND ACTION
---	BEMP 18	Air Quality	Air emissions associated with aircraft and marine traffic: and operations of drill rigs, offshore platforms and shorebases will adversely affect air quality.	Invalid - No action; air quality not a VEC; effects of contaminants from atmospheric sources considered In BREAM R11
BREAM R14	BEMP 19	Bearded Seal	Dredging and deposition of spoils will reduce the bearded seal population.	Valid but untestable - No action required
BREAM R15	BEMP 20	Fish, Birds and Mammals	The discharge or drill cuttings contaminated with oil-based drilling muds during hydrocarbon exploration or production will reduce populations of fish, birds or mammals or will decrease the harvest of these resources due to hydrocarbon accumulation in tissues.	Valid - No need to re-evaluate at this time but should be revalidated In future workshop addressing community-based concerns
---	BEMP 21	Bowhead Whale and Harvest	Tanker traffic and minor oil spills associated with the westward transport of Canadian Beaufort oil will cause reductions in the western arctic population of bowhead whales and/or the harvest of this population by the Alaskan Inupiat.	Invalid - No action required; eliminated because the current development scenario does not include tanker traffic
BREAM R16	MEMP 1	Arctic and Red Fox	The presence or offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a change in the number of arctic and red foxes.	Valid - New Information available which increased predictive capabilities; wording or hypothesis changed
BREAM R17	MEMP 2	Caribou	Increased traffic on roads near or adjacent to insect-relief habitat will decrease the number of caribou and alter their distribution.	Valid·- Detailed evaluation in workshop due to new information and restructuring of hypothesis to exclude reference to roads leading to Mt. Fitton and King Point (hypothesis of wording altered to reflect this change

Table 2-3 (cont'd)

BREAM#	OLD#	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION AND ACTION
BREAM R18	MEMP 3	Grizzly Bear	Gravel extraction, construction, seismic exploration and other development activities, and the presence of camps and garbage will decrease the number of grizzly bears and alter their distribution.	Valid - New Information available to support previous conclusions regarding validity but no need to re-evaluate in workshop
BREAM R19	MEMP 4	Waterfowl, Semi-aquatic Furbearers and Fish	Water withdrawals and land subsidence resulting from hydrocarbon development activities will change the abundance and distribution of waterfowl, semi-aquatic furbearers and fish.	Valid - Detailed evaluation in workshop due to major restructuring of hypothesis to include waterfowl and fish, as well as local subsidence along pipeline. and roads In Mackenzie Delta and Valley
BREAM R20	MEMP 5	Moose	Oil and gas development construction and clearing activities and the presence of an above-ground pipeline and above-ground gathering systems will change the abundance and distribution of moose.	Valid·- Brief evaluation in workshop due to new information and inclusion of above-ground gathering systems (hypothesis reworded to reflect this change)
BREAM R21	MEMP 6	Marten	Oil and gas exploration and development activities that alter habitat permanently or temporarily will influence the distribution and abundance of marten.	Valid - Detailed evaluation In workshop due to new information, rewording of links 9 and 10 to include effect on quality of marten, and addition of linkage related to displacement through sensory disturbance
BREAM R22	MEMP 8	Raptors	Disturbance and habitat alterations duo to hydrocarbon development will alter the distribution and/or abundance of raptors.	Valid·- No action required
BREAM R23	MEMP 9	Waterfowl	The presence of camps and garbage disposal sites will attract predators that will lead to changes in the local abundance of waterfowl.	Valid - No action required

Table 2-3 (cont'd)

BREAM#	OLD#	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION AND ACTION
BREAM R24	MEMP 11	Waterfowl! Fish and Muskrat	Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat	Valid - No need to re-evaluate in workshop; wording of linkage 1 changed to clearly reflect regional land subsidence resulting from oil and gas extraction; wording of links 6, 7 and 8 changed to abundance and distribution of waterfowl, fish and muskrat
---	MEMP 12	Air Quality	Air emissions resulting from oil and gas development and operation will adversely affect air quality.	Invalid·- No action required because air quality not considered a VEC
---	MEMP 13	Fish Quality	Increased local disturbance due to activities related to hydrocarbon development will result in decreases in fish Quality.	Invalid - No action required; was concluded to be invalid in 1985/86 MEMP report
BREAM R25	MEMP 14	Fish	Improved access and fishing pressure will decrease the abundance of fish and affect their distribution,	Valid - New Information available to support validity; no need to re-evaluate
BREAM R26	MEMP 15	Fish	Water discharge and accidental oil/chemical spills will lead to unpotable water and decreased acceptability of fish as a feed source.	Valid·- Active area or research but no need to re-evaluate in workshop: should be revalidated in support or future work by community-based concerns group)
BREAM R27	MEMP 16	Fish and Fish Harvest	The construction and presence of linear corridors will affect the number, distribution and quality of fish and fishing success.	Valid·- Hypothesis restructured to link food production directly to abundance and distribution of fish and to link the latter to fishing success
---	MEMP 17	Wolverine	Wolverines attracted to camp and garbage will be killed as nuisance animals, thus reducing the population.	Invalid - No action required; info suggests this would be rare event
BREAM R28	MEMP 16	White Whale Harvest	Wage employment will change the harvest of white whales.	Valid·- no need to re-evaluate in workshop

Table 2-3 (cont'd)

BREAM#	OLD#	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION AND ACTION
---	MEMP 20	White Whale Harvest	Competition by non-locals will change the number of white whales landed and increase mortality in the population.	Invalid - No action; no longer an Issue because regulated by FJMC
BREAM R29	MEMP 21 MEMP 23	Birds. Fish and Mammal.	Changes in access will affect the harvest of birds, fish and mammals.	Valid·- Restructure MEMP 21 to include birds, fish and mammals; link access directly to numbers and distribution of resources; unlikely given current development scenario; no further research or monitoring required
BREAM R30	MEMP 22	Resource Harvesting	Increased levels of wage employment will change the total annual harvests of resources by communities in the region.	Valid - Linkages reworded In relation to units of production; present revised hypothesis to community-based concerns group
---	MEMP 24	Resource Harvesting	Industrial activities in harvesting areas will reduce the harvests of mammals, birds and fish because of conflicts between industry and harvesters over land use.	No action - eliminated because land use and compensation issues are outside scope of BREAM
---	MEMP 25	Resource Harvesting	Increases in hunting by non-locals will restrict harvests by local natives.	Invalid - No action required; no longer an issue due to claim agreements
BREAM R31	---	Bowhead Whale Harvest	Development activities will change the harvest of bowhead whales.	New Hypothesis - Detailed evaluation required In workshop
BREAM R32	---	Birds, Fish and Mammals	Dredging to facilitate barge access to Parsons Lake gas field will result in a decline in the Husky lakes lake trout population	New Hypothesis - Detailed evaluation required in workshop

A planning meeting of the Catastrophic Oil Spill and Impact Hypothesis Working groups was held in 1991/92 to develop a tentative list of VECs and six oil spill scenarios to facilitate the formulation of new impact hypotheses dealing with catastrophic spills. The first meeting of the Community-based Concerns Working Group was also held this year and focussed primarily on introducing the BREAM process to northern communities, identifying some of the environmental issues of importance to northerners, and determining priorities of the Working Group for the next year.

2.4.3 BREAM 1992/93

The primary emphasis of BREAM in 1992/93 was on catastrophic oil spills and their potential impact on harvestable resources and the habitat of important fish and wildlife resources. A planning meeting and technical meetings of the Catastrophic Oil Spill and Community-based Concerns Working groups were held early in the year, and were followed by a 3-day workshop to identify research and monitoring needs associated with major oil spills and their cleanup/response activities in the region. Nine impact hypotheses were selected for evaluation at the workshop from a larger number formulated by the Catastrophic Oil Spill Working Group. These hypotheses were considered to address those issues of greatest scientific and community concern in the event of an oil spill (see Section 5 of this report).

2.5 IMPORTANT ASPECTS OF THE BEMP, MEMP AND BREAM PROCESS

A number of important and, in some cases, unique aspects of the BEMP/MEMP/BREAM process contributed to the overall success of these programs.

1. The process provided industry, government and community stakeholders with a means of focussing finite funding for research and monitoring on those needs of greatest scientific concern relative to the assessment and management of environmental impacts associated with hydrocarbon development, rather than on individual preferences or desires by agencies, stakeholders or individual researchers. The workshop approach provided a "neutral" ground for the discussion and resolution of environmental issues; that is that participants were encouraged to "take off their respective political caps" and to focus on environmental needs.

2. The concept of Valued Ecosystem Components focussed the discussion of impact hypotheses and research/monitoring needs to those resources and biophysical processes of greatest concern relative to hydrocarbon development in the region, while also defining quantitative measurements by

which impacts would be assessed (e.g., numbers of animals, quality of harvest).

3. The use of impact hypotheses as a focus of discussion forced workshop participants to think about potential impacts in interdisciplinary, quantitative, dynamic terms relating to the interactions between hydrocarbon development and the biophysical environment.

4. The process was flexible to ongoing changes in the probable oil and gas development scenarios, as well as to new information on baseline conditions, ecological processes and impact response mechanisms. The iterative nature of the BEMP, MEMP and BREAM programs promoted:

   (1) a regular re-assessment of the kinds of information which were required to resolve specific impact issues or linkages;

   (2) the regular review of new research, and the incorporation of relevant, new information in the validation and assessment of impact linkages. When linkages were invalidated, the process fostered reformulation of impact hypotheses and, in some cases, a Substantial reduction in the degree of concern for specific impacts or issues; and

   (3) continual updating of environmental issues relative to the most probable development scenario.

On the other hand, some aspects of the BEMP/MEMP/BREAM programs may have restricted its overall acceptance by some individuals and organizations. Perhaps one of the most strongly-voiced criticisms of the process was its restriction in scope to address only environmental and resource harvesting issues. Community representatives frequently expressed strong reservations that social issues related to oil and gas development had been excluded from the process. Although it was recognized that the mandate of BREAM was expanded to include accidental oil spills and assessment issues, it was felt that little had been done to reduce the uncertainty or uneasiness over the social and economic implications of hydrocarbon development. While both the BREAM program sponsors and participants of the program agreed that social issues are an important need that will have to be satisfied prior to future oil/gas development in the region, it was noted that the framework and tools used for BEMP, MEMP and BREAM are not likely to be appropriate to adequately address these concerns and that a new initiative would be needed to address the socio-economic concerns of northern residents.

Despite these perceived shortcomings, BEMP, MEMP and BREAM have provided significant improvements in our understanding of the potential impacts of hydrocarbon development on the environment of the Mackenzie Valley/Delta and Beaufort Sea, the significance of these impacts, the potential for mitigation, and future needs for environmental monitoring. BEMP, MEMP and BREAM also have fostered a cooperative approach to resolution of environmental issues. As part of this approach, all participants gained a better appreciation of concerns by other participants, as well as a better and more holistic knowledge of environmental processes and impact mechanisms. When hydrocarbon exploration and development resumes in the Canadian Beaufort, the Mackenzie Delta and the Mackenzie Valley region, far better information on impact mechanisms and significance will exist as a result of the BEMP, MEMP and BREAM programs than that which existed prior to the Beaufort Sea-Mackenzie Delta EIS.

2.6 FUTURE USE OF INFORMATION FROM THE BEMP, MEMP AND BREAM PROGRAMS

How might the information gained through BEMP, MEMP and BREAM be used in the future? Several large environmental research programs have been proposed or are ongoing within the greater Mackenzie River basin and the Canadian Arctic. Potential benefits of BEMP, MEMP and BREAM to these programs are outlined below.

1. As part of the Gwich'in and Sahtu Land Claims agreements (and eventually the other land claim settlements in the Mackenzie basin), a cumulative effects monitoring program for the Mackenzie Basin is to be designed and implemented. Results of BEMP, MEMP and BREAM will provide valuable information in selecting indicators or key species for consideration in the cumulative effects monitoring program.

2. The Mackenzie River Basin Study, in conjunction with the Northern River Basins Study, is studying the responses of ecological processes and indicator species to a variety of industrial contaminants, as well as potential hydrological changes in the greater Mackenzie basin (Le" the Peace,

Athabasca, Slave and Mackenzie river basins). Information from MEMP and BREAM may be of use in identifying research priorities, VECs and community concerns.

3. The Arctic Environmental Protection Strategy is an international initiative to assess research and monitoring needs, and to design and implement research and monitoring programs to document contaminant fate and effects in arctic ecosystems. Information from BEMP, MEMP and BREAM, particularly in relation to food chain contamination, may be of use in focussing research and monitoring efforts.

BEMP, MEMP and BREAM provide a wealth of information on ecosystem processes and impact response mechanisms. It is important that this information be archived for future use in the Beaufort Sea, Mackenzie Delta and Mackenzie Valley regions, as well as for use by other future research and monitoring programs and impact assessments. Towards this end, the present report has been prepared as a guide to the types of information that are provided by BEMP, MEMP and BREAM, as well as a summary of the events and decisions that shaped these three programs.

3.0 INDUSTRIAL DEVELOPMENT SCENARIOS

Based on the best current understanding of industry's short-and long-term plans for hydrocarbon development and transportation in the Beaufort Sea/Mackenzie Delta and Valley regions, development scenarios were prepared for BEMP, MEMP and BREAM. These scenarios described the likely nature and scope of future development activities in the region and, thus, helped in identifying those specific activities that were expected to cause some impact on the biophysical environment. The development scenarios prepared for BEMP and MEMP focussed solely on those activities associated with routine aspects of exploration, production and transportation of oil and gas, and explicitly excluded environmental emergencies. However, a number of oil spill scenarios were subsequently developed for BREAM to provide the framework for evaluating research and monitoring related to potentially catastrophic spills such as a major well blowout or oil pipeline rupture.

Over the past 10 years of the project, the development scenarios evolved as industry responded to changing market conditions, energy policies, and socio-economic and environmental factors. These changes in industry projections directly influenced the focus of each year of BEMP, MEMP and BREAM, and the priority placed on research and monitoring activities for the region. While detailed descriptions of the development scenarios are provided in the annual reports prepared for BEMP, MEMP and BREAM, the following section highlights the significant changes that were made to these scenarios since 1983 and provides a summary of the scenarios developed to help address the issue of catastrophic/major oil spills.

3.1 EVOLUTION OF SCENARIOS RELATED TO ROUTINE ASPECTS OF HYDROCARBON DEVELOPMENT

3.1.1 BEMP

During the late 1970s and early 1980s, there was considerable optimism regarding the development of Beaufort Sea/Mackenzie Delta hydrocarbon resources. Substantial onshore gas reserves had been confirmed by this time, and offshore exploration activity was revealing the region's potential for large-scale oil production. With declining oil production from conventional sources and a slight growth in demand for oil, it was projected that there would be an oil shortfall in Canada by 1990, which would steadily increase to the year 2000. Frontier development was seen as an opportunity to help achieve oil self sufficiency by the 1990s, while creating employment opportunities and regional development. In July 1980, the issue of Beaufort Sea/Mackenzie Delta hydrocarbon development was referred to the Federal Environmental Assessment Review Office (FEARO) by Indian and Northern Affairs Canada, and an Environmental Assessment Panel was appointed to review the social, technical and environmental considerations associated with oil and gas production in the region. The three principal operators in the region (Dome Petroleum Limited, Esso Resources Canada and Gulf Canada Resources Inc.) prepared the Beaufort Sea-Mackenzie Delta EIS, which addressed all these various issues and set forth a plan for phased development over the next 20 years (Dome et al. 1982).

The development plan prepared for the Beaufort Sea-Mackenzie Delta EIS provided much of the information needed to develop a scenario for BEMP. Four major groups of activities were considered within the plan: (1) exploration activities and drilling associated with discovery and delineation of oil reservoirs; (2) construction of islands and oil production facilities, and the drilling of production wells; (3) gathering of oil to production and transportation facilities; and (4) transportation of produced hydrocarbons to southern markets. The development plan described a scenario where artificial islands would be built in the offshore where most of the larger commercial oil reserves were anticipated, and production systems would be installed both on islands and onshore and would be interconnected with subsea pipelines and onshore gathering systems. Transportation of produced hydrocarbons would occur by tanker, through an overland pipeline or some combination of both.

The range and intensity of these activities were described in detail in the Beaufort Sea-Mackenzie Delta EIS. Many of these estimates, as well as information provided by Dome Petroleum, were used in the hydrocarbon development scenario prepared for the 1983/84 BEMP program. Specifically, this scenario was set at a 30-year time frame and assumed that:

1. four production islands would be constructed in the offshore;
2. the rate of oil production would peak at 100,000 bbl/day;
3. production facilities would not be located in waters less than 5 m deep;

4. if oil-based muds were used for exploratory or production drilling, oil-contaminated cuttings would not be discharged into the marine environment:

5. major dredging operations required for offshore island construction would not be conducted in inshore areas:

6. the initial mode of transporting produced hydrocarbons out of the region would be two ice-breaker tankers:

7. solid-fill causeways would not be required along the Yukon coast and Tuktoyaktuk Peninsula; and

8. all wastes associated with the development would be treated and discharged in accordance with the best practicable technology.

By the 1984/85 BEMP program, two significant changes were made to the development scenario. With renewed interest in production from the Adgo field, the assumption that production facilities would not be located in Shallow waters « 5 m) was no longer valid. The Adgo field is situated in the nearshore zone, where water depths range from 2-3 m. Although the petroleum industry had no plans to incorporate nearshore structures such as jetties or causeways with this or other shallow-water facilities, it was assumed that such structures could be proposed in the future. With this increased probability of a causeway in the Canadian Beaufort, several impact hypotheses concerned with the potential effects of nearshore structures on fish populations in the Beaufort Sea were re-evaluated during the 1984/85 BEMP workshop.

By this time, industry was also contemplating the use of oil-based muds for some exploratory and production drilling applications in the Beaufort Sea. It was assumed that with the use of oil-based muds, cuttings contaminated with oil may be discharged into the marine environment as a result of routine operations. Due to this change in the development scenario, a new hypothesis was developed for evaluation at the 1984/85 workshop. This hypothesis specifically addressed the potential impacts of oil-contaminated cuttings discharge on anadromous fish species.

Over the next year, industry projections for oil and gas exploration and production in the Beaufort Sea/Mackenzie Delta region did not change significantly. Production within the 30-year time frame was still considered a reasonable scenario despite the effect that low world prices of crude oil would have on development in the short term. Completion of the Norman Wells oil pipeline to Zama Lake and its effect on the pace of exploration in adjacent regions maintained the optimism for Beaufort/Mackenzie development. With submission of an application from Polar Gas to construct a gas pipeline from the Mackenzie Delta along the Mackenzie Valley to Alberta, there was hope that such an initiative would spur additional exploration drilling in the Beaufort Sea and Mackenzie Delta. Plans for the Polar Gas pipeline and completion of the Norman Wells line resulted in more interest being directed at construction of pipelines through the Valley as opposed to the marine transportation option. However, use of ice-breaker tankers to transport oil to the south still remained a possibility.

By the mid to late 1980s, industry activity in the Beaufort Sea had slowed in response to the decreasing demand and low world price for oil. Some of the activities of industry in the region included: (1) offshore drilling by Esso at Minuk 1"53 and Kaubivik 1-43; (2) further delineation drilling and an Extended Flow Test by Gulf at Amauligak; and (3) submission of an application by Gulf for an Extended Production Testing Project for Amauligak that would involve a production rate of 3200–5600 m' per day for 100-125 days per year and shipment of oil out of the Beaufort Sea by shuttle tanker on average of about once a week. In response to this submission by Gulf, a new impact hypothesis was developed and evaluated during the 1986/87 BEMP program. This hypothesis specifically addressed the potential effects of westward transport of oil by tanker on bowhead whales. No other changes were made to the development scenario that year or in *1987/88* (the last year of BEMP).

3.1.2 MEMP

In 1985, MEMP was initiated by Indian and Northern Affairs Canada, Environment Canada, Fisheries and Oceans Canada, and the territorial governments of Yukon and the Northwest Territories to guide research and monitoring related to hydrocarbon development in the terrestrial and freshwater environment of the Mackenzie Delta and Valley. To this date, the only production of hydrocarbon reserves in the region had occurred at the Norman Wells field. Seismic and exploratory drilling was occurring in the Colville Lake area with some significant discoveries, and exploration had been occurring over the past 25 years within the Mackenzie Delta area, resulting in the discovery of both oil and gas reserves. However, exploration activity in the region was relatively slow in comparison to the late 1970s and early 1980s. Some of the activities included: (1) the completion of the Interprovincial (IPL) oil pipeline at Norman Wells; (2) continued seismic exploration by Esso in the Delta, particularly in the vicinity of the Tagiu gas field: and (3) exploratory drilling by Chevron near Fort Good Hope and by Conoco near Fort Norman.

By the mid 1980s, several pipelines were being proposed or considered that would have ultimately shaped the nature and intensity of hydrocarbon development in the Mackenzie Delta and Valley region. In addition to the Polar Gas pipeline application mentioned previously, Foothills Pipe Line Ltd. was proposing, as part of their Alaska Highway Gas Pipeline plan, a Dempster Lateral line to carry Mackenzie/Beaufort natural gas to the mainline system in Yukon. Esso was considering a small oil pipeline to carry Mackenzie Delta oil south to market via an interconnection with the Norman Wells pipeline. The pipeline route would follow essentially that put forward by Polar Gas for the gas pipeline. At this time, some northern operators were also considering the feasibility of a mid-sized oil pipeline to carry both onshore and offshore oil from the Mackenzie Delta south along the valley to Zama Lake.

For the purposes of MEMP, a development scenario involving two of the proposed transportation systems (the Polar Gas Pipeline and the Mid-sized Oil Pipeline) was developed as a framework for evaluating research and monitoring priorities for the region. Within the time frame of 1985-2005, the scenario assumed that construction of these pipelines would approximate that desired by the proponents. Plans set out in the Polar Gas Pipeline application called for construction to begin in 1987 and for gas to start flowing by 1991. A delay of at least one year in this plan was considered realistic and, therefore, adopted for the development scenario. This pipeline would be designed to initially transport onshore gas reserves at Taglu, Niglintgak and Parsons Lake and eventually other smaller onshore and possible offshore reserves. The timing of the Mid-Sized Oil Pipeline was very tentative, but it was considered reasonable that construction could begin in 1993 and be complete by 1996-1997. Both offshore and onshore reserves would be candidates for production. Offshore fields such as Amauligak, Tarsuit or Nipterk would likely be developed first, while the first onshore reserves would probably include Adgo, Atkinson, Tuktoyaktuk and Niglintgak.

This development scenario was considered relatively optimistic even at the time. it assumed that several additional hydrocarbon reserves would be discovered in the

Mackenzie Delta region and the Colville Lake region. Of these, five fields (two offshore gas, two offshore oil and one onshore oil) would be identified by 1989. By the 1987 MEMP program, it became apparent that it was unlikely that this scenario would be realized and, therefore, the project schedule for construction of the transport systems would most certainly be delayed to the early 1990s rather than the late 1980s, as assumed by the original development scenario. Other than this, all of the other assumptions made in the scenario were still considered valid. Although there was not agreement among industry as to whether a gas pipeline would proceed an oil pipeline, the timing of these transport systems remained the same in the scenario.

3.1.3 BREAM

By the early 1990s, it became apparent that the most attractive prospects in the Beaufort Sea/Mackenzie Delta and Valley region had likely already been examined. Although exploration for oil and gas continued, being stimulated at times by oil prices and the 'perceived need for gas, most of this work was completed largely to meet existing commitments. At this time, production of Mackenzie Delta gas was not viewed as being economically feasible due to the low price of natural gas and the existence of lower cost alternative supply sources. World oil prices, in conjunction with discovery of insufficient oil reserves, were limiting factors in oil production from the region. However, if prices and market demand for natural gas changed or other significant onshore and offshore oil reserves were discovered, industry would have likely been much more pro-active in pursuing development in the region.

From the producers' perspective, the most probable scenario for development of oil reserves would initially involve production from the major oil discovery at Amauligak. During this first phase of development, offshore production facilities would be put into place at Amauligak and a subsea pipeline would be constructed to carry oil to shore at North Point on Richards Island. Under this scenario, oil would be transported south by a large diameter (20-24") pipeline along the Mackenzie Valley. Use of tankers to transport oil was not considered an option by the petroleum industry. The most probable scenario for the first phase of gas development would be construction of a gas processing plant at Taglu on Richards Island and one at Parsons Lake on the mainland. Gas reserves at Niglintgak would be processed at Taglu. Drilling operations and construction of gathering systems at the three fields as well as construction of two gas plants would be sequenced over a four-year period.

Based on these most likely scenarios for development of oil and gas reserves in the region, the BREAM scenario assumed the eventual construction of three separate transmission pipelines to transport petroleum to southern markets (a natural gas pipeline, an oil pipeline and/or a condensate pipeline). As mentioned earlier in Section 2, the three main pipeline companies (Polar Gas, Foothills and Interprovincial) were working toward establishing a new Joint Venture, which would see the preparation of only one gas pipeline application to replace the existing ones. At this time, there were no proposals for an oil pipeline in the region.

Over the next two years of BREAM, the scenario for development of oil resources in the region reflected less optimism regarding discovery of other significant onshore/offshore reserves and the economic feasibility of "big oil" development. By 1991/92, producers anticipated that the most probable scenario for the first phase of oil development would be a small diameter (8-10") pipeline to transport oil from the Mackenzie Delta to Norman Wells, where it would tie into the existing IPL system. This would involve the transport of 15,000-25,000 barrels of oil per day and would see small onshore fields such as Atkinson, Adgo, Niglintgak, Kumak and Kugpik brought into production. Use of tankers to transport oil out of the north was still not considered an option at this time. However, smaller-scale shuttle of oil from offshore fields to onshore harbour complexes was considered a possibility. It was not anticipated that large-scale oil development would occur until well into the next century.

3.2 SUMMARY OF SCENARIOS RELATED TO CATASTROPHIC OIL SPILLS

Six oil spill scenarios were developed during the 1991/92 BREAM program. These scenarios provided the framework for evaluating spills in the offshore vs. onshore, spills from pipelines vs. production platforms, and spills of different petroleum hydrocarbons (i.e., crude oil vs. condensate). Specifically, these scenarios involved:

(1) a condensate pipeline leak under ice at a river crossing at a rate of 10 barrels/day from February 15 to April 15;

(2) a condensate pipeline leak at a river crossing in Slimmer involving a release of 1000 barrels over a 2-hour period;

(3) an oil pipeline leak at a river crossing in spring involving a release of 10,000 barrels over a 2-week period;

(4) an oil pipeline (weld) failure in summer in a section of pipeline buried beneath the Mackenzie River involving a release of 5000 barrels over a 2-week period;

(5) an artificial island platform blowout (August 1) involving the release of a total of 77,400 barrels of oil over 6 days; and

(6) an offshore sub-sea blowout (September 1) involving the release of a total of 77,400 barrels of oil over 6 days.

In response to concerns raised during the Community-based Concerns Technical Working Group meetings in 1991/92, one additional scenario was developed in the following year to address a diesel fuel spill from a river barge during summer. As discussed later in Section 5, the timing and location of some of these spill scenarios were Subsequently modified, where necessary, to best represent a worst-case situation for evaluation of impact hypotheses.

4.0 ROUTINE ASPECTS OF DEVELOPMENT

During the first years of BEMP and MEMP, lists of development activities and potential Valued Ecosystem Components (VECs) were prepared as part of the initial scoping exercise (Section 2). Identification of the nature, extent and duration of development activities (actions) was based on the most current scenarios for Beaufort and Mackenzie hydrocarbon development, and provided the basis for formulation of impact hypotheses that related development to its potential effects on the biophysical environment. Identification of the VECs was based on perceived environmental concerns and issues related to these activities, and was of critical importance because it focussed discussions of impact hypotheses and research/monitoring programs on those resources of greatest concern with respect to development in the region. While the lists of VECs have not been modified significantly during the course of BEMP, MEMP and BREAM, some .of the issues and concerns surrounding these VECs have changed due to new information gained through research and monitoring, and changes in the development scenarios.

This section provides a review of the suite of issues related to routine aspects of hydrocarbon development that were evaluated through the BEMP, MEMP and BREAM series, and describes how each of these concerns have been alleviated and focussed by these programs. In addition, it also identifies the new issues that the programs have inherited over the past 10 years, and identifies whether these have been addressed through research and monitoring or have yet to be resolved.

4.1 OFFSHORE STRUCTURES AND MARINE VESSEL TRAFFIC

4.1.1 Introduction

Seven hypotheses related to routine offshore oil and gas development activities were evaluated during BEMP/MEMP/BREAM. These hypotheses evaluated the potential effects of: (1) ship traffic (between shore and the development structures offshore and that associated with ice breaking activities): (2) seismic exploration; (3) dredging; (4) activities associated with offshore structures (platforms and artificial islands); (5) the physical presence of offshore structures (platforms and artificial islands); and (6) aircraft overflights on five valued ecosystem components -bowhead whales, beluga (white) whales, ringed seals, bearded seals and polar bears (Table 4.1). The specific hypotheses evaluated are as follows:

BEMP 1: Ship traffic, seismic exploration activities and active offshore platforms/artificial islands will cause a reduction in the western arctic population of bowhead whales.

BEMP 2: Various facilities and activities associated with offshore hydrocarbon development will affect the white whale harvest.

BEMP 3: Marine vessel activities, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of ringed and bearded seal populations in the Beaufort Sea.

BEMP 7: The presence of active facilities will result in increased polar bear mortality.

BEMP 8: Offshore hydrocarbon development activities will reduce the harvest of polar bears.

BEMP 21: Tanker traffic and minor oil spills associated with the westward transport of Canadian Beaufort oil will cause reductions in the Western arctic population of bowhead whales and/or the harvest of this population by the Alaskan Inupiat.

MEMP 19: Vessel traffic will decrease the harvest of white whales.

BREAM R6: The presence of active facilities will result in increased polar bear mortality and reduced harvest levels.

BREAM R31: Development activities will change the harvest of bowhead whales.

Table 4.1
Offshore Structures and Marine Vessel Traffic

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 1 Ship traffic, seismic programs and active offshore platforms and artificial islands will cause a reduction in the western Arctic population of bowhead whales.	Detailed evaluation Hypothesis valid and testable. Group identified need for research on: summer/winter energy balance dynamics; distribution of food supply; acoustical behaviour monitoring methods. Group also identified need to monitor annual distribution of bowheads and behavioural responses to industry activities/facilities; reproductive success; ambient noise monitoring.	Detailed evaluation Remains valid but less importance placed on evaluating short-term, site-specific disturbances. Added link related to cumulative effects leading to large-scale zone of exclusion. Food availability study and integrated systematic survey and photographic program recommended.	Detailed evaluation Validity of hypothesis and linkages supported by continued research and monitoring. As in previous year, emphasis placed on cumulative effects.	Detailed evaluation Majority of participants concluded that either the effect was possible but too difficult to detect, or was not testable. Several participants also believed there was need to continue research on some critical links in the hypothesis, such as bowhead feeding habitats. New Hypothesis developed to deal with effects of tanker traffic on bowhead whales (see BEMP 21).	Review of research Results of research indicate that the interannual variability in the distribution of bowhead whales is caused by responses to fluctuations in the distribution and abundance of food rather than behavioural responses to industrial activity.	Hypothesis review Requires re-evaluation during BREAM. Hypothesis considered valid but unlikely to be testable. No changes were made to the wording of the hypothesis or its associated linkages. Selected for a detailed evaluation during the 1991.92 program due to new information and re-interpretation of existing information.	Detailed evaluation Designated as BREAM R1. Screen decision is that hypothesis is valid. Evaluation in workshop necessary due to new information and reinterpretation of existing information.
BEMP 2 (a) offshore structures will reduce the white whale harvest; (b) frequent icebreaker traffic in the landfast ice will increase harvest; (c) open-water ship traffic in the Mackenzie Estuary will alter white whale distribution and lead to changes in harvest levels; and (d) Inuit employment in the industry will change the white whale harvest.	Detailed evaluation Hypothesis is: (a) unlikely (b) unlikely (c) valid and testable (d) valid and testable. Research: Factors controlling distribution of white whales in Niakunak and Kugmallit bays. Monitoring: Annual monitoring of regional landfast ice extent, distribution and breakup; continuation and revision of existing white whale monitoring	Detailed evaluation Confirmed validity but concluded less emphasis should be placed on several of its linkages. Delayed ice break-up due to the presence of offshore artificial islands and advanced break-up as a result of icebreaker traffic were considered unlikely under the present development scenario.	Review of research ---	Review of research ---	Review of research ---	Hypothesis review Requires re-evaluation during BREAM. Sub-hypotheses (a) and (b) were considered unlikely, while (c) was concluded to be both valid and testable; no change in wording necessary.	Brief evaluation BEMP 2 and MEMP 9 combined to form new BREAM hypothesis (designated R2). New hypothesis also addresses effects of barge traffic. Review needed in relation to site-specific conflicts, climate change on landfast ice and Beluga Protection Plan.

Table 4.1 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 3 Marine vessel activities, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of ringed and bearded seal populations.	Detailed evaluation Hypothesis is valid, but effects would either be hard to detect or not worth testing. No research or monitoring recommended.	Detailed evaluation Concluded during the 1985 workshop that the cumulative effects of all links would probably be inconsequential or too hard to detect (due to natural variability in population levels) at the present level of industrial activity. No specific research or monitoring were recommended.	Review of research ---	Review of research ---	Review of research ---	Hypothesis review Requires re-evaluation during BREAM. Valid but either too hard to detect or not worth testing; no change in wording necessary.	Brief review Inherited by BREAM (designated R3) but not considered necessary to re-evaluate at this time; current development scenario does not warrant additional work.
BEMP 7 The presence of active facilities will result in increased polar bear mortality and reduced harvest levels.	Detailed evaluation Hypothesis is valid. Group supported continuation and expansion of existing polar bear monitoring and deterrent programs.	Detailed evaluation Group concluded hypothesis remains valid.	Review of research ---	Review of research ---	Review of research ---	Hypothesis review Requires re-evaluation during BREAM. No changes in wording necessary.	Overview Wording and structure of BEMP 7 (designated R6) changed to include linkage related to attraction of seals and bears to open water on lee of offshore structures and subsequent reductions in harvest levels. Some new information but does not alter earlier conclusions regarding validity.
BEMP 8 Offshore hydrocarbon development activities will reduce the harvest of polar bears	Detailed evaluation Hypothesis was considered reasonable but need for data on polar bear harvest to evaluate properly. Group identified need to analyze data from existing NWT Wildlife Service monitoring program. These data should also be supplemented with information on development activities in region and ice data.	Detailed evaluation At present level of offshore activity by petroleum industry in Beaufort Sea, it was concluded that hypothesis is unlikely. No specific research or monitoring program requirements identified. However, group emphasized recommendation concerning need to monitor the Alaskan subsistence harvest.	Review of research ---	Review of research ---	Review of research ---	Requires re-evaluation during BREAM. Hypothesis review. Detailed evaluation. Considered unlikely; no changes in wording necessary.	Overview Designated BREAM R7. Given development scenario, not considered necessary to re-evaluated hypothesis

Table 4.1 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 21 Tanker traffic and minor oil spills associated with the westward transport of Canadian Beaufort oil will cause reductions in the Western Arctic population of bowhead whales and/or the harvest of this population by the Alaskan Inupiat.				Detailed evaluation Hypothesis 21 developed and evaluated during workshop. Participants concluded it was valid but most of its links were unlikely to occur at the level of shipping activity envisioned. Further testing of hypothesis unjustified and no research or monitoring recommended.	Review of research Integration of existing data on bowheads to examine possible effects of hydrocarbon development activities. Analysis of data provides information that supports previous conclusions regarding links 5-7.	Hypothesis review Hypothesis valid but not inherited by BREAM because development scenario does not include westward tanker traffic.	
MEMP 19 Vessel traffic will decrease the harvest of white whales.			Detailed evaluation Possible but unlikely in view of present levels of vessel traffic and associated mitigative practices for scheduling of traffic. Group supported continuation of current monitoring program. If development plans change and the potential for interference with white whale harvest increases, scope of monitoring programs should be evaluated.	Review of research One project of relevance to this hypothesis. This study involves summarization of industrial activity during 1986 in the Beaufort Sea and Mackenzie Delta, including: seismic and sounding; vessel activities; aircraft activities; and research activities.		Hypothesis review Requires re-evaluation during BREAM. Hypothesis considered possible but unlikely. Should be combined with BEMP 2.	MEMP 19 merged with BEMP 2 to form new BREAM hypothesis $2 (see above)

Table 4.1 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BREAM 31 Development activities will change the harvest of bowhead whales.							Detailed evaluation new hypothesis developed in response to resumption of bowhead whaling off Yukon coast in 1991 by Inuvialuit. This hypothesis addresses the effects of offshore activities on bowhead harvest. Group concluded that hypothesis is valid and noted that any negative effects on the harvest would be considered a significant effect by the Inuvialuit. Could be mitigated by imposing scheduling on vessel traffic and locations of stationary structures. No new programs recommended since effects could be mitigated, but supported continuation of DFO monitoring/sampling program on bowhead hunt.

4.1.2 Results of Evaluation

The results of the evaluation of each of these hypotheses are presented below.

BEMP 1 (renamed BREAM R1)

The basis of this hypothesis is that industrial activities (noise from offshore islands, platforms, ships) will create exclusion zones for bowhead whales due to avoidance behaviour. This will both interfere with feeding and cause increased energy expenditure leading to an energy deficit that will threaten the survival of individual whales and the ability of bowheads to reproduce. This hypothesis has been the most controversial and most repeatedly examined (five times) hypothesis in the BEMP process. During the period since the inauguration of BEMP, numerous research and monitoring studies have been proposed and conducted to acquire the data necessary to evaluate the various links in the hypothesis where existing information was considered inadequate.

The most recent data suggest that the emphasis on the energetics of the overall bowhead whale population in summer was misdirected. The energetic consequences, on adults and sub-adults, of disturbance and exclusion during summer seem to be of relatively minor importance to the population. The most recent data do, however, indicate that virtually the entire population of age four or five cohorts may be affected by industrial activity. These young whales obtain only about one third of their energy requirements on the summering grounds, and it is obvious that these whales are under intense energetic stress (for example, virtually no growth occurs in the first four or five post-weaning years). The effects of exclusion of these age classes from summer feeding areas remain unknown. New data on the low reproductive rates and the long period required to attain sexual maturity indicate that the population would have a slower recovery rate than originally anticipated. Overall, the working group concluded during the last evaluation of this hypothesis in 1991/92 that the logic of the hypothesis remains valid and that the specific links of the hypothesis are also valid (INAC 1992). If industrial activity affected the entire population of four-or five-year cohorts, then the results would be considered significant.

BEMP 2 (renamed BREAM R2)

a) Offshore structures will reduce the white whale harvest;

b) Frequent icebreaker traffic in the landfast ice will increase white whale harvest;

c) Open water ship traffic in the Mackenzie River Estuary will alter white whale distribution and lead to changes in harvest levels.

This hypothesis was designed to evaluate the effects of the presence of offshore and coastal facilities and ship traffic on the breakup of landfast ice, thereby leading to an alteration in beluga whale distribution that could then result in changes in harvest levels. This was a very high profile hypothesis because of the importance of the beluga harvest to residents within the Inuvialuit Settlement Region. Disturbance in beluga hunting areas was and still is an issue of great concern to the Inuvialuit hunters. Beluga whales are known to swim away from approaching ships, although the distances at which the whales react, and the distances that they travel in response to a ship, are radically different in various parts of the Arctic. These differences apparently depend on habitat, activities of the whales, experience of the whales, and type of vessel.

During the 1991/92 BREAM workshop, the Working Group concluded that less emphasis should be placed on the linkages dealing with changes in the timing of ice breakup because development scenarios at the time involved few offshore structures that could anchor the landfast ice and little icebreaker traffic to enhance breakup (INAC 1992). The principal concerns related to disturbance caused by vessel traffic and by offshore and coastal facilities in and near the beluga hunting grounds in Kugmallit Bay, Niakunak Bay and the Kendall Island area. It was also concluded that a reduction in the beluga harvest would be of significant concern to the Inuvialuit. However, appropriate controls on the timing of vessel traffic and the locations of permanent facilities could prevent these disturbance-induced reductions in the harvest of belugas. The existing Beaufort Sea Region Management Plan addresses these issues.

It was noted at the 1991/92 workshop that several studies funded for 1992 and 1993 would provide relevant new information for this hypothesis (INAC 1992). These include studies (1) quantifying the distance at which beluga whales respond to various ship noises; (2) on the movements of beluga whales between shallow estuaries and offshore feeding areas and movements between the two main summering areas in Kugmallit Bay and Niakunak Bay using satellite tags; (3) using aerial surveys to estimate the size of the

Beaufort Sea beluga whale population; and (4) on numbers and movements of beluga whales in the Mackenzie Delta area.

BEMP 3 (renamed BREAM R3)

This hypothesis focusses on the cumulative effects of vessel, seismic, dredging, aircraft and platform activities on the energy balance of ringed and bearded seals through: (1) reductions in the amount of time available for feeding; or (2) increased energy costs due to avoidance behaviour. A negative energy balance could then lead to reduced reproduction rates in ringed and bearded seal populations.

This hypothesis was first evaluated during BEMP (INAC and Environment Canada 1984). At that time, the workshop participants concluded that the hypothesis was valid, but that the cumulative effects of all hypothesis links would probably be inconsequential and too difficult to detect due to natural variability in population levels. The same conclusions were also reached when the hypothesis was re-evaluated during the 1984/85 BEMP workshop (INAC and Environment Canada 1985). Subsequent to this, a number of research studies were conducted which provided additional data for the evaluation of the hypothesis. For example, studies conducted by DFO since 1981 have shown no correlation between densities of hauled-out seals and proximity to industrial activities. Results of studies also lead to the conclusion that habitat exclusion resulting from the physical presence of offshore structures and marine vessel traffic would be insignificant at both individual and population levels, whereas the energetic costs associated with avoidance and diving responses to aircraft overflights would also be inconsequential from a regional perspective (INAC and Environment Canada 1988). Most recently (BREAM 1990-91), it was decided that a re-evaluation of the hypothesis was unnecessary because no new information relevant to the hypothesis was available. It was concluded that the hypothesis remains valid, but is untestable (INAC 1991).

BEMP 7 (renamed BREAM R6)

This hypothesis is based on the fact that some of the polar bears that encounter active structures or facilities will have to be destroyed for human safety reasons. This mortality of polar bears will lead to a reduction in the harvest of polar bears.

The hypothesis and its linkages were considered valid at the 1983-84 BEMP workshop and upon re-evaluation in 1985 (INAC and Environment Canada 1984, 1985). It was noted that personnel on drill rigs continued to report the coincidence of bears with offshore structures, but that consistently few bears were killed. Although the need to destroy problem bears occurs infrequently in the Beaufort Region, it is still perceived as a potentially significant additive mortality factor in the polar bear population, augmenting natural mortality and population decreases associated with the native harvest. As the harvest of polar bears by the Inuit is thought to be at the maximum sustainable level, significant additional mortality through the need to destroy problem bears could lead to a reduction in present quotas. It has been further noted that considerable progress has been made in the development of methods for detecting and deterring polar bears. Recent research on detection techniques has focussed on microwave and infrared instruments, whereas polar bear deterrent studies have involved further evaluation of the effectiveness of the rubber bullet gun, plastic slugs fired from a shotgun, and sound-producing devices.

Participants in the 1985 workshop re-confirmed support for research on polar bear detection and deterrent techniques, as well as the possible use of certain detection instrumentation developed for census measuring purposes with marine mammals. Considerable concern was expressed regarding the unknown status of the unregulated Alaskan subsistence polar bear harvest, which is focussed on females with cubs. Recent research indicates that polar bears from Cape Bathurst to Point Barrow belong to the same breeding population, although subpopulations are thought to exist. Consequently, it was believed essential to obtain better information on the Alaskan harvest, lest any future declining numbers of polar bears in the Beaufort Region be erroneously attributed to either the Canadian harvest or industrial impacts.

Given that other studies conducted during the period 1985-1987 have provided data which suggests stable population size and reproductive parameters for polar bears in the Eastern Beaufort Sea and Amundsen Gulf, and that the killing of problem bears has been infrequent, it was concluded that polar bear mortality associated with active facilities would not likely be a serious concern unless the level of industrial activity increased substantially beyond that which is outlined in the most recent development Scenarios.

BEMP 8 (renamed BREAM R7)

This hypothesis suggests that reduced harvest of polar bears will result from decreased access by Inuit hunters caused by (1) extension of the offshore boundary of the landfast ice zone due to construction of offshore islands and (2) physical barriers caused by icebreaker traffic.

In the 1983/84 BEMP workshop, this hypothesis was considered to be unlikely at the proposed level of activity in the Beaufort Sea (INAC and Environment Canada 1984). It was also noted that during the time period when polar bears are harvested, icebreaker tracks would quickly refreeze and thus were unlikely to impede hunter travel over the landfast ice. Consequently, no research or monitoring was recommended. Subsequent evaluations of the hypothesis have reaffirmed the original evaluation.

BEMP 21

This hypothesis was developed and evaluated during the 1986-87 BEMP workshop to consider a development scenario that includes the seasonal transport of oil from the Canadian Beaufort Sea in a westward direction off the coast of Alaska (INAC and Environment Canada 1987). It suggests that tanker traffic and minor oil spills that occur during the transfer of oil will cause a reduction in the size and catch per unit effort of the fall bowhead hunt by the Alaskan Inupiat.

The working group concluded that BEMP 21 was a valid hypothesis but most of its linkages were unlikely given the level of shipping activity outlined in the development scenario (i.e., direct mortality from collisions or through entrapment in false leads; disruption of social behaviour; reduced reproductive success as a result of oil spills). Although the possibility of calves becoming separated from cows as a result of tanker-related disturbances was also considered unlikely, the group suggested further study to determine the ranges at which behavioural responses are likely to occur.

It was concluded that tanker traffic could also reduce the size and ease of the fall harvest of bowheads through offshore displacement of the bowhead migration. Recent studies have shown that bowheads disturbed by vessels in shallow water tend to move into deeper water. However, it was considered unlikely that this directional displacement would occur at depths that tankers would operate (> 20 m). It was also noted that any behavioural response of bowheads to tanker-related disturbance would be very difficult to detect. Given the cultural importance of the fall hunt, it was suggested that further research should be undertaken to assess the potential detectability of changes in bowhead migration routes resulting from an Alaskan tanker corridor and other industrial developments.

During the 1990-91 BREAM program, it was decided that a re-evaluation of the hypothesis was unnecessary because tanker traffic was no longer envisioned in the most current development scenario (INAC 1991).

MEMP 19 (renamed BREAM R2)

This hypothesis was evaluated for the first time as part of MEMP in 1985-86. It suggests that vessel traffic in Kugmallit Bay, which is frequented by beluga whales, will directly interfere with hunting activities by reducing the time available for hunting. This would lead to decreased beluga whale harvest. Although this hypothesis was considered theoretically possible, the workshop participants judged it to be unlikely because of the low expected levels of vessel traffic and the associated mitigative practices in place for scheduling of vessel traffic (INAC *et al. 1986).*

During the *1990/91* BREAM program, it was agreed that MEMP 19 should be merged with BEMP 2. This new hypothesis was renamed BREAM R2 and re-evaluated during the *1991/92* BREAM workshop (see earlier discussion of BEMP 2).

BREAM R31

This hypothesis was evaluated for the first time during the 1991/92 BREAM workshop. This was necessitated by the resumption of bowhead whaling off the coast in September 1991 by Inuvialuit from Aklavik. The basis of the hypothesis is that vessel traffic, seismic exploration or the presence of occupied offshore islands and platforms and coastal facilities will (1) reduce the time available for hunting by directly interfering with hunting activities or (2) disturb bowhead whales and change their distribution and availability in potential hunting areas. In either case, the change in the distribution of bowhead whales will affect the harvest.

Evaluation of the hypothesis led to the conclusion that it was valid. (INAC 1992). The workshop participants also concluded that if the bowhead whale harvest was affected negatively by industrial activity, then the Inuvialuit would consider this to be a significant impact. It was thought that effective mitigative measures could be put in place for each hypothesis link. These would include imposing temporal and spatial restrictions on vessel traffic and by imposing restrictions on the locations of stationary structures where possible.

Although the workshop participants did not recommend any new research or monitoring because the effects were thought to be mitigable with known techniques, they did recommend that DFO continue to monitor the bowhead whale hunt and to collect tissue samples. Important information to be collected would include the areas used for the hunts and the number of whaling crews involved.

4.2 ICEBREAKER TRAFFIC

4.2.1 Introduction

In the early 1980s, the development scenario for the Beaufort Sea included a transportation option for year-round tanker-icebreaker traffic from the production area through Amundsen Gulf and into Prince of Wales Strait. To address concerns regarding potential effects of icebreaking activities on marine mammals, four impact hypotheses were developed for BEMP and evaluated during the 1983/84 and 1984/85 project workshops (INAC and Environment Canada 1984, 1985), While BEMP Hypotheses 4, 5 and 6 focussed specifically on impacts of icebreaking activities on ringed and bearded seal populations through reduced pup production, mortality of pups and food chain effects, BEMP 2 addressed the potential effects of various industry-related activities (including icebreaker traffic) on beluga populations and their harvest (Table 4.2).

BEMP 2: Various facilities and activities associated with offshore hydrocarbon development will affect the white whale harvest.

BEMP 4: Increased frequency of icebreaker traffic through the landfast ice and through Amundsen Gulf will reduce ringed seal pup production and have subsequent effects on population levels.

BEMP 5: Icebreaker traffic in the transition (shear) zone will reduce bearded seal pup production.

BEMP 6: Icebreaker traffic in Amundsen Gulf will affect the ringed seal and polar bear populations, BREAM R4: Increased frequency of icebreaker traffic through the landfast ice will reduce ringed seal pup production and population levels.

Table 4.2
Icebreaker Traffic

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 2 Various facilities and activities associated with offshore hydrocarbon development will affect the white whale harvest.	Detailed evaluation Sub-hypothesis b (Links 2-4: effects of icebreaker traffic in landfast ice) considered valid but unlikely given development scenario. Continued monitoring of white whales, and ice-breakup patterns recommended. Research into factors influencing whale distribution within Niakunak and Kugmallit bays also required.	Detailed evaluation Validity of hypothesis confirmed but less emphasis should be placed on Links 2-4. Advanced breakup as a result of icebreaker traffic was considered unlikely in view of scenario. Previously recommended research considered unnecessary due to adequate data base.	Review of research Information collected on ice conditions and timing of break-up and effects of ice breaking on ice regime of Admiralty Inlet provide information relevant to this sub-hypothesis.	Review of research No new research relevant to sub-hypothesis b.	Review of research New study initiated to examine behaviour of white whales to ship traffic and icebreakers at the Admiralty Inlet ice edge. Monitoring of white whales continued.	Hypothesis review Sub-hypothesis b considered valid but unlikely. No changes to wording necessary.	Detailed evaluation Hypothesis merged with MEMP 19 to form new BREAM Hypothesis (R2) which includes effects on white whale harvest, barge traffic, and global climate change. Subhypothesis b theoretically valid but not a concern given scenario involves limited icebreaker traffic and does not include icebreaking in Kugmallit and Niakunak bays.
BEMP 4 Increased frequency of icebreaker traffic through the landfast ice and through Amundsen Gulf will reduce ringed seal pup production and have subsequent effects on population levels.	Detailed evaluation Small-scale alterations to the ice regime in a ship's path and noise-related exclusion of pupping females from vicinity of tracks were both considered possible but effects on pup production and pup mortality not expected to be regionally significant. Remote possibility of large-scale destabilization of Amundsen Gulf ice cover due to icebreaking. However, could be an area of significant concern. Further research into potential for large-scale destabilization recommended.	Detailed evaluation Hypothesis remains valid but areas of ringed seal breeding habitat lost as a result of icebreaker traffic would be small in relation to total available habitat in region. Direct losses of pups would occur but would likely be small proportion of total pup production. Much research into pup production and ice destabilization not possible until some traffic occurs in Gulf. Continued collection of satellite imagery recommended.	Review of research Results of study on effects of icebreaker traffic on ice regime of Admiralty Inlet (see BEMP 2) relevant to this hypothesis. Study indicated icebreaker traffic may have advanced break-up by one or two days be was tithing normal variability.	Review of research No new research relevant to this hypothesis.	Review of research No new research relevant to this hypothesis.	Hypothesis review Linkages dealing with effects of icebreaker traffic in landfast ice on ringed seal pup production and population levels considered unlikely and not worth testing. Linkages dealing with effects of traffic in Amundsen Gulf valid and testable but removed from hypothesis because not within development scenario.	Summary Hypothesis inherited by BREAM (R4) but not evaluated during workshop. Wording changed to remove reference to Amundsen Gulf. No further work necessary. Hypothesis concluded to be valid but insignificant and untestable.

Table 4.2 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 5 Icebreaker traffic in the transition (shear) zone will reduce bearded seal pup production.	Detailed evaluation Level of understanding regarding bearded seal vocalizations and their importance in determining mating success and pup production is inadequate to either accept or reject hypothesis, but unlikely that effects on production would be detectable. Icebreaker traffic would probably result in mortality but losses expected to be insignificant. Research directed at bearded seal vocalizations not a high priority, and monitoring to determine effects of icebreaking on pup production not considered justifiable or practical.	Detailed evaluation No new research conducted since last workshop. Hypothesis still considered valid. No research or monitoring recommended.	Review of research No new research conducted.	Review of research No new research relevant to this hypothesis.	Review of research No new research relevant to this hypothesis.	Hypothesis review Hypothesis considered valid but too difficult to detect change.	Inherited by BREAM (R5) but no action required.
BEMP 6 Icebreaker traffic in Amundsen Gulf will affect the ringed seal and polar bear populations.	Detailed evaluation The hypothesis that icebreaker traffic through Amundsen Gulf will move stable ice edge to the east and lead to food chain effects was considered possible but unlikely. Changes in productivity and distribution of lower trophic levels would be smaller than natural variation and would likely be dampened before affecting higher trophic levels. Analysis of existing data on ice and ringed seals in Beaufort region needed to examine hypothesis further.	Detailed evaluation Hypothesis still probably valid. Studies of ringed seals and polar bears expected to provide data relevant to upper linkages of hypothesis. Many uncertainties related to arctic cod and its trophic relationships in the region.	Review of research Studies on arctic cod and its importance to arctic food chains to provide information on spatial and temporal patterns in abundance and distribution, which in turn affect ringed seal food consumption, seal population dynamics and therefore polar bear populations.	Review of research Ongoing study of Mackenzie shelf fisheries habitat expected to increase understanding of energy flow in the Beaufort Sea and trophic relationships among components of system. Study on the abundance and distribution of arctic cod directly relevant to this hypothesis.	Review of research Continuation of fisheries habitat and arctic cod research.	Hypothesis review Development scenario does not involve tanker traffic. Therefore hypothesis not inherited by BREAM.	---

4.2.2 Results of Evaluation

In the Beaufort Sea region, stable ice areas important for ringed seal pupping occur along the west coast of Banks Island, in northern Amundsen Gulf and in southern Prince of Wales Strait. Tankers moving between the Beaufort production zone and Parry Channel would pass through areas of high pup production, while certain fast ice areas in the Beaufort Sea would also be traversed by icebreakers and ice-strengthening supply vessels. Icebreaking vessels operating in the landfast ice and through Amundsen gulf could reduce the amount of pupping habitat through small-scale alteration of the ice regime in the ship's path and noise-related exclusion of pupping females, and could cause direct mortality of ringed seal pups (BEMP 4). However, these potential losses are expected to insignificant from a regional perspective. While icebreaker traffic could cause large-scale destabilization of the Amundsen Gulf ice cover, which would lead to a major reduction in the amount of ringed seal pupping habitat, evidence suggests that this is only remotely possible (INAC and Environment Canada 1985).

Effects of icebreaker traffic on ringed seal and polar bear populations indirectly through food chain-related effects and directly through alterations in ice type, coverage and location (BEMP 6) was considered possible but unlikely (INAC and Environment Canada 1985). Changes in primary productivity and distribution of flora and fauna at lower trophic levels due to icebreaking activity was expected to be small (i.e., relative to natural variation) and would likely be dampened before affecting members of higher trophic levels such as ringed seals and polar bears. Icebreaking could affect ringed seals by changing the ice so that seals are excluded from the icebreaker tracks, but only small amounts of habitat are expected to physically affected by icebreaking operations.

The bearded seal inhabits loose and broken-ice areas and breeds on the ice surface within the transition zone of the Beaufort Sea. Since these areas are also likely to be the preferred corridors for shipping traffic (including icebreakers), icebreaking activities in this zone during late April to early May could reduce mating success by interfering with vocalizations and result in direct mortality of some pups (BEMP 5). While there is no evidence to suggest that alterations of vocalization rates could reduce mating success, there is some anecdotal evidence of direct mortality of seals due to icebreakers. However, give that the period of vulnerability of seal pups is only 2 or 3 days after birth and that the area of pupping habitat potentially affected by icebreaking activity would only be small proportion of the total available habitat in the region, any losses of bearded seal pups would likely be insignificant at the population level (INAC and Environment Canada 1985).

Sub-hypothesis b of BEMP 2 addresses the concern that icebreaker traffic in the landfast ice in spring will advance break-up of ice barriers across Kugmallit and Niakunak bays, which will influence the timing of entry, numbers and duration of residence of beluga whales and, in turn, influence the harvest of this resource. While icebreaking activities could enhance disintegration of the final ice remnants across these bays and allow earlier access to white whales, icebreaker traffic is not envisaged for either of the areas because they are too shallow for large icebreaker (Class 2) operations. Icebreaking vessels would operate out of shorebases located outside the Mackenzie Estuary (e.g., King Point, Stokes Point, McKinley Bay). However, it was noted that if the development scenario changed to include construction of a shorebase on the Yukon coast, a limited amount of icebreaking would be required in Niakunak Bay during spring (INAC and Environment Canada 1985).

4.3 NEARSHORE STRUCTURES

4.3.1 Introduction

In the early to mid 1980s, the hydrocarbon development scenario for the Canadian Beaufort Sea did not include construction of causeways to other nearshore structures that would have the potential to cause large-scale alterations to nearshore oceanographic regimes. However, based on experience in the Alaskan Beaufort, there were concerns that if development plans changed in the future, the potential existed for shoreline modifications that would cause disruptions to the movement and migration patterns of broad whitefish and Alaskan arctic cisco and subsequent reductions in these fish populations. Two impact hypotheses (BEMP 14 and 15) were developed to evaluate the potential effects of nearshore structures on broad whitefish and arctic cisco (Table 4.3).

BEMP 14: Nearshore structures will disrupt the nearshore band of warm brackish water and reduce the broad whitefish population.

BEMP 15: Nearshore structures will disrupt the nearshore band of warm brackish water and reduce the Alaskan population of arctic cisco.

Table 4.3
Nearshore Structures

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 14 Nearshore structures will disrupt the nearshore band of warm brackish water and reduce broad whitefish populations.	Detailed evaluation Insufficient data to reject or accept hypothesis. Scenario did not include structures that would have potential to alter nearshore oceanographic conditions. No research and monitoring required at the time, but recommendations should be re-examined if development plans change.	Detailed evaluation Links added to consider effects of changing slope of sea bottom. Validity of hypothesis could not be refuted on basis of available information. Studies of Prudhoe Bay causeway indicate nearshore structures could conceivably cause changes in distribution of broad whitefish. A broad-based study on oceanographic conditions in the area was recommended.	Review of research A study of the ARCO causeway at Prudhoe Bay provides direct evidence of effects of nearshore structures on fish distribution.	Review of research. Research conducted by DFO on seasonal movement patterns, habitat preferences and individual stock attributes of broad whitefish lended support to one or more of the linkages in this hypothesis.	Review of research Continued work by DFO lends further support to this hypothesis.	Hypothesis review Considered to be valid and testable but not inherited by BREAM because the development scenario did not include construction of a causeway.	---
BEMP 15 Nearshore structures will disrupt nearshore band of warm brackish water and reduce Alaskan population of Arctic cisco.	Detailed evaluation Hypothesis linkages could not be proved or disproved on basis of existing information. No strong evidence for rejection of overall hypothesis. Oceanographic research (currents, wind, temperature and salinity) and investigations of cisco movements along Yukon coast recommended.	Detailed evaluation Increasing indirect evidence that causeways are affecting fish distributions in Alaskan Beaufort lended support to Link 2 and therefore strengthened validity of hypothesis. Lack of temperature/salinity data within a few hundred metres of shore identified as serious information deficiency. Low level study to examine regional differences in vulnerability of areas to shoreline modifications recommended.	Review of research Review of recently-completed and ongoing research lended further support to hypothesis. A study on the effects of the ARCO causeway at Prudhoe Bay provided evidence that the causeway did result in altered distribution of small Arctic cisco; work by DFO indicated Alaskan Arctic cisco do originate from the Mackenzie River.	Review of research A DFO study to assess Yukon North Slope fish habitat is expected to provide information that would verify or disprove the underlying assumption of this hypothesis (i.e., Alaskan Arctic cisco spawn in the Mackenzie River and juveniles then migrate along the Yukon coast to spend a number of years in Alaskan waters before mature fish return to spawn).	Review of research Studies conducted along the Yukon North Slope and Alaskan Beaufort Sea provided information to verify this assumption.	Hypothesis review Considered valid and testable but not inherited by BREAM because causeways were not envisioned within the development scenario.	---

4.3.2 Results of Evaluation

BEMP hypotheses 14 and 15 were evaluated during the 1983/84 and 1984/85 project workshops (INAC and Environment Canada 1984, 1985). Although it was concluded in both years that there were insufficient data to reject or accept the overall hypotheses, results of studies conducted near the ARCO causeway at Prudhoe Bay lended support to the linkages that nearshore structures could cause changes in longshore flow and temperature and salinity regimes of the warm brackish water band along the Tuktoyaktuk Peninsula and the Yukon coast. The effects of the changes on broad whitefish and arctic cisco would, however, be highly dependent on both the nature of the coastal development and physical characteristics of the shoreline environment at the location of the facility. The location and type of structure (i.e., causeway, wharf, jetty) would have a major influence on its physical and subsequent biological effects, while site-specific oceanographic conditions (e.g., seafloor slope, T/S gradients, currents) would further influence the nature and degree of the impact. It was suggested that different areas along the coast of the southeastern Beaufort Sea would vary in their vulnerability to changes in temperature/salinity characteristics due to broad regional differences in the slope of the seafloor and prevailing currents, but that the potential for disruption of the nearshore T/S patterns would probably be greater along the Yukon coast than the Tuktoyaktuk Peninsula due to the influence of the Mackenzie River plume.

Studies conducted in the Mackenzie Delta area and the Alaskan Beaufort Sea indicated that broad whitefish and arctic cisco appear to be prefer warm, brackish waters in the nearshore and that the most likely factors determining these distribution patterns are temperature and salinity, although other factors such food availability, bottom slope and currents very likely override these primary stimuli for a least short periods of time. While arctic cisco appear to be considerably more tolerant of cold marine waters than broad whitefish, alterations to their distribution patterns could conceivably result in a loss of feeding time or increased mortality due to salinity· induced stress. However, due to a lack of appropriate baseline data on nearshore oceanographic conditions, and habitat, seasonal movement patterns and stock attributes of these species, it was not known if relatively minor or even pronounced effects of nearshore structures could be reflected in reduced population sizes or harvest levels. Over the next three years of BEMP, the results of a number of studies conducted by the Department of Fisheries and Oceans (Freshwater Institute) provided further information related to these fish populations, which lended support to the validity of these hypotheses linkages.

Neither BEMP Hypothesis 14 or 15 were re-evaluated as part of BREAM because the development of causeways and other nearshore structures were still not considered within the development scenario (INAC 1991).

4.4 DREDGING OPERATIONS

4.4.1 Introduction

In 1983, the hydrocarbon development scenarios for the Beaufort Sea involved substantial amounts of dredging to facilitate construction of offshore drilling platforms and subsea pipelines. Although it was agreed during the introductory sessions of BEMP (1983/84) that dredging may be an important area of concern in some parts of the region, this subject was not addressed at the first interdisciplinary workshop because of time constraints associated with each of the working group sessions, An impact hypothesis dealing with the effects of dredging and dredge spoils on marine mammals (BEMP 19) was, however, formulated and evaluated outside the workshop, and later critically reviewed by a number of BEMP participants (INAC and Environment Canada 1984)" The hypothesis underwent further evaluation the following year as part of the 1984/95 BEMP workshop (INAC and Environment Canada 1985; Table 4.4).

By the early 1990s, the most likely scenario for Beaufort/Mackenzie development changed to include construction of a gas processing plant at Taglu on Richards Island and one at Parsons Lake on the mainland to develop the three largest gas reserves in the Delta (Niglintgak, Taglu and Parsons Lake). As part of the Parsons Lake scenario, construction materials for the gathering systems and plant facility would be transported to the site either overland from the Mackenzie River during winter or by water via Liverpool Bay and the Husky Lakes during the open water season. While both modes of transport would be technically feasible, the use of a natural waterway (dredging where necessary) was assumed to be the most likely option. As a result of the expanded geographic scope of BREAM, changes made to the development scenario since the last BEMP workshop in 1986/87, and concerns related to the effects of dredging on fish resources in the Husky Lakes, a new impact hypothesis was developed for BREAM (Hypothesis R32) and evaluated at the first project workshop in 1991/92 (INAC 1992).

Table 4.4
Dredging Operations

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 19 Dredging and deposition of spoils will reduce the bearded seal population.	Evaluation Hypothesis and written text prepared and critically reviewed outside workshop. Hypothesis considered to be valid but unlikely. Relationships among factors that ultimately limit bearded seal populations poorly understood. Significant impacts could result in areas very close to the foreshore or in confined areas that are important habitats of benthic or demersal resources.	Detailed evaluation On the basis of worldwide experience regarding effects of dredging operations and the anticipated level and locations of dredging required in the Beaufort Sea, this hypothesis was considered unlikely. Opportunistic sampling of seal livers for heavy metals recommended because of possible link to human health.	Review of research A nearshore benthic monitoring program is expected to provide information related to effects of dredging on benthic invertebrates in Tuktoyaktuk Peninsula and undisturbed populations in other bays.	Review of research No new information of direct relevance to this hypothesis.	Review of research No new information of direct relevance to this hypothesis.	Hypothesis review Hypothesis considered to be valid but untestable.	Inherited by BREAM (R14), but not evaluated in project workshop. No changes to wording or structure of hypothesis necessary.
BREAM R31 Dredging to facilitate barge access to the Parsons Lake Gas Field will result in a decline in the Husky Lakes lake trout population.						Hypothesis review Due to changes in the development scenario, a new hypothesis was developed to deal with the effects of dredging in Husky Lakes on the lake trout population.	Detailed evaluation Dredging project of this nature would probably be referred to an EIRB and possibly an EARP review. Alternate modes of transporting construction materials would be most desirable.
BREAM R12 The construction of shorebases, pipeline landfalls, and development of shallow-water production fields will result in a decrease in the populations of Arctic cisco and broad whitefish.							Detailed evaluation BEMP 16 revised to include effects of nearshore dredging and trenching on movements of fish in nearshore areas. Effects were expected to be localized, short in duration and insignificant in terms of population effects. No research or monitoring needs were identified.

During the 1991/92 BREAM program, BEMP Hypothesis 16 was revised to include potential effects of nearshore dredging and trenching on the movements of fish in the nearshore area. The original hypothesis focussed primarily on effects of production waste discharges on fish populations (see Section 4.6) and did not consider pipeline landfalls, which was now part of the development scenario. This revised hypothesis (designated BREAM R12) was subsequently evaluated during the project workshop held that year (INAC 1992).

BEMP 19: Dredging and dredge spoils will reduce the bearded seal population.

BREAM R32: Dredging to facilitate barge access to the Parsons Lake gas field will result in a decline in the Husky Lakes lake trout population.

BREAM R12: The construction of shorebases, pipeline landfalls, and development of shallow-water production fields will result in a decrease in the populations of arctic cisco and broad whitefish.

4.4.2 Results of Evaluation

Loss of Habitat and Contaminant Exposure

BEMP Hypothesis 19 and its associated linkages state that dredging and deposition of spoil will Cause a reduction in the bearded seal population as a direct result of: (1) increased' concentrations of suspended solids within the water column; (2) mortality of benthic invertebrates and fish, and loss of habitat; and (3) the release of contaminants from sediments. While it was concluded by BEMP workshop participants that each of these pathways are generally valid, they are unlikely to be areas of significant concern in the Beaufort Sea given the anticipated intensity and locations of dredging required for development in the region (INAC and Environment Canada 1985). There is little doubt that dredging activities can increase suspended sediment concentrations beyond normal background levels, and that removal of the surface layer of the seafloor and its deposition in other areas will cause mortality of benthic organisms and to a lesser extent fish. However, the spatial and temporal extent of these effects are relatively limited. Increased turbidity is usually confined to an area within 500 m of dredging activities and only persists for brief periods of time. In most shallow areas along the Beaufort Sea coast (<: 5 m depth), natural processes and sediment input from the Mackenzie River would tend to mask any increases in suspended solids due to dredging operations. Effects of spoil removal and deposition on benthos, fish and their habitat would also be small relative to the regional population and available habitat in the Beaufort Sea, and would be limited primarily to the areas of direct physical disturbance. While this could represent a significant loss if a unique benthos or fish population was affected, no such population is known to exist in the Beaufort Sea.

The release of contaminants from sediments during dredging and disposal operations and subsequent uptake by fish and benthos is possible but is usually very limited. No significant long-term increases in contaminant concentrations in the water column have been observed at dredging sites, and uptake and accumulation of contaminants into tissues of benthos and fish have been rarely reported. While it is possible that a limited number of individual organisms could accumulate contaminants to concentrations significantly above background, it was considered unreasonable to expect that this could lead to measurable reductions in the populations of fish and benthic invertebrates and subsequent reductions in the population of bearded seals. (The effects of contaminants from production activities is addressed in Section 4.6).

Migration Barrier

BREAM R12 states that broad whitefish populations will be affected by dredging and trenching operations in nearshore areas and coastal embayments as a result of loss of access to important feeding and overwintering habitats, and mortality of young-of-the-year fish due to salinity and temperature-induced stress. The nearshore band of warm brackish water serves as a critical migration corridor for broad whitefish to coastal streams, which provide access to feeding and overwintering habitat. Participants of the *1991/92* BREAM workshop concluded that these effects would likely be inconsequential due to the short duration of and limited requirement for trenching and dredging operations, the opportunity for selecting less sensitive time windows, and the tolerance of fish to short-term exposure to high levels of suspended solids (INAC 1992).

While BEMP 19 and BREAM R12 were considered unlikely given the estimated levels of dredging identified in the development scenario, the potential effects of dredging on lake trout populations in Liverpool Bay and Husky Lakes were considered to be an area of greater concern (BREAM R32). This hypothesis focusses on the effects of increased suspended sediment concentrations, changes in bottom profile, and subtidal, shoreline and nearshore slumping on spawning habitat, benthic biomass, and feeding efficiency of lake trout. A number of realistic assumptions regarding the nature, location and timing of a potential dredging operation in Liverpool

Bay/Husky Lakes were made in order to evaluate the validity of this hypothesis. However, a link-by-link evaluation of BREAM R32 was never completed because it became evident that a project of this nature would probably be referred to an EIRB and, possibly, an EARP review, and would not likely receive approval. In addition to environment concerns related to dredging within the area, it was also noted that this project would be an area of considerable concern to regional residents since Liverpool Bay and Husky Lakes is culturally a high profile area.

No research or monitoring needs were identified in relation to BEMP 19, BREAM R12 or BREAM R32. However, it was suggested that seal livers be sampled, on an opportunistic basis, because of the possible link between bioaccumulation of heavy metals in bearded seal livers and human health.

4.5 CHRONIC (EPISODIC) OIL SPILLS

4.5.1 Introduction

Oil spills that occur as a result of normal hydrocarbon development activities in the Beaufort Sea and Mackenzie Valley are largely restricted to fuels that are used in various shorebased and offshore operations. Future sources of chronic spills could include shorebases (diesel, slops), offshore drilling and production facilities (diesel, crude, lubricants and other wastes) and subsea/onland pipelines, and gathering systems (crude). To address concerns related to the potential increase in frequency of spills and their effects on birds and marine mammals, a total of four impact hypotheses were developed for BEMP and MEMP (Table 4.5). BEMP Hypothesis 9 focussed specifically on the polar bear, while the remaining hypotheses (BEMP 10, 11 and MEMP 10) dealt with waterfowl (INAC and Environment Canada 1984,1985; INAC *et al. 1986).*

During the *1984/85* BEMP workshop, BEMP 10 and 11 were combined to form one hypothesis. It was noted that BEMP 11 was a special case of BEMP 10 and, therefore, could be included as part of this more general hypothesis. Many of the linkages in Hypothesis 11 were found to be invalid or improbable during the 1983/84 workshop (e.g., effects of particulate emissions and fugitive dust on formation of open water; and effects of moving ice on open water surrounding offshore structures). Consequently, these linkages were not incorporated into the new BEMP hypothesis 10.

In 1991/92, all three of the remaining hypotheses were inherited by the BREAM program. While it was not considered necessary to evaluate these as part of this new initiative, BEMP and MEMP Hypotheses 10 were merged to form a new BREAM hypothesis (R9), which would address the potential effects of chronic oil spills in both marine and freshwater environment on waterfowl and waterbirds. A preliminary assessment of BREAM R9 was completed during the 1991/92 BREAM workshop to determine the significance of the potential impacts addressed by this hypothesis (INAC 1992).

Table 4.5
Chronic (Episodic) Oil Spills

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 9 Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of polar bears.	Detailed evaluation Potential for polar bears to contact oil exists but number of animals affected would probably be limited. Group identified information deficiency related to behavioural responses of polar bear to oil-covered waters and prey, but recognized the public/political opposition a study of this nature would receive.	Detailed evaluation Hypothesis remains valid. Group recommended: (1) continued support of polar bear deterrent research; (2) extending objectives of Polar Bear Action Plan or development of new plan to include other marine mammal species and to address opportunistic research and monitoring; and (3) encouraging publication of the Action Plan report.	Review of research Two studies expected to provide an improved understanding of the behaviour and fate of oil in peak ice.	Review of research ---	Review of research ---	Hypothesis review Hypothesis considered valid.	Inherited by BREAM (R8). Hypothesis reworded to include reduced harvest levels but no need to re-evaluate. Adequate information exists, no further work required.
BEMP 10 Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of certain bird species.	Detailed evaluation Hypothesis considered valid, but significance of oil-induced mortality on population levels uncertain. Group recommended an opportunistic monitoring of short-term and long-term effects of chronic spills.	Detailed evaluation BEMP 10 and 11 combined. Four studies discussed in terms of new information, but it was concluded that none of these provide results that change the validity of the hypothesis or its linkages. Infrequency of spills and lack of reports of bird mortality do not appear to necessitate implementation of a monitoring program.	Review of research New information from physical studies that describe processes that could influence the fate of spilled oil.	Review of research ---	Review of research ---	Hypothesis review Hypothesis considered valid. Substantial body of new information relevant to this hypothesis.	Preliminary assessment BEMP 10 and MEMP 10 consolidated to form new BREAM hypothesis (R9). New information supports earlier conclusion of validity and, therefore, no need to re-evaluate at workshop. Potential impacts of spills on migrating waterfowl insignificant during normal and extreme ice years. Effects on feeding/staging/ moulting birds would also be insignificant. No research or monitoring recommended.

Table 4.5 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 11 Oil slicks in open-water areas around offshore structures during normal periods of ice cover will cause increased mortality of eiders and diving ducks.	Detailed evaluation Valid but group concluded that it would be impractical to design a specific monitoring program to test this hypothesis.	BEMP 11 combined with BEMP 10, and no longer exists in its original form (see above).					
MEMP 10 Chronic/episodic spills of crude oil and diesel fuel near staging and moulting areas of nesting colonies will reduce the abundance of waterfowl.			Detailed evaluation Sufficient information to accept hypothesis. However, chronic spill unlikely to cause significant mortality of waterfowl. Group recommended systematic monitoring program if frequency or volume of spills increase substantially, and supported ongoing documentation in oil spill reports of oil-contaminated birds.	Review of research Studies either recently completed or ongoing to provide information on: (1) effects of dispersants and dispersed oil on birds; (2) ecological characteristics of 35-year old crude oil spills in tundra plant communities; and (3) key bird areas in coastal regions of the Canadian Beaufort Sea.		Hypothesis review Hypothesis considered valid. Substantial body of new information relevant to this hypothesis.	MEMP 10 merged with BEMP 10 (see above)

As part of the BREAM program, BEMP hypothesis 9 underwent slight modifications to include a linkage related to reduced harvest levels of polar bears as a result of chronic oil spills. This new BREAM hypothesis (R8) was not evaluated during the 1991/92 workshop because participants agreed that adequate information existed to validate this hypothesis.

BEMP 9: Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of polar bears.

BEMP 10: Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of certain bird species.

BEMP 11: Oil slicks in open-water areas around offshore structures during normal periods of ice cover will cause increased mortality of eiders and diving ducks.

MEMP 10: Chronic/episodic spills of crude oil and diesel fuel near staging and moulting areas of nesting colonies will reduce the abundance of waterfowl.

BREAM R8: Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of polar bears and reduced harvest levels.

BREAM R9: Chronic (episodic) oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the aquatic environment will result in mortality and decreased productivity of certain species of waterbirds.

4.5.2 Results of Evaluation

Polar bears could be affected by chronic spills associated with routine activities of development either directly through fouling following contact with surface slicks or indirectly through consumption of oil during grooming or ingestion of contaminated prey (BEMP 9). Although fouling with oil as a result of swimming through oil-covered waters has not been documented in the wild, the potential for direct contact would be high due to their occurrence in areas near offshore facilities and artificial islands, their attraction to sources of human activity, and the time spent swimming (often at considerable distances from shore). While fouling could lead to mortality as a result of hypothermia (loss of insulative capacity of the fur), the actual extent of fouling would depend on a number of factors. These include: (1) whether or not a bear would actually swim through oil-covered waters; (2) the potential for repeated contact with surface slicks; (3) the type, thickness and viscosity of the oil; and (4) the amount of oil trapped in the fur. Ingestion of oil through grooming and consumption of oil-contaminated carcasses and prey (fish and seals) was also considered possible (INAC and Environment Canada 1984, 1985). Although participants noted that little is known about the behavioural responses of polar bears to oil-contaminated waters and prey, it was concluded that the number of bears affected by chronic oil spills would be small, and probably not significant at a population level unless the population is being hunted at maximum sustainable yield.

During the BEMP and MEMP workshops, it was concluded that chronic/episodic oil spills would likely cause mortality of seabirds and waterfowl under certain circumstances (BEMP 10 and 11, MEMP 10). The effects of oil on birds has been well documented and include: (1) physical effects on thermoregulatory capacity and buoyancy; (2) toxic effects of petroleum hydrocarbons ingested during preening or feeding activities; and (3) contamination of eggs. However, the combination of circumstances which may lead to mortality (i.e., volume of spill, oil type, time of year, slick thickness and movement, and behaviour of birds), and the significance of oil-induced mortality on populations levels was uncertain. Because there are few locations in the Mackenzie Valley were concentrations of waterfowl could be exposed to oil from chronic spills, it was concluded that most waterfowl species would not be expected to be at major risk. Waterfowl were considered most susceptible to oil spills during the period of spring migration when they are attracted to areas that are (or appear to be) open water. Nevertheless, for most species (except snow geese which tend to congregate in large numbers in small areas of open water), the number of individuals contacting oil slicks was expected to be small in relation to the regional population.

Although predicted hydrocarbon development levels in the Beaufort Sea and Mackenzie Delta Valley did not justify recommending laboratory and experimental oil spill research programs directed at birds, working groups of the 1983/84 and 1984/85 BEMP workshops and 1985/86 MEMP workshops did support continuation and close scrutiny of oil spill reports of contaminated wildlife.

A preliminary assessment of BREAM Hypothesis R9 (combined BEMP 10/11 and MEMP 10) during the 1991/92 workshop supported these earlier conclusions regarding the significance of oil-induced mortality of waterfowl. This working group also concluded (using a worst-case scenario involving the release of 10 bbls of diesel from the Atkinson platform at a time when a large number (15,000 -20,000) of moulting birds are in Hutchinson

Bay) that mortality of feeding/staging/moulting birds as a result of open water oil slicks would likely be insignificant on bird population levels given the percentage of the populations affected and their recovery potential.

4.6 CONTAMINANTS

4.6.1 Introduction

The potential for hydrocarbon and heavy metal contamination and subsequent decrease in the palatability of harvested fish and potability of water was expressed as areas of potential concern in relation to hydrocarbon production activities in the Beaufort Sea and Mackenzie Valley regions. These concerns existed because of: (1) existing and possible use of fish and potable water; (2) reports of possible deterioration of fish quality in the Mackenzie River; and (3) experience with tainting elsewhere in the world. In response to these concerns, two Impact hypotheses were developed (BEMP 13 and MEMP 15; Table 4.6). While BEMP 13 dealt solely with the potential effects of release of these contaminants from shorebases and shallow-water production facilities on fish harvests (INAC and Environment Canada 1984, 1985), MEMP 15 addressed both potential tainting as well as effects on the potability of water (INAC at al. 1986). Both of these hypotheses were later inherited by BREAM in 1991192, and underwent revisions to include contaminants from both local and distant (LRTAP) sources (INAC 1992).

A third impact hypothesis (BEMP 16) was developed to specifically address the potential for attraction of fish to thermal plumes created by warm water effluent discharges from production facilities and subsequent effects on population levels. These effects included: (1) exposure to elevated levels of hydrocarbons and heavy metals leading to direct mortality and reduced growth; and (2) aggregations of fish leading to reduced food availability and increased metabolic stress. BEMP 16 was evaluated at both the 1983184 and 1984/85 BEMP workshops (INAC and Environment Canada 1984, 1985). By the 1991192 BREAM program, BEMP 16 was considered too restrictive in its project activity definition and underwent major revisions to address concerns related to pipeline landfalls and the possible interference of coastal fish migrations as a result of nearshore dredging and construction activities (see Section 4.4). This revised hypothesis (R12) was examined at the 1991192 BREAM workshop (INAC 1992).

Table 4.6
Contaminants

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 13 Shorebases and shallow-water production facilities will release hydrocarbons and heavy metals at sufficient levels such that fish harvest will be reduced through tainting and heavy metal accumulation.	Detailed evaluation Hydrocarbon tainting in fish unlikely to be a significant concern except in sheltered bays where subsistence fishing takes place, substantial numbers of fish are present for a relatively long time, and hydrocarbons are used on a daily basis. Hypothesis valid for mercury, but unlikely that sufficient quantities of heavy metals would be used in Beaufort hydrocarbon development. Recommended time series measurements of hydrocarbon concentrations in fish flesh in Tuk Harbour.	Detailed evaluation Hypothesis still considered valid and an area of relatively high profile, particularly those links leading to hydrocarbon tainting of fish. Federal government agencies collected data on hydrocarbon and trace metals in sediments and biota in several areas of Beaufort Sea. Recommended comparative analysis of these data to identify areas where elevated body burdens can be correlated with contamination of sediments, and conduct of taste test program. Results of ESRF study on tainting also considered a priority.	Review of research Study initiated in Tuktoyaktuk Harbour to detect effects of potential contaminants.	Review of research ---	Review of research NOGAP project (Beaufort Sea oceanography) to provide a better understanding of the natural hydrocarbon distributions and primary productivity in the oil exploration zone of the Mackenzie River estuary. Results of Tuk Harbour benthic monitoring program show accumulations of hydrocarbons in flounder. However, unknown whether these concentrations would affect fisheries since this species is not harvested.	Hypothesis review Hypothesis (designated BREAM R11) considered valid but reworded to include contaminants derived from air emissions and to remove referenced to human health. Active area of research but no need to re-evaluate in 1992 workshop.	Preliminary assessment Hypothesis designated BREAM R11. Effects of hydrocarbons and heavy metals on fish would likely be significant due to perception/fear of taint and effects on human health. Effect would be regional and both short term (single event) and long term (chronic exposure). Recommended research into metal levels in fish and marine mammals of western Arctic, and conduct of a taste testing program.
BEMP 16 The construction of shorebases and shallow production fields will result in a decrease in the populations of Arctic cisco and broad cicso.	Detailed evaluation Hypothesis considered extremely unlikely and not worth further consideration if wastes are discharged in water deeper than 5 m.	Detailed evaluation Hypothesis re-evaluated in light of change in development scenario (possible production from Adgo field in >5 m water depth). However, considered unlikely due to small volumes of effluent expected from Adgo.	Review of research Study on broad whitefish habitats in Mackenzie Delta and importance of area for feeding.	Review of research ---	Review of research ---	Hypothesis review Need to re-evaluate hypothesis due to new information and concerns related to shorebases. Wording changed to include reference to pipeline landfall, brackish water, and effects on fish movements.	Detailed evaluation Inherited by BREAM (R 12). Effects of development of shallow-water production fields and activities associated with pipeline landfalls/shorebases on whitefish and cisco would be insignificant due to localized nature and short duration of effects.

Table 4.6 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 20 The discharge of cuttings contaminated with oil-based drilling muds during development of shallow-water production facilities will reduce populations of Arctic cisco, broad whitefish and lake whitefish and will also decrease the harvest of these species due to hydrocarbon accumulation (tainting).		Detailed evaluation New hypothesis developed due to possible use of oil-based muds for certain applications. Tainting of anadromous fish could occur as a result of ingesting contaminated benthos. Although considered both valid and testable from a site-specific perspective, effects would be insignificant from a regional perspective. Recommended review of ESRF tainting study.	Review of research Workshop cancelled. Hypothesis reworded to include marine mammals and birds. Several studies on effects of oil-based drilling fluids.	Detailed evaluation Accumulation of hydrocarbons in fish, birds and marine mammals through ingestion of contaminated benthic prey organisms and subsequent reductions in these populations considered highly unlikely and would not justify monitoring. Effects on habitat and bioaccumulation and biomagnifications considered valid and testable on site-specific basis. Research needed on fate of oil-contaminated cuttings, hydrocarbon baseline data, identification of critical habitats, oxygen demand of oiled cuttings, and downhole generation of PAHs.	Review of research Several research and monitoring programs related to use of oil-based drilling muds in Beaufort Sea initiated.	Hypothesis review Hypothesis valid and testable. No changes to wording necessary.	Inherited by BREAM (R 15) but not re-evaluated at workshop.

Table 4.6 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 15 Water discharges and accidental oil/chemical spills will lead to unpotable water and decreased acceptability of fish as a food source.				Detailed evaluation Based on current and anticipated levels of activity in the region, considered unlikely that waste discharges and accidental spills could lead to unpalatable fish and unpotable water. However, any local effects could be significant. Subgroup recommended continuation of a DFO monitoring program to determine contaminant levels in burbot and whitefish as well as an EPS monitoring program to determine natural and anthropogenic contributions to contaminant levels in the Mackenzie River.	Review of research Study on the flux of suspended particulates, hydrocarbons and trace metals from the Mackenzie River provides data to better estimate natural loading of contaminant chemical species. Result of this study and a study of freshwater impacts from Norman Wells broadens understanding of hydrocarbon/fish interactions in the Mackenzie and the flux of hydrocarbons in the river. Assessment of the performance of abandoned sumps provides data to support link 2 of hypothesis. Study on fish quality does not unequivocably link Norman Wells development to deterioration in fish quality.	Hypothesis review Considered unlikely but local concern. No changes in wording necessary.	Detailed evaluation Hypothesis (designated R26) revised to include long-range atmospheric transport of contaminants and to remove reference to potable water. Potential for taint or perception of taint considered significant. Subgroup identified need to determine relative importance of local and LRTAP sources for contaminants in region and identification of major contaminant pathways.

During the 1984/85 BEMP program, a new impact hypothesis (BEMP 20) was formulated due to the possible use of oil-base drilling fluids for delineation and development drilling in the Beaufort Sea and its potential effects on fish populations and their harvest. While it originally focussed on fish species (broad whitefish, lake whitefish and arctic cisco), it's scope was broadened to also include birds and marine mammals (INAC and Environment Canada 1985,1987), BEMP 20 was inherited by BREAM in *1991/92* (designated R15), but was not re-examined as part of this program.

BEMP 13: Shorebases and shallow-water production facilities will release hydrocarbons and heavy metals at sufficient levels such that fish harvest will be reduced through tainting and heavy metal accumulation.

MEMP 15: Waste discharges and accidental oil/chemical spills will lead to unpotable water and decreased acceptability of fish as a food source.

BEMP 20: The discharge of cuttings contaminated with oil-based drilling muds during development of shallow-water production facilities will reduce populations of fish, birds or marine mammals or will decrease the harvest of these resources due to hydrocarbon accumulation in tissues.

BEMP 16: The construction of shorebases and development of shallow-water production fields will result in a decrease in the populations of arctic cisco and broad whitefish.

BREAM R12: The construction of shorebases, pipeline landfalls, and development of shallow-water production fields will result in a decrease in the populations of arctic cisco and broad whitefish.

BREAM R26: Contaminants from local and distant sources will lead to decreased acceptability and availability of fish as a food source.

Due to the technical nature and more detailed treatment of some of these hypotheses, the following provides a summary of the conclusions reached during the evaluations of each of the four hypotheses. Readers that are interested in the technical details are referred to the annual BEMP, MEMP and BREAM reports referenced above.

4.6.2 Results of Evaluation

Effect of Hydrocarbons and Heavy Metals on Potable Water

Increased contaminant concentrations in subsurface waters could occur as a result of: (1) direct discharge of contaminants to rivers, streams and lakes; (2) discharges to treatment ponds; and/or (3) terrestrial spills. Contaminants in subsurface waters could enter surface waters via springs or in areas of river banks, cliffs and slumps, and lead to increased contaminant concentrations if those compounds are present in higher concentrations within the groundwater. During the 1985/86 MEMP workshop, it was considered possible that this could lead to unpotable water (INAC *et* at. 1986). However, the likelihood of this occurring would depend on the scale of activities. Using the Norman Wells refinery as an example, it was concluded that the potential inputs of oil and grease from refinery effluent would not likely be sufficient to cause the water in the Mackenzie River to become unpotable, except on a very local scale. However, it was uncertain whether waste characteristics observed at Norman Wells were representative of those that may occur in the future, and it was noted that a better estimate of natural and anthropogenic contributions to contaminant levels in the river are needed to properly assess this impact. In the following year' of MEMP, the results of a monitoring program directed by Environmental Protection Service provided data to determine a mass balance for hydrocarbons within the Mackenzie River in the vicinity of Norman Wells.

During the 1991/92 BREAM program, MEMP Hypothesis 15 (designated BREAM R26) was revised to remove reference to the effects of contaminants on potable water because potable water did not satisfy the definition of a Valued Ecosystem Component (INAC 1992).

Effects of Hydrocarbon/Heavy Metal Accumulations on Fish Populations and their Harvest

Hydrocarbons and heavy metals are released into marine and freshwater environments from oil production facilities as a result of accidental chronic or episodic spills and intentional releases associated with normal operations. During the evaluation of both BEMP 13 and MEMP 15, it was concluded that fish could accumulate hydrocarbons through direct uptake from water, sediment and contaminated prey organisms which could lead to decreased acceptability of these fish as a food source for local residents. Heavy metal accumulation (mercury, cadmium) in fish could also occur both directly through water and sediment as well as indirectly through the food chain, and cause a decrease in the desirability of harvested fish. However, this effect was considered unlikely because quantities of heavy metals necessary to represent an area of environmental concern would probably not be associated with hydrocarbon development in the Beaufort Sea (INAC and Environment Canada 1985; INAC *et al.* 1986). It was noted that any potential problems could be addressed through standardized compliance monitoring of waste streams and screening of materials before selection and use in the region.

Based on the current and proposed levels of hydrocarbon development in the Beaufort Sea and Mackenzie Valley regions, it was agreed that tainting from hydrocarbon accumulation would not likely occur except in: (1) sheltered bays where subsistence fishing takes place, substantial numbers of fish are present for relatively long periods of time, and hydrocarbons are used on a daily basis; or (2) around production platforms Where hydrocarbons are discharged as part of normal operations. Nevertheless, in recognition of the importance of the domestic fisheries and the fact that concerns had been expressed regarding abnormal burbot livers and soft, watery flesh in whitefish, the subgroup supported continuation of an on-going DFO monitoring program to determine contaminant levels in burbot and whitefish as well as an EPS monitoring program to determine the anthropogenic and natural contributions to contaminant levels in the Mackenzie River. It was also recommended that a time series measurement of hydrocarbon concentrations in fish flesh be initiated in Tuktoyaktuk Harbour. If this study indicates significant increases in hydrocarbon concentrations or if complaints of tainting occur, the group recommended that a taste test program be implemented.

Evaluation of BEMP 20 (effects of oil-based drilling muds) during the 1984/85 workshop supported earlier conclusions regarding the potential for tainting of fish as a result of hydrocarbon development activities. Specifically, it was concluded that while uptake of hydrocarbons from contaminated drill cuttings would occur in marine and anadromous fish (through ingestion of contaminated prey, absorption through the skin and absorption through the gills), this would be very limited. This is because: (1) the potential for exposure would be low due to the small *area* containing contaminated prey; (2) the duration of exposure would be relatively short and intermittent due to the mobility of fish; and (3) the total benthic biomass and, therefore, total amount of hydrocarbons available to fish in their prey would be low. Starry flounder and arctic flounder would be most likely to accumulate hydrocarbons from contaminated benthic prey but these species are not currently harvested in the southern Beaufort Sea. The likelihood that fish populations would decrease in number as a result of reductions in the availability of benthic epifauna was considered highly improbable. The main cause of decreases in the abundance of benthos would be smothering by physical burial by the cuttings and, to a lesser extent, direct toxicity of the hydrocarbons, low oxygen levels, and changes in substrate texture. However, the areal extent of the zone of smothering and toxicity would be limited to the area directly under the cutting pile, which would be small from a regional perspective.

During the 1986/87 BEMP workshop, BEMP 20 was revised to include a wider range of species, including birds, fish and marine mammals. Since the last workshop on this hypothesis in 1985, the use of Oil-based muds became a reality in the Beaufort Sea and a substantial amount of new information regarding the use, disposal and possible fate and effects of oil-based muds became available. However, the conclusions of the evaluation in regards to fish populations and their harvest did not differ significantly from those reached in the previous workshop (INAC and Environment Canada 1987). Accumulation of hydrocarbons by birds and marine mammals through ingestion of contaminated prey was also expected to be very limited. However, the potential effect on the harvest of these resources as well as fish resources was considered to be an important area of concern due to the fact that the mere perception of taint could reduce their desirability. Population effects of increased body burdens of petroleum hydrocarbons were not expected in fish, bird or marine mammal populations due to the total amount and areal extent of hydrocarbon released to the marine environment. However, severe effects could occur in individual animals. Linkages of BEMP 20 related to reductions in bird, fish and marine mammal populations as a result of reduced availability of food organism (smothering, toxic effects, oxygen depletion) were considered to be invalid given the anticipated scale of drilling operations in the region.

During the 1991/92 BREAM workshop, it was considered unnecessary to re-examine BEMP 20 (designated R15). However, BEMP 13 (R11) and MEMP 15 (R26) were re-visited due to the need to address the effects of long-range transport of atmospheric pollutants (LRTAP). These two hypotheses were reworded to include the potential effects of contaminants from both local sources (i.e., accidental spills, overflow from treatment ponds, authorized discharges) and LRTAP sources on the palatability of harvested fish. Assessment of these hypotheses led to the conclusion that the potential for taint was important on all spatial levels (i.e., site-specific, local, regional and international) and that the temporal scale of this impact can be both short term (aftermath of a single spill event) and long term (collective effects of chronic exposure) (INAC 1992). The potential for taint was considered a significant issue because of its high profile nature and the fact that it exists as a management concern even when only the perception of taint exists. The working group agreed that there was a need to determine the relative importance of local and LRTAP sources for the major contaminants (metals, petroleum hydrocarbons, PAHs and organochiorines) in the region, and to identify which contaminant pathways are most relevant to each harvest group in the area. It was also recommended that research into metal levels in fish and marine mammals of the western Arctic be implemented.

Effects of Discharges of Warm Water and Pollutants on Fish Populations

BEMP 16 addresses the potential effects of production waste discharges on arctic cisco and broad whitefish populations. These included: (1) direct mortality due to exposure to elevated levels of petroleum hydrocarbons and dissolved metals; (2) reductions in growth and reproduction due to decreases in food supply; and (3) increased metabolic stress caused by over competition for food sources. During the 1983/84 BEMP workshop, it was assumed that production drilling would result in the discharge of up to 16,000 m^3*/day* of warm (40°C), saline (60 ppt) water from a single offshore production field (> 5 m depth). (On the basis of the development scenario for the Beaufort Sea, it was assumed that this would not involve facilities sited in water depths less than 5 m.) These daily discharge rates were used to assess the potential magnitude of local changes in temperature and salinity and elevated contaminant levels, and subsequently their effect on fish populations in these areas.

During the ice-free season, the probability of thermal enhancement and increased contaminant concentrations in shallow areas (i.e., 5-15 m depth) would be extremely remote due to very high dilution rates in these high-energy environments. Contaminant concentrations would not be expected to reach levels that would be hazardous to biota, except in the immediate vicinity of the discharge site (i.e., within 200 m of the source). While concentrations could be higher during periods of ice cover, this was not expected to be an area of concern since anadromous fish are absent or few in numbers in waters greater than 5 m deep during winter. Effluent streams from production platforms in deeper waters would be diluted rapidly and effects on biota would be minimal.

During the 1984/85 BEMP and 1991/92 BREAM workshops, BEMP 16 was re-evaluated in light of possible production from the Adgo field (located in water depths less than 3 m). Based on estimated amounts of production water from this field, it was concluded that impacts on broad whitefish and arctic cisco populations would be insignificant (INAC and Environment Canada 1985; INAC 1992). Although population-wide effects of production wastes were not anticipated, it was noted however that an unknown proportion of individuals migrating along or overwintering in the outer Mackenzie Delta could be exposed to production wastes in nearshore habitats. Effects on these individuals could include attraction to areas with warmer water, resultant increases in growth rates, disruption of normal movement patterns or mortality due to cold shock if thermal discharges are abruptly terminated.

4.7 MARINE AND FRESHWATER WITHDRAWAL

4.7.1 Introduction

In 1983, waterflooding was not proposed as part of the hydrocarbon development scenario for the Canadian Beaufort Sea. However, this subject was addressed during the 1983/84 and 1984/85 BEMP workshops due to potential widespread use in the Alaskan Beaufort (INAC and Environment Canada 1984, 1985; Table 4.7). Concerns related to marine water intakes focussed on the potential for loss of arctic cisco and broad whitefish as a result of impingement and entrainment (BEMP Hypothesis 17). Although the degree to which small anadromous fish may be entrained or impinged on the intake screens is unknown, losses associated with the cooling water intakes of nuclear and fossil fuel power plants suggested that this could be an area of significant concern.

During the MEMP program, one impact hypothesis (MEMP 4) was developed to address concerns related to water withdrawal from freshwater systems for hydrostatic testing of pipelines, water re-injection at production wells, and water supplies at construction camps and processing facilities. This hypothesis focussed specifically on the effects of changing water levels and distribution on muskrat populations in the Mackenzie Delta (INAC *et al*. 1986). Later as part of the 1991/92 BREAM program, this hypothesis and its linkages were restructured to include the potential effects of local land subsidence and new VECs (waterfowl, fish and semi-aquatic furbearers). This new BREAM hypothesis (R19) was evaluated during the workshop held that year (INAC 1992).

Table 4.7
Marine and Freshwater Withdrawal

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 17 Marine water intakes will reduce populations of broad whitefish and Arctic cisco.	Detailed evaluation Hypothesis considered extremely unlikely and not worth testing. Recommend review of U.S. monitoring program to determine need for re-evaluation of hypothesis in future.	Detailed evaluation Review of hypothesis led to same conclusions and recommendations as those made during previous workshop.	Review of research No new research.	Review of research No new research.	Review of research No new research.	Hypothesis review Unlikely and not worth testing.	Invalid with respect to marine water intakes. Not inherited by BREAM given current development scenario but new hypothesis developed to address freshwater intakes (see BREAM R13).
MEMP 4 Oil and gas development activities will alter the water regime and decrease muskrat populations.			Detailed evaluation First two primary linkages were considered invalid, therefore entire hypothesis invalid. No research or monitoring recommended.	Review of research Several studies on muskrat habitat characteristics, and the Mackenzie Delta ecosystem provide information with which to evaluate upper linkages of hypothesis.	---	Hypothesis review Rationale for previous conclusion of validity needs to be reviewed. Remove reference to permanent elevated roads and change VECs to semi-aquatic furbearers, fish and waterfowl.	Detailed evaluation MEMP 4 restructured to include new VECs and local land subsidence. New hypothesis (R19) considered valid. (See Section 4.13 for discussion of effects of drainage barriers and land subsidence).
BREAM 13 Water withdrawal from freshwater lakes for use in land-based production facilities will result in a reduced population of broad whitefish.						Hypothesis review New hypothesis developed for BREAM to address the effects of lake water drawdown on broad whitefish populations.	Detailed evaluation Hypothesis considered to be conceptually valid. Based on a scenario involving a requirement for 500–5000 m^3 water, effects on broad whitefish would be regionally significant and long term. Recommended continuation of hydrology work and modelling of hydrometeorlogy of selected watersheds.

By the early 1990s, the development scenario for production of oil reserves **in** the Beaufort/Mackenzie region included a requirement for large volumes of water for field flooding and smaller volumes at onshore facilities to condition and cool produced oil. A new hypothesis (BREAM R13) was developed during the 1991/92 BREAM program to address concerns regarding potential water withdrawal from lakes on Tuktoyaktuk Peninsula and Richards Island that provide important nursery, overwintering, summer feeding habitat for broad whitefish. Problems with water supply to the Hamlet of Tuktoyaktuk suggested that withdrawal of water from these lakes could cause further problems to the water supply and could potentially interrupt fish movements to these lakes.

BEMP 17: Water intakes will reduce populations of broad whitefish and arctic cisco.

MEMP 4: Oil and gas development activities will alter the water regime and decrease muskrat populations.

BREAM R13: Water withdrawal from freshwater lakes for use in land-based production facilities will result in a reduced population of broad Whitefish.

BREAM R19: Water withdrawal from hydrocarbon development and land subsidence and drainage barriers resulting from linear corridors will change the population characteristics of birds, semi-aquatic furbearers and fish.

4.7.2 Results of Evaluation

During the 1983/84 and 1984/85 BEMP workshops, it was concluded that entrainment and impingement of juvenile broad whitefish and arctic cisco at marine water intakes and subsequent reductions in these fish populations (BEMP 17) was possible but extremely unlikely given the development scenario. The only nearshore field in the Canadian Beaufort Sea that was under consideration for development at the time was the Adgo field. Consequently, most of the nearshore waters of the outer Mackenzie Delta and the nearshore zone >3 m depth) that are utilized by broad whitefish and arctic cisco would not likely be sites of water intake for waterflood projects. In addition, it was estimated that the water requirement for a field the size of Adgo would be only a fraction of that required for the larger Alaskan nearshore fields (100 m^3/d vs. 320,000 m^3/d), which are expected to result in only small (if any) declines in the populations of broad Whitefish and arctic cisco. (INAC and Environment Canada 1985). However, water withdrawal from freshwater lakes on Tuktoyaktuk Peninsula and Richards Island for land-based production facilities could be much greater than that envisioned for the Adgo field (500–5000 m^3/d) and could potentially cause significant impacts on broad whitefish that utilize these lakes for feeding and overwintering (BREAM R13; INAC 1992).

Streams that drain the lakes are relatively shallow, are characterized by shallow sills at the lake outlets and are frequently clogged with coastal drift wood. Under normal conditions, fish passage to and from some of the Peninsula lake systems has often been recognized as a problem. Water withdrawal from the lakes could further restrict access of broad whitefish to their feeding habitat and food supply, and could result in winterkills when flow into and out of the lakes ceases. While the extent of reduced access and mortality of fish would depend on the rate and duration of water use, it was concluded that a requirement of 500–5000 m^3 water could result in a reduction in the population of broad whitefish that use these lakes. The recovery potential was, however, considered to be high due to the fact that broad whitefish do not exhibit a high degree of fidelity to their summer feeding habitat and reinvasion by broad whitefish from other coastal watersheds would likely occur. It was recommended that alternate sources of water supply be used where removal for field flooding and/or processing would have inconsequential effects of broad whitefish (e.g., Husky Lakes, coastal waters, Mackenzie River).

During the 1985/86 MEMP workshop, it was concluded that the effects of freshwater withdrawal on water flow patterns and consequently muskrat habitat in the Mackenzie Delta (MEMP Hypothesis 4) would be inconsequential (INAC et *al.* 1985). It was noted that air rather than water would likely be used as a medium for testing the integrity of small-diameter pipelines. If water testing was required for large diameter, high-pressure pipelines, larger streams and lakes or shuttle testing would be used to minimize the effects on water levels. Water injection at production wells could require large amounts of water, however, this is not expected to result in large-scale changes to water levels because most of the production facilities would be located adjacent to large water bodies. Similarly, water required for construction camps would typically be taken from mainstem Mackenzie River channels.

Because both of the primary linkages of MEMP 4 (Link 1 -changing water flow patterns; Link 2 -creation of drainage barriers) were consider invalid or inconsequential, the remaining links of the hypothesis were not evaluated, and no further research or monitoring programs were recommended. (See Section 4.12 for discussion of potential land subsidence). However, this hypothesis was re-examined during the 1991/1992 BREAM program in its revised form (i.e., VECs expanded to include fish, waterfowl and semi-aquatic furbearers; BREAM R19).

Evaluation of BREAM R19 led to the conclusion that although large water bodies along the pipeline route and adjacent to production facilities would provide the water required for hydrostatic testing, water re-injection and camp supply, it is conceivable that smaller streams and lakes could be utilized when these are the only available sources of water (INAG 1992). It was concluded that water withdrawal from these systems could reduce water levels and flow, which in turn could affect ice and thermal regimes. However, the significance of these changes to the abundance and distribution of waterfowl, furbearers and fish could not be assessed due to the lack of specific information regarding volumes and sources of water required.

4.8 OVERFLIGHTS

4.8.1 Introduction

Helicopters and fixed-winged aircraft are a necessary mode of transportation in the Canadian Arctic, and are used regularly by the petroleum industry in the Beaufort Sea and Mackenzie Valley/Delta regions. Concerns regarding the potential effects of disturbances caused by aircraft overflights on marine mammal and bird populations were the focus of four impact hypotheses (BEMP 3, BEMP 12, MEMP 7 and MEMP 8; Table 4.8). While BEMP 12 focussed specifically on the effects of frequent low-altitude overflights on staging brant, the remaining three hypotheses were much broader in their scope and dealt with various activities associated with hydrocarbon development. BEMP 3 and BEMP 12 were evaluated during the 1983/84 and 1984/85 BEMP workshops, and the results of these evaluations are presented in INAC and Environment Canada (1984, 1985). MEMP 7 and MEMP 8 were assessed during the first and final MEMP workshop held in 1985/86 (INAC *et* al. 1986).

BEMP 3: Marine vessel activities, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of ringed and bearded seal populations in the Beaufort Sea.

BEMP 12: Frequent low altitude aircraft flights over staging brant will cause increased overwinter mortality.

MEMP 7: Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.

MEMP 8: Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.

BREAM R10: Activities associated with hydrocarbon development will affect the abundance and distribution of aggregations of staging, moulting and nesting birds.

Table 4.8
Overflights

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 3 Marine vessel traffic, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of the Beaufort Sea populations of ringed and bearded seals.	Detailed evaluation Noise from aircraft overflights could disturb hauled-out seals and lead to increased energy costs (Link 7). However, the effects of this increase would be insignificant in a regional context. No research or monitoring programs were recommended.	Detailed evaluation Observations of seal behaviour following aircraft overflights was inconclusive. Hypothesis link still considered to be valid but effects on energy balance would likely be insignificant from a regional perspective.	Review of research No new information of direct relevance to this hypothesis linkage.	Review of research A seal monitoring study conducted from 1981 to 1984 supports the conclusion that energetic costs associated with avoidance and diving responses to overflights would be inconsequential.	Review of research No new information of relevance to this hypothesis linkage.	Hypothesis review Hypothesis considered to be valid but either too hard to detect or not worth testing. No changes to wording of hypothesis or its linkages necessary.	Summary Inherited by BREAM (R3) but not re-evaluated in project workshop because development scenario does not warrant additional work.
BEMP 12 Frequent low altitude aircraft flights over staging brant will cause increased overwinter mortality.	Detailed evaluation Possible disturbances caused by low-level aircraft overflights would probably have little or no measureable effect on the physiology of staging brant. Hypothesis considered to be invalid. No research or monitoring programs were recommended.	Hypothesis invalid, not re-evaluated.	Review of research No new information.	Review of research No new information.	Review of research No new information.	Hypothesis review Hypothesis considered invalid but should be reviewed in light of expanded geographic scope of BREAM and current development scenario.	Summary BEMP 12 already addressed by MEMP 7 within the broader context of increased energy costs to birds by aircraft disturbance. Hypothesis merged with MEMP 7 (see below).

Table 4.8 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 7 Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.			Detailed evaluation Link 1 (increases in aircraft overflights will increase disturbance to waterfowl) was considered valid. However, the effects of disturbance on nesting success would likely be minor. Displacement of birds from critical habitat and increased energy costs during moulting and fall migration would be unlikely given the development scenario and aircraft operating conditions.	Review of research Recent studies conducted during Norman Wells Project indicate major source of disturbance being twin- and single engine fixed-winged aircraft, helicopters and some ground-based sources. However, in general development activities during spring had only minor and local impacts on staging waterfowl. Distribution and abundance of waterfowl affected more by environmental factors. Other studies initiated that will provide information relevant to hypothesis.		Hypothesis review MEMP 7 considered possible but difficult to detect. No changes in wording necessary.	Summary MEMP 7 merged with BEMP 12 to form a new, more comprehensive hypothesis (BREAM R10). This hypothesis addresses effects of overflights on staging, moulting and nesting birds, and also included effects of gas compressor noise on these aggregations. New hypothesis not evaluated in workshop because adequate information exists to support conclusion of validity.
MEMP 8 Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.			Detailed evaluation Persistent aircraft activity at low altitudes could disturb nesting raptors (Link 7) and lead to decreased reproductive success (Link 8). However, the likelihood of this occurring would be small give the anticipated location of development in the region and available mitigative measures. No research or monitoring programs to address these linkages were recommended.	Review of research Four-year monitoring program expected to provide information on effects of IPL activities on nesting raptors.		Hypothesis review Hypothesis considered valid. No changes to wording considered necessary.	Summary Hypothesis inherited by BREAM (R22). New information available to better predict effects but does not alter conclusion of validity.

4.8.2 Results of Evaluation

The likelihood of low altitude aircraft overflights causing changes in the distribution and abundance of marine mammals and birds through displacement and increased energy costs would be highly dependent on the species, time of year, and the level and persistence of exposure. Given the development scenarios for the region, it was concluded by BEMP, MEMP and BREAM workshop participants that population effects on staging brant would be extremely unlikely and that effects on ringed and bearded seals would probably be inconsequential from a regional perspective (INAC and Environment Canada 1985; INAC *et al.* 1985; INAC 1992). However, effects of aircraft overflight disturbances on nesting, staging and moulting birds could range from local to regionally significant. The justification for these conclusions is presented below by hypothesis.

Ringed and Bearded Seals

BEMP Hypothesis 3 addresses the concern that the cumulative effects of marine vessel traffic, active offshore platforms and aircraft noise could affect the energy balance of ringed and bearded seals by reducing the amount of time available for feeding and/or by increasing energetic costs through avoidance behaviour. Hauled-out seals have been reported to dive in response to overflights by low-flying aircraft, however, reactions of individuals to repeated overflights have not been studied. During the 1983/84 BEMP workshop, it was suggested that seals repeatedly overflown could either react by vacating the area or would become habituated to the disturbance. Opportunistic recordings of dive responses have not provided conclusive data on the potential for habitat exclusion or the level of aircraft activity and flight altitudes that may elicit such a response. However, it was concluded that, at the level of industry activity envisioned for the region, energetic costs associated with avoidance or diving responses would probably be insignificant from a regional perspective.

Although no research or monitoring program related to this hypothesis was recommended by the workshop participants, results of a 4-year seal monitoring program initiated in 1981 (prior to BEMP) were reviewed as part of the 1986/87 BEMP program (INAC and Environment Canada 1987). This study examined whether oil and gas industry activities in the Beaufort Sea were causing any detectable effects on the abundance and distribution of ringed seals in the region. While this study provided information that is directly relevant to Link 1 of BEMP Hypothesis 3 (i.e., effects of active offshore platforms/islands), results of this work also lend support to the conclusion that the cumulative effects of all links in this hypothesis would probably be inconsequential.

Waterfowl

Links 1 and 5 of MEMP Hypothesis 7 address potential disturbance to nesting, staging or moulting waterfowl as a result of aircraft overflights. During the 1985/86 MEMP workshop, it was noted that the susceptibility of waterfowl to disturbance by aircraft varies with the species, time of year, type of aircraft and altitude of the overflight. For example, white-fronted geese and snow geese appear to most sensitive to overflights, whereas whistling swans seldom show any disturbance response. Given development plans for the region and regulations regarding aircraft operating conditions, it was concluded that aircraft disturbance would likely have only minor effects on the nesting success of colonial waterfowl (geese) and solitary nesting species. The potential for displacement of waterfowl from spring staging areas and interference with feeding, courtship and nesting was considered to be unlikely since: (1) the majority of feeding by spring migrating geese occurs on the prairies and therefore areas on the Mackenzie River are of less relative importance at this time; and (2) spring staging habitat along the Mackenzie River is extensive and only a small portion of it is likely to be affected by development activities. On the other hand, moulting waterfowl (both non-breeders and adults with young) would be most vulnerable to aircraft disturbance since these birds are physiologically stressed and flightless during the moult.

Moulting geese react quickly to any disturbance by massing into tight flocks on water or by running overland. Although they normally return to feeding activities shortly after the disturbance has stopped, disturbances that persist for extended periods of time could cause serious effects on the usually continuous feeding activity of flightless geese. Given the development scenario, the group concluded that persistent disturbance by aircraft would not likely occur and that increased energy costs due to avoidance behaviour would likely be inconsequential. Any effects on moulting geese would be difficult, if not impossible, to measure and distinguish from the effects of natural events.

Possible disturbances of staging brant from low-level aircraft flights were examined through BEMP Hypothesis 12 (INAC and Environment Canada 1984). The rationale for consideration of this hypothesis was the assumption that staging brant may be affected by overflights through a mechanism similar to that documented for snow geese. However, unlike snow geese which appear to be very susceptible to disturbance by low-flying aircraft and stage in very large numbers in a few relatively discrete areas along the coast, brant typically remain in staging and feeding areas for no more than a day or two and are apparently only temporarily displaced by disturbance by aircraft. Consequently, it was concluded that possible disturbances caused by low-level overflights across anyone of these staging areas at any given time would probably have little or no measurable effect on the physiology (e.g., fat accumulation) of staging brant. BEMP participants, therefore, concluded that this hypothesis was invalid and did not warrant further evaluation during the 1984/85 BEMP program. No monitoring program related to this hypothesis was recommended because it was believed that such a program would be impractical and would provide only limited relevant information.

BEMP Hypothesis 12 was subsequently reviewed as part of the 1990/91 BREAM program, and consolidated with MEMP 7 (the more comprehensive of the two hypotheses) to form BREAM R10 (INAC 1991). The rationale for merging these hypotheses was that specific issues dealing with energy expenditures, fat loss and increased winter mortality of brant due to aircraft disturbance was already addressed by MEMP 7 within the broader context of increased energy costs to birds caused by various disturbances associated with hydrocarbon development. This new BREAM hypothesis was later revised to include all bird species with the exception to raptors (the focus of MEMP 81 BREAM R22), and reviewed during the 1991/92 BREAM workshop (INAC 1992).

It was not considered necessary to evaluate the validity of BREAM R10 during the project workshop because adequate information existed to support the previous conclusions of MEMP participants (i.e., MEMP 7). The potential impacts of industry-related disturbances on staging, nesting and moulting birds are well documented in the literature and further research was not considered necessary at the time. However, the workshop group did assess the significance of the potential impacts caused by industry-related disturbances and concluded that the effects of aircraft overflights, vessel traffic and stationary facilities on staging, moulting and some nesting could be significant and long term.

Raptors

MEMP Hypothesis 8 addresses the potential impacts of aircraft overflights on raptors within the broader context of all the various industry-related disturbances. Several species of raptors in the Arctic have high national and international profiles because of their relatively low numbers in the region and their general rarity elsewhere in North America, and there was concern that hydrocarbon development in the Mackenzie Delta and Valley could jeopardize the viability of these populations. Disturbance at raptor nest sites could potentially cause: (1) nest abandonment: (2) egg loss due to insufficient incubation or accidental knocking of the egg from the nest by the adult; (3) chick mortality due to abandonment; and (4) decreased fitness of young due to insufficient feeding during the nestling stage or premature fledging. Although the likelihood of this occurring would depend on the level and persistence of the overflights and the ability of the species to habituate to the disturbance, decreased reproductive success due to disturbance at nesting sites was considered possible. However, given the widespread distribution of raptor nests and the localized nature of aircraft disturbances expected in view of the development scenario, MEMP participants concluded that reductions in reproductive success of raptors due to aircraft-related disturbances would likely be local and insignificant in terms of the regional population. Participants of the 1991/92 BREAM workshop confirmed the validity of the hypothesis but concluded that losses of raptors due to the cumulative effects of all industry-related disturbances would likely be significant and long term given the small size of raptor populations in the region. No research or monitoring programs related to this hypothesis were recommended by the group.

4.9 AIR EMISSIONS

4.9.1 Introduction

Operation of production facilities, shorebases/support bases and camps, drill rigs, aircraft and marine vessels in the Beaufort Sea and Mackenzie Delta regions will result in a variety of gaseous and particulate emissions to the atmosphere. While a large portion of these discharges such as nitrogen, carbon dioxide, and water vapour are not considered harmful, a small portion are classified as pollutants (e.g., sulphur oxides, nitrogen oxides) and their ambient concentrations are regulated under the Ambient Air Quality Objectives established by Environment Canada. Two impact hypotheses (BEMP 18 and MEMP 12) were developed to address this concern (Table 4.9). While evaluation of BEMP 18 was the subject of a subgroup meeting and open discussion at the 1983/84 BEMP workshop (INAC and Environment Canada 1984), MEMP 12 was prepared and presented during the plenary session of the 1985/86 MEMP workshop (INAC el al. 1985).

BEMP 18: Air emissions resulting from the operation of aircraft, marine vessels, drill rigs, offshore platforms and shorebases will adversely affect air quality

MEMP 12: Air emissions resulting from oil and gas development and operation will adversely affect air quality.

4.9.2 Results of Evaluation

The primary sources of air emissions associated with exploration, production and transport of petroleum hydrocarbons in the Beaufort Sea and Mackenzie Delta regions were identified as being: (1) solid waste incineration at production facilities, marine vessels, support bases and camps; (2) diesel fuel combustion at development wells/drill rigs, support bases and camps, and by marine vessels; (3) separated gas combustion for power generation at production facilities; (4) gas flaring at production facilities; (5) fuel evaporation from tanks at support bases/shorebases; (6) natural gas combustion to power pipeline compressor stations; (7) propane combustion at support camps; and (8) aviation fuel combustion. Based on data from the Beaufort Sea -Mackenzie Delta EIS (Dome Petroleum et al. 1982), estimates were made of the quantity of pollutants emitted into the atmosphere under worst-case conditions from each of these sources. To assess the significance of these emissions on regional air quality, total emissions of each pollutant during peak production were estimated, and dispersion calculations were made to estimate the order of magnitude of ambient ground level concentrations. Comparisons of estimated maximum 24-hour ground level concentrations of the primary pollutants (CO, NO_x, SO_x, HC, TSP) with regulatory guidelines indicated that, in all cases, the regional maximum average concentrations would be well below the guidelines. Based on these analyses, it was concluded that regional air quality would not be significantly affected by production activities. No regional monitoring program was recommended.

Table 4.9
Air Emissions

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP 18 Air emissions resulting from the operation of aircraft, marine vessels, drill rigs, offshore platforms, and shorebases will adversely affect air quality.	Detailed evaluation Hypothesis considered unlikely given the anticipated quantities of air emissions associated with offshore hydrocarbon development in the Beaufort region. Design and implementation of monitoring program not warranted.	Not evaluated	---	---	---	Hypothesis review Hypothesis considered unlikely.	No action Hypothesis not inherited by BREAM because air quality not considered a VEC. Effects of contaminants from atmospheric sources considered in BREAM R11.
MEMP 12 Air emissions resulting from oil and gas development and operation will adversely affect air quality.			Detailed evaluation The hypothesis that regional air quality will be adversely affected to an extent that would warrant the design and implementation of a monitoring program was rejected.	---		Hypothesis review Hypothesis still considered invalid but should evaluate specific emissions such as ice fog.	No action Hypothesis not inherited by BREAM because air quality is not considered a VEC.

Hypotheses BEMP 18 and MEMP 12 were not addressed further through BEMP, MEMP or BREAM. During the 1990/91 BREAM program, air quality was eliminated from the suite of issues considered by the program because it was concluded that air quality monitoring would be conducted as part of the regulatory process to ensure industry complies with the environmental terms and conditions of its operating permits rather than part of effects monitoring designed to test specific impact hypotheses.

4.10 INCREASED ROAD TRAFFIC

4.10.1 Introduction

Most concerns related to the effects of increased road traffic on wildlife were focussed on barren-ground caribou (MEMP 2, BREAM R17). However, concerns for increased road kills of moose were also identified as part of MEMP 5 (BREAM R20).

The Dempster Highway was constructed to provide an all-weather road connection between Inuvik and the Klondike Highway. The highway routing crosses the Mackenzie River at Arctic Red River, then heads southwest into the Yukon through the Richardson and Ogilvie Mountains to the vicinity of Dawson City. In conjunction with probable hydrocarbon development in the Beaufort Sea and Mackenzie delta during the early and mid 1980s, it was proposed that deep-water port facilities be built on the western edge of the Mackenzie Delta at either King Point and/or Stokes Point, with the latter being the favoured location (INAC et al. 1986). An all-weather road had been suggested to provide a transportation link between King Point and the Dempster Highway, with the most probable routing being north from Fort McPherson along the northeastern flanks of the Richardson Mountains to the vicinity of Shingle Point and King Point. An alternate route was also suggested that would cross through the Richardson Mountains in the vicinity of Mount Fitton or Blow Pass. In addition, a haul road was proposed from Stokes Point and/or King Point to a quarry site at Mount Sedgewick in the northern Richardson Mountains to access construction rock for both American and Canadian operators.

A variety of concerns regarding the effects of the King Point road and the quarry haul road on the Porcupine caribou herd were addressed in MEMP 2 (Table 4.10). MEMP 2 was evaluated during the 1985/86 MEMP workshop (INAC et al. 1986), and additional information relevant to this hypothesis was collected and summarized in 1987/88

(INAC 1988). In 1991/92, BREAM participants concluded that there was a need to re-evaluate MEMP 2 (re-designated BREAM R17) since (1) a substantial body of new and relevant data was available on the Porcupine caribou herd, and (2) the construction of a road inland to Mount Fitton was unlikely. However, it was noted that the Yukon government or other industrial interests may still consider a roadway through the Richardson Mountains (e.g., Blow Pass) to the Yukon coast to stimulate tourism and industrial development along the Yukon North Slope. It was also noted that pipeline gathering systems on the Tuktoyaktuk Peninsula could obstruct movements of the Bluenose caribou herd (INAC 1992) (this concern is addressed below under linear corridors in Section 4.14).

MEMP 2: Increased traffic on the Dempster Highway and roads on the North Slope will decrease the number of caribou and alter their distribution.

MEMP 5: Oil and gas development, construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose.

BREAM R17: Hydrocarbon development in the Beaufort region and roadway development to the Yukon North Slope will alter the number and distribution of barren ground caribou and their distribution.

BREAM R20: Oil and gas development, construction, and activities and the presence of an above-ground pipeline and gathering system will change the abundance and distribution of moose.

Table 4.10
Increased Road Traffic

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 2 Increased traffic on the Dempster Highway and roads on the North Slope will decrease the number of caribou and alter their distribution.			Detailed evaluation Likely valid, particularly in relation to insect harassment; road kills could result in loss of 300 caribou per year; shifts in caribou distribution as a result of Dempster Highway could change winter distribution and success of native hunters. Recommended research on use of insect relief habitat. Also identified need for aerial surveys of caribou movements on Yukon North Slope; and documentation on road kills.	Review of research Review of relevant research (21 documents) in relation to caribou movements and industrial developments or roads (15 studies), habitat use (1 study), energy budgets (2 studies) and wolf-caribou interactions (1 study).		Hypothesis review Requires re-evaluation during BREAM. Likely valid; remove reference to North Slope as no longer part of development scenario.	Detailed evaluation Inherited by BREAM (R17). Need to re-evaluate as substantial body of new information; and development scenario modified. Effects of roads could be significant, but could be mitigated. Road kills would not be a significant effect. Need to quantify effects of insect harassment on body condition, assess factors influencing degree of insect harassment, effects of hunting on caribou response to roads, assess winter habitat quality and use. Long-term monitoring of caribou range recommended.
MEMP 5 Oil and gas development construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose.			Detailed evaluation Overall hypothesis is valid, but unlikely that seasonal distribution and energy balance would be affected. No specific research recommendations, but basic research should be continued Identified need to monitor road kills..	Review of research Total of 8 research projects reviewed in relation to moose responses to oil pipeline crossing, browse use and digestibility, winter activity patterns, and revegetation monitoring.		Hypothesis review Requires re-evaluation during BREAM. Hypothesis considered unlikely; Remove reference to above-ground pipelines (not in scenario) and develop new hypothesis for effects above-ground gathering systems on local movements.	Detailed evaluation Revised hypothesis inherited by BREAM (R20) and evaluated. As number of road kills associated with permanent roads are small, the impact of moose-vehicle collisions on moose abundance and productivity concluded to be insignificant. No further research recommended.

4.10.2 Results of Evaluation

MEMP 2 addressed several different potential effects of roadways on the Porcupine caribou herd:

- ♦ blockage or delays in the movements by a large segment of the Porcupine caribou herd to insect-relief habitat in the northern Richardson Mountains as a result of traffic on the road inland to Mount Fitton, thereby resulting in increased energetic stress (due to insect avoidance), reduced calving success, poorer meat quality and reduced quality of caribou hides;
- ♦ blockage or delays in the movements by the Porcupine caribou herd to winter habitat in the Ogilvie Mountains as a result of increased traffic on the Dempster Highway;
- ♦ increased road kills on the Dempster Highway as a result of increased traffic volumes; and
- ♦ blockage or delays in the movements by the bull and barren cow segments of the Porcupine caribou herd as a result of traffic on the road inland from King Point.

Blockage of Caribou Movements in the Richardson Mountains

Based on information on the responses of barren ground caribou to the Dempster Highway, in the Alaskan oil fields and other locations, it was concluded that frequent traffic on the road inland to Mount Fitton (or through Blow Pass) could interfere with eastward movements by some segments of the Porcupine caribou herd to the Richardson Mountains in July and August. However, because the migration is fairly rapid (i.e., 1-2 weeks) and predictable, potential impacts could be effectively mitigated through measures such as convoying of traffic or temporary closure of the roadway. As a result of these concerns, a substantial research program was undertaken to assess the movements, behaviour and energetics of the Porcupine caribou herd. A large amount of information on responses of barren ground caribou to roadways was provided by monitoring studies in the Prudhoe Bay oil field.

During the 1991/92 BREAM program, the inland roadway and associated port facilities were no longer considered within the development scenario, but there was potential that an all-weather road would be built through the Ogilvie and Richardson mountains to connect the Yukon North Slope with the Klondike Highway. Because roadways in the Prudhoe Bay oil field have been shown to delay caribou movements to insect escape terrain, it was concluded that an all-weather road in this region could significantly affect a large portion of the herd over a long time period. Evidence suggested that insect harassment in combination with severe winters can reduce calf survival the following spring. As a means of belter assessing the effects of altered caribou distributions on animal energetics and reproduction, workshops participants identified the need for research to determine (1) the factors which influence insect harassment and the degree of insect harassment to caribou; and (2) the effects of insect harassment on animal condition. Research on the relationship between habitat quality and caribou use of winter range was being completed the Canadian Wildlife Service. An assessment of the long-term effects of the highways (i.e., the Dempster Highway) on caribou distributions and habitat use was identified as being important, but not achievable due to difficulties in separating the effects of environmental factors from man-caused disturbances.

During MEMP, concerns had been expressed that increased insect harassment would lead to reductions in the quality of caribou meat and hides and, ultimately, in the harvest of animals by local residents. It was noted that because caribou are not commonly hunted during July and August when insect harassment is greatest, effects on meat quality and hides may not be an important concern. Community participants in the BREAM workshop supported this conclusion.

Blockage of Caribou Movements by the Dempster Highway

During the MEMP workshop in 1985/86, participants expressed concerns that increased volumes and frequency of traffic on the Dempster Highway would result in: (1) increased sensory disturbance and energy expenditures (with subsequent effects on reproductive success and meat quality); (2) short-term delays in crossing the highway and reaching overwintering habitat; and (3) longer-term displacement in which caribou do not cross the highway or move long distances (i.e., 10s of kilometres) before crossing. Based on evidence from studies along the Dempster Highway and elsewhere, it was concluded that sensory disturbances and small effects on energy balances, as well as short-term delays and longer-term displacement were possible (INAC et al. 1986).

During the BREAM workshop in 1991/92, concerns remained that increased traffic volumes and frequency on the Dempster highway would affect caribou movements to wintering habitats south of the highway. Recent observations of the Porcupine caribou herd in the vicinity of the highway suggested that heavier traffic volumes in combination with higher levels of hunting along the highway had resulted in a stronger avoidance of the highway by caribou than previously observed. If small-scale hydrocarbon development proceeds, it was believed that impacts on caribou would be insignificant. However, if large-scale projects proceed and large increases in traffic volumes occur, caribou movements could be delayed or even prevented. In either case, impacts can likely be mitigated by (1) regulating winter road traffic (i.e., convoys, road closures): or (2) regulating subsistence and recreational hunting adjacent to the highway. Research on habitat quality and regional use of wintering habitats by caribou, which was underway during 1992/93, should help in determining the implications of reduced access by caribou to specific portions of their range and the factors that influence Seasonal distributions of caribou.

Increased Road Kills

During the 1985/86 MEMP and the 1991/92 BREAM workshops, participants agreed that increased volumes of traffic on the Dempster highway would result in increased numbers of road kills, but that the number of kills would be insignificant in relation to the overall Porcupine caribou herd. It was recommended, however, that road kills be documented along the highway in order that mitigative measures (e.g., warning signs, speed limits, use of convoys) could be used to reduce kills at problem locations during specific time periods.

Although increased road traffic is likely to result in increased numbers of road kills of moose, participants in 1985/86 MEMP workshop concluded that only permanent roads (such as the Dempster Highway) were likely to result in serious or fatal collisions. Road conditions on the Dempster Highway would permit high speed traffic, whereas conditions on winter roads and other rights-of-way are generally poor and vehicles must travel much more slowly. No monitoring was recommended.

Blockage of Movements by the King Point Highway

As noted above, studies from other areas suggested that caribou movements can be affected by increased traffic. It was, therefore, considered possible that movements of bulls and barren cows along the North Slope to the post-calving congregations could be affected by vehicular use of a road from King Point inland to the proposed quarry site. Although workshop participants agreed that the road may affect spring movements, it was also agreed that these movements are not as important as those during the insect season. Other than annual monitoring of caribou movements to assist in the implementation of mitigation measures (e.g., convoys), no further monitoring was recommended. This potential effect was not considered further in BREAM, as development of the King Point road was considered unlikely under the development scenario for the Beaufort region.

4.11 ONSHORE DEVELOPMENT ACTIVITIES

4.11.1 Introduction

During the exploration, construction and operational phases of hydrocarbon development in the Mackenzie Valley, Mackenzie Delta and Beaufort Sea regions, there would be a large number of onshore development activities that may detrimentally affect fish, vegetation, wildlife, and resource harvesting activities, Onshore development activities and their potential impacts considered during MEMP and BREAM were as follows (Table 4.11):

♦ gravel extraction resulting in loss of denning habitat for red and arctic foxes (MEMP 1, BREAM R16) and grizzly bear (MEMP 3, BREAM R18), as well as losses of nesting habitats for some raptors (MEMP 8, BREAM R22);

♦ clearing of vegetation associated with permanent facilities, roadways, pipelines and other rights-of-way resulting in:

(1) permanent and/or temporary losses of habitat for moose (MEMP 5, BREAM R20), marten (MEMP 6, BREAM R21), raptors (MEMP 8, BREAM R22), fish (BREAM R12B), as well as permanent and/or temporary disruption of harvesting areas (i.e., hunting, trapping) (MEMP 24);

Table 4.11
Onshore Development Activities

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 1 The presence of offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a decrease in the number of Arctic and red foxes.			Detailed evaluation Group concluded linkages related to effects of gravel extraction are invalid for Arctic fox but valid for red fox. Other linkages were valid but of low significance. Identified need for radiotelemetry study of Arctic fox movements. Catch per unit effort should also be determined through harvest surveys.	Review of research Review of nine projects relevant to this hypothesis: several involved assessments of den sites for Arctic foxes, effects of Arctic foxes on geese and swans, distribution and abundance of seals, and movements and behaviour of polar bear.		Hypothesis review Hypothesis requires re-evaluation during BREAM. Previous conclusion on validity should be reviewed. May be need to break into two separate hypotheses because camps and garbage may increase populations, whereas other effects have negative effect on abundance.	Detailed evaluation Hypothesis inherited by BREAM (R16). Concurred with conclusions of MEMP that effects are possible but likely to be insignificant. Impacts of den loss may be minimized through land use regulations. Recommended that wildlife use of gravel pits be assessed with end objective being the development of reclamation guidelines.
MEMP 3 Gravel extraction, construction, seismic exploration and other development activities, and the presence of camps and garbage will decrease the number of grizzly bears and alter their distribution.			Detailed evaluation Hypothesis concluded to be valid; increased bear mortality due to development would be significant given present harvest levels and low reproductive rates. Considered unlikely that development will affect energy balance and overwinter survival or reproduction. Group recommended that records of bear kills be maintained; bear deterrent study be continued; support for ongoing radio-telemetry study of bears on Richardson Island.	Review of research Four projects of relevance to hypothesis were reviewed: bear population studies (2); habitat assessment (1); and grizzly bear conservation and management (1).		Hypothesis review Requires re-evaluation during BREAM. Hypothesis considered	

Table 4.11 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 5 Oil and gas development construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose.			Detailed evaluation Overall hypothesis is valid but considered unlikely that construction activities will affect seasonal distribution or energy balance. No new research recommended but supported continuation of baseline population studies. Group also recommended that: woody browse regeneration on areas cleared for wood chip production e monitored; if above-ground pipeline constructed, moose movements along pipeline be monitored.	Review of research Eight project overviews were completed. Information provided on responses of moose to industrial disturbances and facilities, revegetation Reponses, browse digestibility, and winter activity patterns.		Hypothesis review Requires re-evaluation during BREAM. Hypothesis considered unlikely; remove reference to above-ground pipeline sections (not in scenario), and develop new impact pathway for above-ground gathering systems.	Detailed evaluation MEMP 5 (designated BREAM R20) evaluated due to new information and changes in development scenario. All impact pathways are valid (effects of forest clearing, increased vehicular traffic and above-ground gathering systems). Forest clearing and increased vehicular traffic impacts would likely be insignificant to regional populations. Effects of above-ground gathering system or pipeline would be insignificant and could be mitigated through use of crossing sites for moose.
MEMP 6 Oil and gas exploration and development activities that alter habitat permanently or temporarily will influence the distribution and abundance of marten.			Detailed evaluation Valid, but only changes that result in a substantial part of the home range expected to decrease marten numbers. Overall effects will be insignificant at the population level. No research or monitoring recommended.	Review of research Three research projects were reviewed for this hypothesis. One focused on responses of prey to forest clearing, one on winter habitat use and home ranges of martens, and one on the distribution and habitat use of prey.		Hypothesis review Requires re-evaluation during BREAM. Considered unlikely but community-based concerns relative to the trapping industry. No changes in wording necessary.	Detailed evaluation Hypothesis inherited by BREAM (R21); need to evaluate due to new information and need to restructure hypothesis since food and denning habitats are similar. Group concluded that clearing activities will result in insignificant changes in local availability of marten habitat; insignificant effects on distribution, abundance and productivity of marten in study area. No new research recommended.

Table 4.11 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 7 Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.			Detailed evaluation Hypothesis concluded to be valid. Effects of disturbance will be localized and impossible to detect at the regional level. Increased energy costs considered unlikely. Major concern that increased human access to colonial species and brood-rearing or moulting areas would result in reduced reproductive success. No cause-effect research programs warranted.	Review of research Four relevant projects were identified which address effects of industrial disturbance on waterfowl (2), and effects of aircraft overflights (2).		Hypothesis review Requires re-evaluation during BREAM. Hypothesis considered unlikely, but is an important community-based concern.	Preliminary assessment This hypothesis was merged with MEMP 12 to form a new BREAM hypothesis (R10). Structure and wording of R10 was discusses at workshop but no evaluation undertaken. Conclusion of MEMP supported. Group agreed that hypothesis should be expanded to include all bird VECs (common elders, diving ducks, king elders, brant, thick-billed murre, snow geese and loons). No new studies recommended by group.
MEMP 8 Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.			Detailed evaluation Although all links of hypothesis are theoretically valid, the cumulative effects o fall links would most likely be inconsequential at the population level. No new research or monitoring programs recommended. However, group did support continuation of routine monitoring of raptor populations. Specific operating regulations should continue to be enforced to mitigate potential disturbances.	Review of research Two research projects were reviewed. One involved the potential effects of aircraft overflights on raptors, while the other involved monitoring raptor populations adjacent to the Norman Wells pipeline.		Hypothesis review Hypothesis requires re-evaluation as part of BREAM. Considered valid but of low significance. No wording changes considered necessary.	Preliminary assessment No need to evaluate MEMP 8 (designated BREAM R22) at this time. Hypothesis remains valid. New information on use of stationary facilities as nesting platforms does not alter conclusion. Group concluded that effects of disturbances on raptors could be significant due to the duration of project and the size of the regional raptor population. No research or monitoring programs recommended.

Table 4.11 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 9 The presence of camps and garbage disposal sites will attract predators that will lead to changes in the local abundance and distribution of waterfowl.			Detailed evaluation Valid but insignificant because locations of proposed facilities are separated from key waterfowl habitat and employee education can reduce potential for attraction of predators. No research or monitoring programs recommended.	Review of research Study assessed effects of construction activities on geese and swans, including attraction of predators to camps and garbage and increased predation on waterfowl.		Hypothesis review Hypothesis considered valid and necessary to re-evaluate during BREAM. No changes to wording required.	Preliminary assessment MEMP 9 (designated BREAM R23) reviewed. Result of studies on effects of foxes and other predators on waterfowl not available until 1993. Wording changed to include all bird VECs except loons, and potential for effects on regional as opposed to local populations. Group supported earlier conclusion of MEMP. Recommended research on effects of camps and disposal sites on local densities of foxes and predation rates on waterfowl; and on modification of home ranges of foxes by camps and garbage.
MEMP 17 Wolverines that are attracted to camps and garbage will be killed as nuisance animals, thus reducing the population.			Detailed evaluation Hypothesis considered invalid because wolverine normally are not attracted to large operations and animals are rarely removed due to "nuisance" problems. No new research or monitoring programs recommended.	Review of research ----		Hypothesis review No re-evaluation of hypothesis considered necessary. Considered invalid and therefore not inherited by BREAM.	

Table 4.11 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 24 Industrial activities in harvesting areas will reduce the harvest of mammals, birds and fish because of conflicts between industry and harvesters over land use.			Detailed evaluation Hypothesis concluded to be valid; industrial development and land use conflicts may result in reduced harvest, particularly for trappers. Group identified need to obtain harvest and land use information prior to disturbances.	Review of research Two relevant projects were identified. The Dene Land Use study will provide historical information on traditional land use. The other study involved a review of the public consultation and regulatory process for the Norman Wells pipeline.		Hypothesis review Hypothesis requires re-evaluation during BREAM. Considered valid on a local basis, particularly for trapping. No changes in wording necessary.	Eliminated because land use and compensation issues outside scope of BREAM.

(2) temporary gains in habitat availability for moose (MEMP 5, BREAM R20) and marten (MEMP 6, BREAM R21) due to re-establishment of early successional vegetation; and

(3) creation of new nest sites for some raptors (MEMP 8, BREAM R22).

- construction activities and human presence resulting in sensory disturbances with subsequent effects on:

(1) energy balances and ultimately reproductive success in grizzly bear (MEMP 3, BREAM R18), moose (MEMP 5, BREAM R20), waterfowl (MEMP 7, BREAM R23), and raptors (MEMP 8, BREAM R22);

(2) habitat use (i.e., habitat alienation) and/or localized movements by grizzly bear (MEMP 3, BREAM R18), moose (MEMP 5, BREAM R20), and waterfowl (MEMP 7, BREAM R10); and

(3) nest use, resulting in nest or brood abandonment by waterfowl (MEMP 7, BREAM R10) and raptors (MEMP 8, BREAM R22).

- attraction of wildlife to camps and garbage disposal areas, the creation of nuisance animal problems and the likelihood of the destruction of problem animals such as red and arctic foxes (MEMP 1, BREAM R16), grizzly bear (MEMP 2, BREAM R18), and wolverine (MEMP 17). There was also concern that predators such as foxes, grizzly bear, jaegers, gulls and ravens would be attracted by camps and garbage, resulting in increased predation on waterfowl nests and reduced numbers of waterfowl (MEMP 9, BREAM R23);

- construction of above-ground pipeline systems and resulting effects on seasonal movements or migration by moose (MEMP 5, BREAM R20) and barren ground caribou (BREAM R17) (see Section 4.15 below);

- creation of new access or improvement in existing access and resulting changes in harvesting pressures and distribution (see Section 4.13); and

- increases in the number of residents and subsequent increases in recreational and subsistence hunting and fishing pressures (see Section 4.18).

MEMP 1: The presence of offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a decrease in the number of arctic and red foxes.

MEMP 3: Gravel extraction, construction, seismic exploration and other development activities, and the presence of camps and garbage will decrease the number of grizzly bears and alter their distribution.

MEMP 5: Oil and gas development construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose.

MEMP 6: Oil and gas exploration and development activities that alter habitat permanently or temporarily will influence the distribution and abundance of marten.

MEMP 7: Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.

MEMP 8: Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.

MEMP 9: The presence of camps and garbage disposal sites will attract predators that will lead to changes in the local abundance and distribution of waterfowl.

MEMP 17: Wolverines that are attracted to camps and garbage will be killed as nuisance animals, thus reducing the population.

MEMP 24: Industrial activities in harvesting areas will reduce the harvest of mammals, birds and fish because of conflicts between industry and harvesters over land use.

BREAM R10: Activities associated with hydrocarbon development will affect the abundance and distribution of aggregations of staging, moulting and nesting birds.

BREAM R12: The construction of shorebases, pipeline landfalls, and development of shallow water production fields will result in a decrease in the populations of arctic cisco and broad white fish.

BREAM R23: The presence of camps and garbage disposal sites will attract predators that change the abundance and distribution of birds.

4.11.2 Results of Evaluation

Gravel Extraction

Loss of denning habitat as a result of gravel extraction was identified as a concern for arctic and red foxes and grizzly bear. During the 1985/86 MEMP workshop, participants agreed that loss of arctic fox dens in the Yukon North Slope was not an issue since all known den sites are west of the Babbage River in areas where gravel extraction is unlikely. In contrast, losses of den sites for red foxes within the Mackenzie Delta was of higher concern due to the scarcity of gravel in the delta. Nevertheless, it was considered unlikely that all dens sites would be removed. It was also noted that foxes may den in gravel berms and pads in the vicinity of various man-built facilities. Because no important effects on regional populations of either species of fox were considered likely, the linkage was considered invalid. During the information review for BEMP in 1990/91 and the BREAM 1991/92 workshop, it was noted that substantial information had become available on arctic fox dens and the preferred biophysical characteristics of dens, and that remote sensing had been used to assess den availability along the Yukon coast (INAC 1992), Participants in the BREAM workshop agreed that den losses during gravel extraction would not have significant permanent effects on arctic or red fox populations. However, it was recommended that guidelines for reclamation of gravel pits be established to allow wildlife use after their closure.

Effects of gravel extraction were also expected to be insignificant to the regional grizzly bear population. During the 1985/86 MEMP workshop, it was noted that grizzly bears preferred to den in well-drained sites along lake shores and streams. The land use permitting system does not typically permit sand and gravel excavation near water bodies or water courses and, therefore, there would be little overlap between extraction sites and den sites. Evidence presented during the 1991/92 BREAM workshop indicated that grizzly bears do not use sand and gravel deposits for den sites, nor have any existing dens been disturbed by gravel excavation. It was, therefore, concluded that this link was invalid,

Development of borrow pits could either destroy or create nest sites for some raptors. As discussed in INAC et al. (1986), rock quarry operations could destroy active nest sites or result in nest abandonment due to the high levels of human activities. In contrast, creation of new rock faces could create nesting ledges for species such as golden eagles. From a regional perspective, however, none of these effects was not expected to have a significant impact on raptor populations. This hypothesis was not evaluated further as part of the BREAM program.

Habitat Losses and Gains

Clearing of sites during construction of permanent facilities and all-weather roads was expected to result in permanent losses of feeding habitats for moose, feeding and denning habitat for marten, and nesting sites for raptors. Participants in the 1985/86 MEMP workshop agreed that although losses of habitat for moose and marten would occur as a result of the construction of permanent facilities, the losses would be insignificant at even a local scale and higher order impacts on overwinter survival and/or reproduction would be unlikely. Potential losses of raptor nest sites as a result of facility construction were considered to be inconsequential relative to the potential impacts of increased human access and disturbance on nest use and nesting success (INAC et at. 1986).

Temporary disturbances such as seismic lines, wood chip operations, temporary winter roads, and other rights-of-way would reduce the availability of habitat for moose and marten, but effects of these losses on population numbers and reproductive success were predicted to be to minor, if even detectable (INAC et a/. 1986). Regrowth of early successional habitats in these sites would likely temporarily improve feeding habitats for moose and marten.

Construction of tall structures such as power poles and towers may create nesting sites for ravens, rough-legged hawks and eagles. Participants in the 1985/86 MEMP workshop expected that tall, man-made structures would be used by these species, and that gyrfalcons, who do not build nests of their own, would likely occupy some of these nest in future years. Because the availability of nest sites may be a limiting factor in the number of gyrfalcons that occur in certain tundra areas, the creation of new nest sites may result in an increase in the number of breeding pairs of this species. Based on the likely number of tall structures to be built and a comparison with nesting densities in other areas where nest sites are not limiting, it was concluded that the maximum increase in the number of gyrfalcons would be approximately 10 nesting pairs (INAC et a/. 1986). During the 1991/92 BREAM program, the hypothesis Working Group concluded that this hypothesis (renamed BREAM R22) remained valid.

Mechanical and Human Disturbances: Effects on Energy Balances and Reproductive Success

During the 1985/86 MEMP workshop, a number of concerns were raised related to potential mechanical and human disturbances on grizzly bear, moose, waterfowl and raptors, and subsequent effects on energy balances, overwinter survival, and/or reproductive success (INAC et al. 1986).

Participants in both the MEMP and BREAM workshops concurred that construction activities could affect feeding activities of grizzly bears. However, it would be unlikely that bears would avoid large portions of their range or be disturbed sufficiently to affect accumulation of fat reserves and reproductive success given the scale and timing of hydrocarbon development in the region. Disturbances of denning bears by exploration construction activities would also be possible, but could be controlled through land use planning and environmental protection measures (i.e., buffer zones around all active den sites).

Based on assessments of moose responses to the construction of the IPL pipeline and other facilities, it was concluded by participants in the 1985/86 MEMP workshop that the changes in energy balances of moose resulting from mechanical and human disturbances would not be significant This pathway was, therefore, considered to be invalid. The participants of the 1991/92 BREAM workshop supported this conclusion.

MEMP workshop participants also agreed that while human and mechanical disturbances could cause temporary displacement of waterfowl, it was improbable that this would affect energy balances such that reproductive success or survival would be reduced given the extensive nature of staging, breeding and nesting habitat for waterfowl in the region relative to the small scale of the proposed development In contrast, increased human disturbances associated with improved access to nesting areas of colonial species and to brood rearing and moulting areas (see Section 4.13) could result in temporary nest abandonment and significant effects on reproductive success (INAC et al. 1986). During the 1985/86 BREAM workshop, MEMP 7 (effects of disturbances on waterfowl) was combined with MEMP 12 (effects of aircraft overflights on brant), and the new hypothesis was expanded to include all bird VECs (i.e., common eiders, diving ducks, king eiders, brant, thick-billed murres, snow geese and loons) (INAC 1992).

Human and mechanical disturbances have been demonstrated to reduce the nesting success of some species of raptors through (1) nest abandonment, (2) egg mortality due to insufficient incubation or loss, (3) chick mortality due to abandonment or exposure, and (4) decreased fitness of young (INAC €lt €ll. 1986). Although the subgroup of the 1985/86 MEMP workshop concluded that effects of disturbances on reproductive success are possible, impacts would be local and insignificant in terms of the regional population due to the widespread nature of raptor nest sites, the localized scale of hydrocarbon development and the low potential for facilities or activities to occur in known nesting habitats for raptors. In addition, environmental protection plans could ensure that activities near active nest sites are minimized or prevented during the nesting season, and that nest sites are not destroyed. BREAM workshop participants concurred with this evaluation (INAC 1992).

Mechanical and Human Disturbances: Effects on Habitat Use

Frequent mechanical and human disturbances of some wildlife species can result in temporary or permanent abandonment of habitat; this phenomenon is commonly referred to as habitat alienation. Concerns for habitat alienation were identified for grizzly bear, moose and waterfowl during the 1985/86 MEMP workshop (INAC el al. 1986). In all cases, habitat alienation was considered to be one of the causative steps that could result in energetic stress and reduced reproductive success in these species.

Two types of habitat alienation or abandonment were identified as potential impacts to grizzly bears: (1) disruption of feeding activities during late summer and avoidance of human activity centres; and (2) abandonment of overwintering dens. Field studies of bear responses to oil and gas activity in the Mackenzie Delta region and Alaska support both of these impact linkages. Participants in the MEMP workshop concluded that habitat alienation was possible, but that impacts could be mitigated through careful land use planning to avoid areas of importance to grizzly bears. The greatest concern was the potential for removal of problem animals and subsequent effects on population abundance and reproduction. The conclusions of the MEMP working group were supported during the 1991/92 BREAM workshop.

Potential impacts of habitat alienation on moose include: displacement of female moose and their young from suitable habitat, and displacement of moose populations in general by construction activities and traffic. Based on studies of moose responses to the IPL pipeline and roadways, it appears that although moose may temporarily avoid areas of high human and mechanical activity (i.e., a few days to a few weeks), animals quickly return to their original locale once construction ceases. The working groups of both the 1985/86 MEMP workshop and the 1991/92 BREAM workshop concluded that short-term avoidance may occur, but that effects on moose distributions and energy balance would be insignificant.

During the 1985/86 MEMP workshop, participants expressed concerns that exploration, processing and distribution facilities could result in disturbances of waterfowl and avoidance of habitats in proximity to these activity centres. The potential for increased human access and increased barge traffic could also result In disturbances to waterfowl and temporary habitat abandonment. In all cases, the primary concern was that disturbances would displace birds from staging areas, as well as interfere with feeding, courtship and nesting. MEMP participants, however, concluded that effects of mechanical and human disturbances would tend to be localized and small relative to the regional population, and that effects would be difficult to detect at a regional population level given the natural variability in the distribution, production levels and population levels of waterfowl. Effects of facilities and associated human activities were generally considered by participants in both the MEMP and BEMP workshops to be of minor significance to regional populations, but effects would be long term. In contrast, effects of increased human access on colonial nesting sites and on brood rearing and moulting areas were considered to have the potential to significantly affect regional populations (this impact is described in more detail in Section 4.13).

Mechanical and Human Disturbances: Effects on Nesting Activities

Although it is possible that mechanical and human disturbances associated with various hydrocarbon facilities could result in nest desertion by waterfowl, participants in the 1985/86 MEMP workshop concluded that effects on nesting success of colonial waterfowl (i.e., geese) and solitary nesting species would be minor. This conclusion was based on the fact that (1) land use regulations would not permit construction of permanent facilities in important nesting areas or temporary facilities during the season of use; and (2) no facilities were planned in proximity to known important nesting habitats. As noted above, the major concern was the potential effects of increased human access on waterfowl nesting.

Attraction of Wildlife to Camps and Garbage Disposal Areas

It has been documented that availability of food wastes at campsites and garbage disposal sites results in the attraction of a variety of arctic wildlife, most notably arctic and red foxes, grizzly bear and wolverine. Attraction of wildlife to these sites can cause impacts to wildlife or resource use through three different pathways:

- Animals that are attracted to food wastes or handouts from workers are likely to interact with humans and, when human-wildlife interactions or confrontations occur (i.e., "problem Wildlife"), nuisance animals may be shot, kill trapped or transplanted outside of the region. The net effect of these actions is a reduction in the abundance of wildlife. For species such as grizzly bear or wolverine that have slow reproductive cycles, losses of even a few animals can have important consequences on regional populations, particularly if the population is subjected to traditional and/or recreational hunting or trapping pressure.

- Species such as arctic fox or red fox may concentrate in the vicinity of camps, thereby reducing animal densities In the surrounding areas. This change in distribution can negatively affect the trapping success of Inuvialuit who use these peripheral areas, whereas the concentration of foxes near the camps may increase the likelihood that animals will be trapped.

- Attraction of predators such as arctic and red foxes, grizzly bear, jaegers, gulls and ravens to food wastes and handouts may result in local increased densities of predators which, in turn, may increase predation rates on waterfowl nests and moulting adult birds. In combination with other impacts on nesting birds, this impact could ultimately result in reduced breeding success and reduce abundance of birds in the regional population.

In general, the hydrocarbon industry has adopted codes of good practice to minimize or eliminate the attraction of wildlife to camps and garbage disposal areas. These have included better handling and disposal of food wastes, worker education on the consequences of poor garbage handling and providing food handouts to wildlife, and the development of wildlife protection plans which include methods for deterring animals from camp areas and methods for handling problem animals. In some cases, local communities have been involved to help reduce nuisance animal problems and minimize effects on regional populations. For example, a program was implemented in the Tuktoyaktuk area where removal of grizzly bears at campsites was linked with the setting of quotas for the grizzly bear hunt.

Effects of these impact pathways on arctic and red foxes were concluded by participants in the 1985/86 MEMP and 1991/92 BREAM workshops to be insignificant (i.e., local, short-term and mitigatable). Participants in the MEMP workshop recommended that a study be undertaken to document the origin and duration of occupancy of arctic and red foxes that are attracted to camp sites and garbage dumps. This information could then be used to assess the importance of distributional changes in these canid populations, as well as potential effects on local trapping efforts. This research was not implemented, likely in response to declining industry interests in the region and the reduction in exploration activity and campsites.

Impacts on grizzly bears could be significant, particularly if control of nuisance animals results in an annual loss of animals from the regional population. It was recommended by workshop participants that: (1) the numbers of grizzly bears observed or killed near camps be monitored on an ongoing basis, and that the results of these programs be integrated with regional population studies; and (2) the potential for aversive conditioning of bears (as was being tested in Alaska) be investigated for use in relation to future hydrocarbon development activities in the Beaufort/Mackenzie region.

During the 1985/86 MEMP workshop, participants concluded that it was possible that camps and garbage disposal activities could result in increased numbers of predators in the vicinity of these facilities, thereby resulting in increased predation pressures on nesting birds, eggs, young, and moulting adult birds. However, given that (1) none of the proposed facilities were in the immediate vicinity of important nesting or moulting habitats for waterfowl, and (2) attraction of predators can be controlled through proper handling of garbage and prevention of handouts by workers to wildlife, it was concluded that camps and garbage disposal sites would not result in increased predation on waterfowl.

During the 1991/92 BREAM workshop, the impact hypothesis was modified to include all bird VECs, as opposed to just waterfowl. Participants concluded that there was insufficient information to assess the potential significance of impacts associated with this hypothesis. Consequently, it was recommended that studies be initiated to: (1) assess the effects of camps and other facilities on densities of arctic and red foxes and, in turn, the effects on predation rates to local bird populations; and (2) determine if the home ranges of foxes are altered by camps and other facilities, thereby modifying predation rates on nesting and moulting birds in areas distant from these facilities.

Above-Ground Pipelines and Wildlife Movements

Development scenarios for oil and gas development in the Beaufort Sea and Mackenzie Delta region included the requirement for construction of some sections of above-ground pipelines, as well as networks of above-ground gathering systems to collect products from production sites and transport them to processing facilities or major transportation facilities *(e.g.,* a valley pipeline, tankers). During the MEMP and BREAM programs, concerns were identified that local or seasonal movements by moose and barren-ground caribou, respectively, could be affected by above-ground segments of the Mackenzie Valley pipeline if it was constructed (INAC *el al.* 1986; INAC 1992). In addition, it was also noted during the BREAM workshop that gathering systems on the Tuktoyaktuk Peninsula could affect local habitat use and movements by some caribou in the Bluenose herd (INAC 1992).

During the MEMP program (1985-1987), it was considered possible that a large-diameter, heated oil pipeline might be built along the Mackenzie Valley. Concern was expressed that local movements by moose could be hindered by those segments of the pipeline that would have to be built above ground to avoid permafrost areas. Raised portions of the pipeline would most Likely be constructed in valley bottoms, which are important overwintering habitats for moose. Although experiences in Alaska with above-ground pipelines suggested that pipelines can be built to minimize effects on moose, monitoring studies of moose movements had shown that some animals avoided the area of the pipeline and did not cross. It was, therefore, concluded by the workshop participants that impacts on moose were possible, but that careful planning of the pipeline (to avoid elevated sections in the vicinity of important movement corridors) and use of mitigation measures as part of the pipeline design could minimize or eliminate these impacts.

During BREAM, participants agreed that impacts of above-ground pipeline sections on moose movements could be mitigated. In addition, it was noted that during the construction of buried pipeline segments, moose movements could also be temporarily obstructed. However, given that mitigation measures and good environmental protection planning can minimize or eliminate both of these impacts, participants concluded that this impact pathway was unlikely to occur (i.e., invalid).

As noted above, under the probable development scenario for BREAM, gathering pipelines systems would be built on the Tuktoyaktuk Peninsula and along the east side of the Mackenzie River to transport gas and condensate from the production wells to a central gathering facility, Community representatives expressed concerns that because the gathering systems would cross the western periphery of the range of the Bluenose caribou herd, late fall distributions of caribou could be altered. Although it was agreed that effects on the caribou herd would be insignificant, changes in the fall distribution of caribou could affect access by residents of Tuktoyaktuk and Inuvik to caribou during the fall hunt. It was recommended by the participants that measures such as earthen berms and raised pipeline crossing sites be incorporated into the design of the gathering systems to ensure that effects on caribou movements and crossings by local hunters are minimized.

4.12 LAND SUBSIDENCE

4.12.1 Introduction

In the Mackenzie Delta, land surface subsidence and a concomitant rise in the relative sea level continues to occur naturally as a result of regional subsidence of the Mackenzie sedimentary basin, subsidence due to weight of accumulated sediments and subsidence due to consolidation of deltaic sediments. There is concern that induced subsidence associated with the hydrocarbon withdrawal from oil and gas fields in the Delta along with natural subsidence may result in losses of important reproductive, overwintering and feeding habitat for waterfowl, muskrat and fish, particularly in low-lying areas of the Delta. During the 1985/86 MEMP program, one impact hypothesis (MEMP 11) was developed to address this concern and was the subject of a subgroup meeting and open discussion during the interdisciplinary workshop held that year (Table 4.12) (INAC et a/. 1986).

During the review of all MEMP and BEMP impact hypotheses in 1990/91, BREAM participants concluded that MEMP 11 was unlikely and that no changes to the wording of its linkages were necessary. The hypothesis was later inherited by BREAM in 1991/92 (designated R24) and the wording was changed to include the cumulative effects of natural and induced land subsidence and increasing sea levels due to global climate change. Although this revised hypothesis was not evaluated during the interdisciplinary workshop held that year, a number of general research requirements were identified.

In 1991/92, BREAM participants identified the need to address the potential impacts of local land subsidence along pipelines and roads within the Mackenzie Delta and Valley. Monitoring of the Norman Wells pipeline indicated that although erosion control structures have performed well in limiting surface erosion in most cases, numerous small-scale events have occurred, frequently initiated by intense summer rainstorms. MEMP Hypothesis 4, which originally dealt with withdrawal of water from streams and lakes and subsequent effects on water regimes (see Section 4.7) was restructured during the 1991/92 BREAM program to include the effects of local land subsidence and creation of drainage barriers along linear corridors. This revised hypothesis (BREAM R19) was re-evaluated during the 1991/92 project workshop (INAC 1992).

MEMP 11: Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat.

BREAM R19: Water withdrawals from hydrocarbon development, and land subsidence and drainage barriers resulting from linear corridors will change the population characteristics of birds, semi-aquatic furbearers and fish.

BREAM R24: The cumulative effects of natural land subsidence, induced land subsidence (from hydrocarbon withdrawal) and increasing sea levels due to global climate change will alter wetland and aquatic habitats in the Mackenzie Delta and result in changes in the distribution and abundance of waterfowl, fish and muskrat.

Table 4.12
Land Subsidence

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 11 Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat.			Detailed evaluation Changes in area and quality of available habitat and numbers of muskrat, waterfowl and fish due to subsidence associated with reservoir depletion likely to be inconsequential at population levels. No reliable method to predict reservoir compaction and direct subsidence. Recommended research into reservoir geology of Niglintgak area, importance of permafrost on mechanical properties of reservoir rock, and distribution of permafrost in areas of hydrocarbon reservoirs. Monitoring of ground surface elevations also recommended.	Review of research Studies provide evidence of high degree of local variation in permafrost conditions in Delta. Thaw consolidation and thermokarst activity resulting from induced land subsidence can therefore be expected to show similar spatial variability.	---	Hypothesis review Hypothesis considered unlikely. No changes to the wording necessary.	Review Inherited by BREAM (R24) and wording changed to include cumulative effects of natural and induced land subsidence and increasing sea levels due to global climate change. Hypothesis not evaluated but a number of general research requirements were identified.
BREAM R19 Water withdrawals and land Subsidence resulting from hydrocarbon development activities will change the abundance and distribution of waterfowl, semi-aquatic furbearers and fish.							Detailed evaluation Considered necessary to re-evaluate hypothesis (originally MEMP 4) due to major restructuring of hypothesis to include fish and waterfowl as well as local subsidence along pipelines and roads. Hypothesis considered to be valid.

Results of Evaluation

Of the oil and gas fields in the Mackenzie Delta, the Niglintgak reservoir is considered to be most susceptible to subsidence. Although it is difficult to predict the extent of ground surface subsidence induced by hydrocarbon withdrawal because of site-specific variations in reservoir properties, fluid pressure, reservoir geometry and mechanical properties of the rock, two estimates of the depth of potential subsidence at Niglintgak (Kyle et al. 1979; cited in INAC et al. 1986) were presented during the evaluation of MEMP Hypothesis 11. Based on a high probability (90%) that the reservoir has been pre-stressed by the presence of a large ice cap in the recent past, maximum direct subsidence after 25 years of production was estimated at about 0.5 m. If a large ice cap was not present in this area, directly-induced subsidence at the Niglintgak field could be as great as 2.6 m. Although the extent and distribution of permafrost and ground ice in the area is unknown, thawing of this layer could influence a larger area than originally predicted on the basis of reservoir geology.

Approximately 80% of the outer Delta is flooded each spring. Under the best-case scenario (i.e., 90% probability that maximum subsidence will only be 0.5 m), only minor and localized effects on flooding would be expected to occur. If the spatial extent of direct subsidence is restricted to that predicted in this scenario and indirectly-induced subsidence does not occur, it was concluded that loss of muskrat, fish and waterfowl habitat would be inconsequential relative to the total available habitat in the area. However, in the worst-case Situation (i.e., 10% probability that subsidence will be as great as 2.6 m), it was estimated that the southern edge of the island on which most of the Niglintgak reservoir is located would be submerged throughout the summer. Substantial alterations to surface topography would also occur as a result of indirect effects such as thermokarst and thermal erosion. However, the effects of this on the quality and quantity of muskrat, fish and waterfowl habitat in the area was unknown.

To evaluate these predictions regarding potential subsidence in the Niglintgak area, several research programs on reservoir geology, terrain and permafrost distributions at Niglintgak were recommended. During the 1987 MEMP program, a number of studies of direct relevance to this hypothesis were reviewed. The results of two studies on geothermal conditions in the Mackenzie Delta/Beaufort Sea region indicated that there is substantial variability in geothermal and ground ice conditions in both the nearshore and onshore. This high degree of variation in permafrost conditions suggests that thaw consolidation and thermokarst activity resulting from induced land subsidence can be expected to show similar spatial variations,

As part of the 1991/92 BREAM program, MEMP Hypothesis 4 underwent major restructuring to include the effects of water withdrawal and creation of drainage barriers on waterfowl and fish as well as muskrat (see Section 4.7), and the impacts of local land subsidence along pipelines and roads within the Mackenzie Delta and Valley (re-designated BREAM R19). As discussed above, regional land subsidence resulting from hydrocarbon withdrawal was already addressed through MEMP 11.

During the evaluation of BREAM R19, it was concluded that the linkages relating land subsidence and the creation of drainage barriers to changes in waterfowl, fish and semi-aquatic furbearer populations were valid. While potential drainage and erosion problems along a ROW could be minimized by special construction procedures and ongoing monitoring and maintenance programs, localized changes in water flow patterns and subsequent changes in water levels and distribution could occur. Although it would be unlikely that such changes in water flow would affect the thermal regime of large watercourses such as the Mackenzie River, it could lead to changes in the level and distribution of nutrients and sediments in smaller streams and lakes. This, in turn, could affect the quality and quantity of available habitat (food and cover) for birds, semi-aquatic furbearers and fish. Although the impact of land subsidence on these resources was expected to be insignificant given their widespread distribution throughout the region and the small area likely to be affected, impacts on shorebirds could be more significant due to the importance of the Delta as nesting habitat. However, it was noted that research into waterflow patterns and the extent of available nesting habitat on the Delta is needed to better assess this impact.

4.13 IMPROVED ACCESS

4.13.1 Introduction

During development of oil and gas resources in the Beaufort Sea, Mackenzie Delta and Mackenzie Valley regions, it was expected that a number of new rights-of-way would be constructed (INAC et I'll. 1986). These were likely to include: (1) permanent access roads from wharves to production facilities; (2) rights-of-way associated with pipelines along the Mackenzie Valley; (3) development of new, all-weather roads; (4) development of winter roads to access some remote sites; (5) construction of seismic lines in hydrocarbon exploration areas; and (5) construction of landing strips or helicopter pads to provide air access to remote sites.

During the MEMP and BREAM programs, two major types of impacts were examined in relation to increased access (Table 4.13).

(1) As a result of new or altered travel routes and rights-of-way, domestic and recreational hunting activities, and domestic, recreational and commercial fishing activities will increase in areas that were formerly less accessible, thereby resulting in increased harvests and reduced availability of fish and wildlife (MEMP 8, MEMP 14/BREAM R25, MEMP 21 and MEMP 23/BREAM R29).

(2) Increased access will result in higher levels of sensory disturbance to wildlife (MEMP 7/BREAM R10, MEMP 8/BREAM R22). Many of the impacts addressed by these hypotheses have already been discussed in Section 4.11 in relation to impacts of onshore developments.

Depending on the impact hypothesis, regional increases in human populations were explicitly or implicitly included as part of the impact mechanisms that link increased access to increased harvest levels and reduced abundance of harvestable resources, or increased access to increased levels of sensory disturbance (and habitat alienation). For example, MEMP Hypotheses 7, 8, and 14 address the potential effects of improved access and increased numbers of people (particularly construction workers) on the distribution and intensity of harvesting pressures on waterfowl, raptors (i.e., poaching of chicks) and fish, respectively.

MEMP 7: Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.

MEMP 8: Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.

MEMP 14: Improved access and increased fishing pressure will decrease the abundance of fish and affect their distribution.

MEMP 21: Increased or improved access associated with hydrocarbon development will increase the harvest of waterfowl, which will lead to a reduction in the number and alter the distribution of waterfowl.

MEMP 23: Changes in access will alter the harvest of birds, fish and mammals.

BREAM R10: Activities associated with hydrocarbon development will affect the abundance and distribution of aggregations of staging, moulting and nesting birds.

BREAM R29: Changes in access will affect the harvest of birds, fish and mammals, which will lead to a reduction in the abundance and alter the distribution of these populations.

Table 4.13
Improved Access

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 7 Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.			Detailed evaluation Overall hypothesis valid. Of all the potential impacts considered in this hypothesis, increased access to colonial nesting areas and brood-rearing or moulting areas was considered to be potentially the most significant. No new research or monitoring programs recommended.	Review of research Four relevant projects were identified which addressed effects of industrial disturbance on waterfowl (2), and effects of aircraft overflights (2).		Hypothesis review Re-evaluation of hypothesis required during BREAM. Considered unlikely but is an important community-based concern.	Preliminary assessment MEMP 7 merged with MEMP 12 to form new BREAM hypothesis (R10). Structure and wording of new hypothesis was discussed at workshop, but no evaluation. Conclusion of MEMP supported. Agreed that hypothesis would be expanded to include all bird VECs: common eiders, diving ducks, king eiders, brant, thick-billed murre, snow geese and loons. No new research studies recommended.
MEMP 8 Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.			Detailed evaluation Impact pathway linking increased access to increased poaching considered valid but not testable. Impact pathway linking increased access to increased disturbances theoretically valid but unlikely, as facilities will not be constructed near nesting habitats and mitigative measures can be used to avoid impacts. No new research or monitoring programs recommended.	Review of research Two research projects were reviewed. One involved the potential effects of aircraft overflights on raptors. The other involved monitoring of raptor populations adjacent to the Norman Wells pipeline.		Hypothesis review Requires re-evaluation during BREAM. Hypothesis valid but of low significance. No wording changes considered necessary.	Preliminary assessment MEMP 8 inherited by BREAM (R22) but no need to re-evaluate because hypothesis remains valid. New information on use of stationary facilities as nesting platforms does not alter conclusions. Group concluded that effects of disturbances on raptors could be significant due to the duration of the project and the size of the regional raptor population. No research or monitoring programs recommended.

Table 4.13 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 14 Improved access and fishing pressure will decrease the abundance of fish and affect their distribution.			Detailed evaluation Hypothesis concluded to be valid; common result of increased human access into previously remote areas. Regulation to control catch can be used but are generally difficult to establish and enforce, particularly in the north due to overriding social and economic considerations. Information required no response of western Arctic char populations to exploitation; documentation of the distribution of lake trout; baseline data on whitefish stocks; and experimental harvest study on grayling. Need to monitor total annual catch, and index monitoring of catch and fish populations.	Review of research Review of research identified 7 relevant projects. Three studies involved baseline data on Arctic char stocks and data from domestic and commercial fisheries. Two studies involved stock identification in whitefish. Remaining two studies provided general information on fish populations.		Hypothesis review Requires re-evaluation during BREAM. Hypothesis considered valid; no changes in wording necessary.	Preliminary assessment Hypothesis inherited by BREAM (R25) but only briefly examined during workshop. Group agreed that it would be more appropriate to evaluate this issue through community-based concerns group. Given lack of information on fish stocks, not possible to evaluate the significance of effects of increased access on fish abundance and distribution. Group noted that if scenario involved winter construction of pipeline, concerns related to increased access and fish would be reduced. Need for information on basic biology and population size of important species.

4.13.2 Results of Evaluation

Improved Access and Harvesting Activities

MEMP 14 describes the potential effects of improved access and fishing pressure on the abundance and distribution of fish. During the 1985/86 MEMP program, concerns regarding potential impacts on various fisheries were related primarily to the Norman Wells area, but additional concerns were also expressed for lake trout and the arctic char fishery along the Yukon coast. As discussed in INAC al a/. (1986), sport fishing occurred in a number of smaller tributaries to the Mackenzie as well as in several drainage basins in the vicinity of Norman Wells prior to expansion of oil facilities at Norman Wells. Fly-in fishing also occurred in the Great Bear region. Domestic fisheries were located primarily along the Mackenzie River or in basins adjacent to the river. During expansion of the facilities, as many as 1300 workers were located at Norman Wells. Although fishing pressures increased, there were no data to quantify this change.

Arctic char, lake trout and arctic grayling were considered to be most susceptible to increased sport harvesting. Lake trout were regarded as being the most sensitive due to their popularity, the small number of lakes within the region that support this species, and their slow recovery rate. Although participants in the MEMP workshop concluded that sport harvesting would increase as the regional population increases, the increase in fishing pressure due to temporary residents/workers would not be as high as that caused by permanent residents. It was noted that construction workers would likely have little leisure time for fishing, and most construction would occur during winter.

Improved access may affect commercial and domestic fisheries in two ways. improved local access to fishing areas would almost certainly result in increased fishing pressure, particularly if access is provided to previously remote areas. In addition, improved access out of the region may stimulate commercial fisheries, particularly for high-value species like arctic char and lake trout, if transportation costs to southern markets are reduced.

Participants in the MEMP workshop concluded that improved access and increased human populations would result in increased fishing pressure and changes in the abundance of fish stocks. Although fishing regulations can reduce some impacts, such regulations are often ineffective due to the difficulty in establishing and enforcing regulations, particularly in the Arctic where there are overriding social and economic considerations (INAC el al. 1986). Recommendations for further research focussed primarily on the need for baseline information on the current status of fish stocks, and the distribution and intensity of domestic, recreational and commercial fishing.

During the 1991/92 BREAM workshop, this hypothesis was not evaluated further. However, it was recommended that the emphasis of the hypothesis be shifted from changes in fish abundance and distribution to fish harvest opportunities and patterns for future evaluations (INAC 1992).

MEMP 21 addresses similar concerns to those already addressed by MEMP 14, except that it examines potential effects of improved access and increased harvesting pressures on waterfowl. Limited information prior to 1986 suggested that domestic and recreational hunting had no detectable effect on the number of waterfowl present in the Mackenzie Delta. Based on the development scenario for MEMP, workshop participants agreed that some forms of new access would not affect waterfowl hunting or abundance. However, new access routes such as the proposed road between Inuvik and Tuktoyaktuk or the Dempster Highway and the Yukon North Slope could provide greatly improved access to important spring and fall staging areas for snow geese and other waterfowl. Most concerns were related to improved access for the domestic harvest, particularly on snow geese adjacent to the proposed Inuvik-Tuktoyaktuk roadway. Sport hunting of waterfowl was considered to constitute only a very small portion of the annual harvest. Although participants of the MEMP workshop concluded that increased access would increase waterfowl hunting and mortality (i.e., the hypothesis is valid), effects of improved access on other areas would only marginally improve opportunities for domestic harvesting since it was unlikely that the Inuvik-Tuktoyaktuk road would be built. As a result, it was concluded that impacts on the regional population would not likely be significant.

During the 1990/91 BREAM program, it was recommended that MEMP 21 be combined with MEMP 23, which addresses effects of increased or improved access on traditional hunting, trapping and fishing areas. This new hypothesis (BREAM R29) included three different pathways by which increased or improved access would affect harvesting activities.

(1) Changes in access will decrease the amount of time that will have to be spent harvesting by individual harvesters, thereby affecting the level of effort and harvesting levels.

(2) Increased access into an area will result in more people using specific areas and will ultimately lead to greater competition for resources.

(3) Improved access will affect the distribution of harvesting and, possibly, the species that are hunted.

Participants of the MEMP workshop did not believe that improved access and reduced travel time would result in increased local harvesting activities or harvests, since travel time does not appear to have a major effect on effort. Furthermore, many hunts appear to end once the target harvest level has been reached (INAC et a/. 1986). In contrast, improved access may result in increased numbers of people using distant areas for harvesting, as well as short-to long-term Changes in the distribution of harvesting activities. It was also concluded that changes in regional harvesting levels would likely occur because of the increased ease with which harvesting could occur. Changes in access would most likely affect the harvests of big game, furbearers and fish because these resources tend to be concentrated in certain areas. However, changes in access would probably not significantly affect migratory birds since they are highly dispersed (except in areas such as staging areas and colonial nesting sites). Harvesting of big game would most likely be affected by all-weather roads, winter road and seismic lines, while furbearer harvesting would most likely be affected by seismic lines. Increased access on all-weather roads would affect harvesting of fish, particularly if the routing of roads intersects and passes close to watercourses or waterbodies that are important habitats or migration routes for fish.

To assess the potential significance of increased access on harvests, workshop participants recommended that harvest studies be completed to document the level, composition and location of the harvest, and that information on changes in the location and types of access also be compiled.

Although this hypothesis did not undergo a detailed evaluation during the 1992/92 BREAM workshop, participants agreed that various linear corridors that may be associated with large-scale hydrocarbon developments would result in improved access to previously remote areas. This, in turn, would expose fish, waterfowl, furbearers and large game to domestic and recreational harvesting activities.

One of the impact pathways of MEMP 8 addressed the concern that various linear rights-of-way would result in increased access by humans to nesting habitat for sensitive raptor species such as peregrine falcons and gyrfalcons, thereby increasing the risk of poaching of young birds and/or eggs. Participants of the MEMP workshop concluded that although this hypothesis was theoretically valid, it would be difficult or impossible to separate natural population changes from the effects of poaching activities.

Increased Access and Disturbances to Wildlife

During the 1985/86 MEMP and 1991/92 BREAM workshops, concerns were expressed that increased access by equipment and humans would result in increased sensory disturbance to wildlife and habitat alienation. MEMP 7 addressed the combined effects of improved access and increased numbers of people in the region on waterfowl. The working group considered the effects of increased access on birds and their summering and nesting habitats to be one of the most important potential impacts of hydrocarbon development on birds in the Mackenzie Valley region. In particular, increased human access to colonial nesting areas and to brood rearing or moulting areas could result in direct and indirect effects on waterfowl reproductive success. Indirect effects such as increased predation on waterfowl eggs and young by gulls, jaegers and foxes once adult birds have been flushed were considered to be more significant than direct effects.

MEMP 8 similarly addressed the concern that improved access and increased numbers of people would result in disturbances to nesting raptors, which in turn could cause nest abandonment, loss of eggs due to insufficient incubation or accidental knocking from the nest, Chick mortality due to abandonment and exposure, and decreased fitness of young. Disturbances by tourists were noted as being one of the most serious concerns. During the MEMP workshop, it was concluded that 'improved access and increased human disturbance could affect raptor nesting Success, but that effects as a direct result of the hydrocarbon industry were unlikely given that industry facilities and activities would probably not be located in known nesting habitat of raptors. Land use planning could also help to reduce the potential for overlap between industrial activities and raptor nesting through the use of area closures and/or seasonal closures. However, during the BREAM workshop, participants concluded that the combined effects of all disturbances on raptors (see Section 4.11) could result in significant, long-term effects on raptor populations given the small populations in the region and the long-term nature of the proposed hydrocarbon activities.

4.14 LINEAR CORRIDORS

4.14.1 Introduction

The hydrocarbon development scenarios for the Beaufort Sea, Mackenzie Delta and Mackenzie Valley region envisage development of a variety of linear corridors. These include large-diameter pipelines, small-diameter pipelines and gathering systems, undersea pipelines, seismic lines, all-weather roads, and winter roads. Impacts associated with the construction and operation of these linear facilities were addressed in several impact hypotheses, and included:

- direct physical disturbances to aquatic and terrestrial habitats;
- indirect disturbances such as sedimentation, surface erosion or changes in channel morphology;
- physical obstructions to wildlife and fish movements;
- increased human access and resulting effects on harvesting efforts and distributions;
- increased sensory disturbances and the potential for habitat alienation;
- increased sensory disturbances and the potential for delays or blockage of wildlife movements;
- direct mortality of wildlife;
- negative and positive effects on travel patterns of local residents, and effects on harvesting patterns and intensity; and
- alienation of traditional use areas and harvesting areas for local residents.

A number of these impacts have already been discussed In earlier sections of this report and will not be repeated here. In this section of the report, only the direct effects associated With the construction, operation and physical presence of linear corridors are discussed. (The effects of increased road traffic, sensory disturbance/habitat alteration, and increased access are described in sections 4.10, 4.11 and 4.13, respectively.) The effects of linear corridors were considered in relation to two different types of impact mechanisms (Table 4.14).

Table 4.14
Linear Corridors

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 2 Increased traffic on the Dempster Highway and roads on the North Slope will decrease the number of caribou and alter their distribution.			Detailed evaluation Hypothesis concluded to be valid. Evidence from Dempster Highway suggests that roadways can cause some caribou to alter or delay their movements. No research directly related to linear access was recommended. However, the group did suggest that sightings of caribou along Dempster should be documented. Suggestions also made that a monitoring program should be established to assess distribution of caribou during fall migration relative to traffic volumes and hunter activity.	Review of research Review of relevant research (21 documents) in relation to caribou movements and industrial developments or roads (15 studies), habitat use (1 study) and wolf-caribou interactions (1 study).		Hypothesis review Requires re-evaluation during BREAM. Hypothesis likely valid; but remove reference to North Slope as no longer part of development scenario.	Detailed evaluation Hypothesis reworded (BREAM R17). Need to re-evaluate as substantial body of new information available and development scenario modified. Need to asses effects of above-ground gathering system and pipeline on Bluenose Herd. Group concluded that effects of roads could be significant but can be mitigated. Above-ground gathering system and pipeline would be of low concern to caribou, but could affect local harvest. Mitigatable using crossings. No research related to effects of linear corridors. (see Table 4.10).

Table 4.14 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 5 Oil and gas development construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose.			Detailed evaluation Hypothesis valid, concern that elevated pipeline sections will deter or delay moose movements. However, impacts can be minimized or eliminated by including crossing sites. No new research or monitoring program recommended for linear corridor impacts.	Review of research Total of 8 research projects reviewed in relation to moose responses to oil pipeline crossing, browse use and digestibility, winter activity patterns, and revegetation monitoring.		Hypothesis review Requires re-evaulation during BREAM. Hypothesis considered unlikely; remove reference to above-ground pipelines (not in scenario) and develop new hypothesis for effects of above-ground gathering systems on local movements.	Detailed evaluation MEMP 5 reworded to address above-ground gathering systems. New hypothesis (R20) evaluated as new information available on moose distributions and habitat use. Group concluded hypothesis is valid but effects would not be significant. Use of crossings sites can minimize effects on moose movements. Moose in Mackenzie do not undertake seasonal migrations (only local movements) and are few in numbers in areas of proposed above-ground gathering systems.
MEMP 16 The construction and presence of linear corridors will affect the number, distribution and quality of fish, and fishing success.			Detailed evaluation Hypothesis valid. Pathway involving affects on fishing success from increased sedimentation valid but impacts short-term and localized. Fish quality (i.e., size) unlikely to be affected. Effects on fish numbers and distributions possible but can be minimized by route selection and protection planning. Group recommended following studies: design of culverts, assessment of distribution, movements and critical habitat for whitefish and grayling, systematic monitoring of fish and expansion of existing hydromnetric network.	Review of research Review of recent research identified 19 relevant projects. These studies provided information on the basic biology of several species (5 studies), effects of pipelines on fish (5 studies), water quality (4 studies), river sediment and channel dynamics (4 studies), culvert designs (1 study) and exposure to sediments (1 study).		Hypothesis review Requires re-evaluation during BREAM. Hypothesis valid. Community-based concerns on impacts to fish and fishing success. No wording changes necessary.	Brief evaluation MEMP 6 inherited by BREAM (designated R27). Suggested that this hypothesis would be more appropriately considered at a community-based concerns workshop. Effects on regional fish stocks would likely be insignificant. In future evaluations of this hypothesis, linkages should be restructured to focus on fishing success rather than fish populations. Effects could be significant, but are mitagatable through good routing and environmental protection planning.

(1) The physical presence of roadways and pipelines may inhibit or prevent seasonal or local movements by some wildlife species, thereby altering the distribution of wildlife (MEMP 2, MEMP 5, BREAM R17, BREAM R20).

(2) Construction and operation of pipelines will result in increased sedimentation and changes in channel geometry, which will affect aquatic habitat availability and quality, the abundance, productivity, and distribution of fish, and fishing success (MEMP 16, BREAM R27).

MEMP 2: Increased traffic on the Dempster Highway and roads on the North Slope will decrease the number of caribou and alter their distribution.

MEMP 5: Oil and gas development construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose.

MEMP 16: The construction and presence of linear corridors will affect the number, distribution and quality of fish, and fishing success.

BREAM R17: Hydrocarbon development in the Beaufort Region and roadway development to the Yukon North Slope will alter the number of barren ground caribou and their distribution.

BREAM R20: Oil and gas development, construction, and activities and the presence of an above-ground pipeline and gathering system will change the abundance and distribution of moose.

4.14.2 Results of Evaluation

Physical Obstructions Associated with Linear Corridors

Concerns related to the physical obstruction of seasonal or local movements by wildlife were identified for caribou and moose. MEMP 2 examined the potential effects of several different proposed or existing roadways (e.g., Dempster Highway, the proposed connector from the Dempster to the Yukon North Slope, the proposed roadways to quarries in the Richardson Mountains) on seasonal movements by animals in the Porcupine caribou herd. Most of these concerns reflected the potential for the presence of humans and vehicles and/or sensory disturbances to temporarily defied or even prevent caribou movements across roadways. As was already discussed in Section 4.10, existing information indicates that effects on caribou movements are possible. However, mitigation methods such as convoying of traffic or road closures during the most sensitive time periods for caribou could minimize or prevent such effects.

During the BREAM program, this hypothesis was re-evaluated (renamed BREAM R17). Participants of the 1991/92 BREAM workshop concurred with the conclusions of the MEMP workshop, but noted that there was potential for oil and gas gathering systems on the Tuktoyaktuk Peninsula, as well as a pipeline along the eastern side of the Mackenzie River to obstruct some movements of the Bluenose caribou herd. Changes in the fall distribution of the Bluenose herd as a result of the pipeline gathering systems or the Mackenzie pipeline were considered to be insignificant because only a small portion of the range would be affected, and impacts could be mitigated through the use of earthen berms and/or buried pipeline sections to promote crossings by caribou. In contrast, the impact of the gathering systems and pipeline on harvesting of caribou by residents of Inuvik and Tuktoyaktuk could be significant (i.e., could affect a large portion of the regional harvest over a long period of time). However, impacts could be mitigated through the use of methods to promote safe crossing of the pipeline systems by vehicles, skidoos and other modes of transportation.

During the MEMP program, similar concerns were expressed that above-ground pipelines would prevent the passage of moose, and lead to changes in moose migration patterns (MEMP 5). Although the MEMP development scenario did not include construction of above-ground pipelines in the Mackenzie Delta and Valley, it is possible that a heated oil pipeline would have to be built above ground in certain areas of discontinuous permafrost. Based on evidence from Alaska, the working group of the MEMP workshop concluded that there was potential for above-ground pipelines to affect seasonal movements of moose. However, as methods exist to construct pipelines so that moose movements are not obstructed, effects would not likely be significant.

This impact hypothesis was revisited briefly during the 1991/92 BREAM workshop. It was noted that concerns related to the effects of above-ground gathering systems on moose movements were only applicable to the Mackenzie Valley region, as moose are uncommon in coastal areas. Within the Mackenzie Valley, there is potential for a small portion of the proposed pipelines to be above ground (Le., the proposed Foothills pipeline included 11 km of above-ground pipe Over a distance of approximately 800 km). Because the above-ground sections would likely be placed on continuous gravel berms and would most likely be built in river valleys, there is potential for these pipeline sections to interfere with moose use of important over-wintering habitats in these valleys. Because moose in the Mackenzie Valley do not appear to undergo seasonal migrations between summer and winter ranges, potential obstructions would affect local movements as opposed to seasonal migrations. Participants also identified concerns that construction of pipeline (i.e., open trenches, human activities) would temporarily delay moose movements. However, given that methods exist to promote moose movements under or over above-ground pipeline sections, as well as to avoid temporary obstructions during pipeline construction (e.g., small work spreads, use of ditch plugs at regular intervals), no significant impacts on moose were anticipated.

Construction and Presence of Linear Corridors

MEMP 16 (BREAM R27) addressed the potential effects of construction and operation of linear corridors on aquatic habitats from sediment production and changes in channel geometry. Four possible impact pathways were evaluated in relation to sedimentation (INAC *et al. 1986):*

(1) Reduced water clarity and effects on fishing success. Although increased sedimentation would result in reduced water clarity, effects on fishing success were concluded to be insignificant. This is because (i) the Mackenzie River is naturally turbid and any increases in turbidity would likely be undetectable, (ii) sport fishing occurs primarily in smaller streams during summer whereas most construction will occur during winter, and (iii) effects of road construction on turbidity would occur at a time when public access is limited and sport fishing is unlikely to occur.

(2) Reduced abundance or availability of prey species and subsequent reductions in fish production *and/or* distributions. Existing evidence suggested that increased sediment production would not affect the availability of benthic organisms and forage fish, and that if effects do occur, they would be of short-term duration and highly localized. As a result, the working group concluded that fish quality and availability would not be affected by the levels of increased sedimentation that might be expected during hydrocarbon development in the Mackenzie region.

(3) Lethal and sublethal *effects* on fish and *effects* on the numbers and distribution of fish. Although lethal effects of sedimentation on fish would be highly unlikely, it is possible that increased sedimentation would induce a

variety of sublethal and behavioural effects in fish. For example, increased sediment loads have been found to reduce growth and respiratory efficiency, lower resistance to disease, and reduce spawning success and fecundity. In contrast, some fish may benefit from turbid water as this may provide hiding cover or increased food supplies. The working group concluded that increased sediment loads would result in changes in the number and distribution of fish (primarily through avoidance, migration or attraction), but that effects would be minor due to the short-term, site-specific nature of increased sediment concentrations.

(4) Effects on streambed material size, particularly the amount of fine-textured materials, and the survival of eggs and larvae. The fate of sediment in stream channels would depend on the particle size composition, the volume of material, channel geometry, existing bed material size, and the discharge regime of the watercourse. Flushing of sediments from streambeds would also depend on the volume of sediments and the sediment transport capability of the stream. There is evidence that significant increases in fine materials within or on a stream substrate will decrease the survival of eggs and larval fish. Effects would be most severe on species such as arctic char, which are fall spawners, have large eggs and a long period of incubation. in contrast, effects would be least for spring spawning species such as grayling, which have small eggs and short incubation periods.

Changes in channel geometry may occur as a result of in-stream construction, removal of bed materials during construction, the placement of structures (such as culverts, bridges, berms or diversion channels), and construction-or operation-related changes in the thermal regime or pattern of water flow that promote icing (or aufeis). Two potential impact pathways were evaluated.

(5) Changes **in** the extent and distribution of in-stream habitat, which will ultimately affect the abundance and/or distribution of fish. Construction activities such as the placement of riprap, bridge abutment and berms can alter natural changes in channel morphology. In-stream constrictions can also alter the channel morphology and stream bed composition. The working group at the 1985/86 MEMP workshop concluded that linear corridors could

affect channel geometry and in-stream habitat, but that appropriate engineering designs could be used to minimize or avoid impacts. Furthermore, if impacts did occur, a variety of options were available for providing replacement habitat. With the exception of arctic char, alterations to most habitats would be of minor significance since most fish species are widely distributed and effects would be localized. In contrast, arctic char occur only in a few streams, and overwinter and spawn in localized areas that are spatially limited and susceptible to local disturbances.

(6) Blockage or obstructions to fish movements to important habitats, and reduced spawning, rearing success and/or overwinter survival. Fish movements may be affected by changes in channel geometry associated with increased water velocities resulting from channel Constrictions or placement of structures, reduced water depth as a result of gravel extraction or winter roads (i.e., ice barriers), thermal regimes associated with heated pipelines (and interference with thermal cues), and alteration in local drainage patterns.

Blockages of movements could reduce spawning success, particularly for species that utilize small streams for spawning, such as arctic char and grayling. In contrast, species that spawn in larger tributaries and the Mackenzie River are less likely to encounter blockages. Fish rearing habitat are unlikely to be affected by linear corridors, perhaps with the exception of small streams along the Mackenzie Delta and Tuktoyaktuk Peninsula that are used by juvenile and adult coregonids for rearing and feeding. The greatest risk may be the blockage of arctic char and grayling movements to spatially-restricted critical overwintering habitats (i.e., spring-fed areas of smaller streams). Although effects could be significant, participants of the MEMP workshop concluded that impacts could be minimized by careful route selection and design, development of appropriate mitigation strategies, routine on-site supervision during construction, and post-construction monitoring and maintenance of structures.

During the 1991/92 BREAM workshop, this hypothesis (designated BREAM R27) was only briefly considered. Although workshop participants concurred with the conclusions reached during the MEMP workshop, it was recommended that the hypothesis be modified to focus on fishing success rather than fish populations. Effects on fishing success could also be significant, but effects could be mitigated through measures similar to those identified during the MEMP workshop.

4.15 INCREASED LEVELS OF WAGE EMPLOYMENT

4.15.1 Introduction

In light of the potential for future hydrocarbon developments in the Beaufort Sea and Mackenzie Delta and Valley regions, community residents expressed concern that increased wage employment would result in changes in harvesting activities by regional residents. In response to this concern, two impact hypotheses were developed as part of the MEMP program. MEMP 18 examined the effects of wage employment on the harvest of white whales, while MEMP 22 examined the changes in resource harvesting (fish, waterfowl, big game) due to a wage economy (INAC €lt at, 1986). Both of these hypotheses had a number of themes in common:

- wage employment will affect the amount and quality of time that is available for harvesting activities;
- wage employment will affect the types of information that is available on harvested species (i.e., location, numbers);
- wage employment will delay the learning of harvesting skills;
- wage employment will alter the composition of the harvesting groups, thereby affecting the level of experience of the harvesting group; and
- wage employment will allow expansion and modification of harvesting equipment (i.e., purchase of new equipment).

Similar concerns were addressed during BEMP in regards to changes in harvesting of marine birds and marine mammals. Although an impact hypothesis was developed (BEMP A1), it was never evaluated (INAC and Environment Canada 1984, pages 289-290).

MEMP hypotheses 18 and 22 underwent detailed evaluations during the 1985/86 MEMP workshop and were briefly re-examined during the 1991/92 BREAM workshop (Table 4.15) (INAC et at. 1986; INAC 1992). Due to the socio-economic nature of these impacts, it was necessary for workshop participants to make a number of assumptions on the flexibility of wage employment to harvesting activities (e.g., timing, location and duration), the importance of harvesting activities relative to wage employment, community social processes (e.g., resource sharing), the level of effort required to maintain harvesting skills, and the importance of hunting and fishing for domestic needs. It was also necessary to make several assumptions regarding the factors that limit the domestic harvest.

MEMP 18: Wage employment will change the harvest of white whales.

MEMP 22: Increased levels of wage employment will change the total annual harvest of resources by communities in the region.

BEMP A1: Increased native employment in industry will change marine bird and mammal harvest levels (see Appendix III, INAC and Environment Canada 1984).

Table 4.15
Increased Levels of Wage Employment

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 18 Wage employment will change the harvest of white whales.			Detailed evaluation Some pathways of this hypothesis were concluded to be valid. Wage employment may reduce the time available for hunting and , in turn, hunter selectivity and the composition of the harvest. No effect on level of harvest was expected. Wage employment unlikely to change the level of information on the distribution and availability of white whales. Group supported continuation of white whale harvest study, but recommended expanding to include status of hunter employment.		Review of research Ten relevant studies were identified which addressed wage employment issues (2 studies), harvest statistics (4 studies) and impacts of industrial development and mitigation (4 studies).		Hypothesis review Requires re-evaulation during BREAM. Hypothesis considered valid for harvest composition but not level; no changes in wording necessary.
BEMP Appendix III-1 increased native employment in industry will change marine bird and mammal harvest levels.	Flowchart development Due to a lack of appropriate expertise at the workshop, no evaluation was completed. Not considered further during BEMP.		Concerns embodied in this hypothesis were incorporated into MEMP 18 and 22 (see above).				

4.15.2 Results of Evaluation

MEMP 18 addressed the potential for increasing wage employment to affect the harvest of white Whales by residents of the Mackenzie Delta (e.g., Tuktoyaktuk, Aklavik, and Inuvik). Historical data indicated that the harvest of white whales has declined over the years. This was thought to reflect the declining dependence of residents on white whales as a source of food, as more residents are employed in a wage economy and supplement their diet with commercial food. MEMP 18 involved four potential pathways through which the whale harvest could be affected.

(1) Wage employment will result in less time being available for the White whale hunt, thereby decreasing the numbers of whales taken and/or the sex/age composition of the harvest. Participants concluded that this was a possible impact.

(2) Wage employment will reduce the amount of information on white whales that is available to the community, and reduce harvesting success. Community representatives concluded that increased wage employment would not affect the amount of new information on the distribution and availability of white whales and, as a result, would not affect the harvest.

(3) Wage employment will alter the number and/or composition of the hunting groups and, as a result of reduced skills or quality of equipment, will alter hunter efficiency and the success of the hunt. This was concluded to be one of the most likely effects on the harvest.

(4) Wage employment will change the quality of equipment used by hunters, thereby reducing hunter efficiency and the success of the hunt. This impact was also considered likely.

The working group at the MEMP workshop agreed that wage employment would not prevent hunters from participating in the annual white whale harvest. Although the actual time spent hunting may not be reduced, weekend or short-term hunters (employed in the wage economy) would have less time to become involved in other important socio-cultural activities at the whaling camps. Hunters may also be less selective. For example, the first whales seen may be taken, as opposed to the present preference for the large male animals. The most probable effect of the wage economy on the white whale harvest would be that fewer people will participate in the whale hunt, or that individuals may hunt by themselves rather than as part of a family group. Furthermore, because camp experience is considered important to learning the specific skills and the selection, care and handling of equipment, the level of skills and the quality of equipment may also decline. Despite these negative effects, the working group concluded that community pressure and education had prevented a decrease in the white whale harvest. During the 1991/92 BREAM workshop, the conclusions of MEMP working group were supported, and no changes were made to the wording or structure of the impact hypothesis.

MEMP 22 was very similar to MEMP 18, except that it addressed the effects of a wage economy on a broad range of harvesting activities for fish, waterfowl, furbearers and large game, as opposed to solely white whales. Three impact pathways were evaluated.

(1) Wage employment reduces the amount of time available for hunting. Workshop participants concluded that this was not a valid pathway since time was not necessarily a limiting factor to hunting by wage earners, and wage earners were often able to arrange holidays or time-off to allow harvesting during specific, preferred time periods.

(2) Wage employment will decrease or delay opportunities to learn harvesting skills. Community representatives and other participants believed that this pathway was also invalid because there would be opportunities for inexperienced people to learn skills through other qualified hunters within or outside their households or family groups. It was noted, however, that skills appeared to be lost more rapidly in females than males.

(3) Wage employment will allow expansion and improvement of harvesting equipment that will improve travel or search time (e.g., skidoos, motorized boats) and improve effectiveness in killing and retrieval (e.g., high-powered rifles). Participants concluded that wage employment would not affect the level of effort by households (even though individual efforts may be affected), nor would it significantly affect the total community harvesting effort. It was noted that it is still common in northern communities for country foods to be shared. To allow better evaluation of this impact hypothesis, participants

recommended that community-based programs be developed to obtain information on wage employment, harvest effort, types of harvest, and mutual aid, cooperation and sharing.

4.16 CONFLICTS BETWEEN INDUSTRY AND HARVESTERS

4.16.1 Introduction

To address concerns related to potential conflicts between resource harvesting activities and industrial activities associated with hydrocarbon development in the Mackenzie Delta region, MEMP Hypothesis 24 was developed and subsequently evaluated in the 1985/86 project workshop (INAC et a/. 1986). This hypothesis focussed on potential loss of harvests as a result of alienation from specific harvesting locations, damage to fish and Wildlife habitat, and loss of fishing/trapping equipment (Table 4.16).

MEMP 24: Industrial activities in harvesting areas will reduce the harvests of mammals, birds and fish because of conflicts between industry and harvesters over land use.

4.16.2 Results of Evaluation

Although efforts are made by the petroleum industry to prevent conflicts with traditional land use activities, temporary or permanent exclusion of resource harvesters from hunting or trapping areas could occur as a result of the presence of an installation (e.g., drill rig), human safety considerations or loss of access. While relocation of harvesting activities could offset the loss of harvesting opportunity in a particular area, this is not always a reasonable solution. Relocation of trapping sites could be costly, and may result in conflicts among trappers. Land around each community is often fully allocated to local members of the Hunters and Trappers Association, and any vacant trapping area would be distant from the community or of poor quality. Greater numbers of full-time trappers and recreational and part-time trapping by residents involved in the wage economy have already created conflicts and competition among harvesters. When expansion into new harvesting areas is not possible or hunting/trapping opportunity is lost as a result of equipment damage, it was noted that industry would likely be required to compensate harvesters (both individuals and organizations) for their loss.

Table 4.16
Conflicts between Industry and Harvesters

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 24 Industrial activities in harvesting areas will reduce the harvest of mammals, birds and fish because of conflicts between industry and harvesters over land use.			Detailed evaluation Industrial development and land use conflicts may result in localized losses to harvest, particularly for trappers. Negotiation, mitigation and compensation process should be established.	Review of research A Dene mapping project underway, which will provide a historical database of traditional land use information.		Hypothesis review Hypothesis valid.	Hypothesis not inherited by BREAM because land use and compensation issues are outside the scope of the program.

Evaluation of MEMP Hypothesis 24 led to the recommendation that a negotiation, mitigation and compensation process should be established by industry and that harvest and land use information be collected to support future compensation claims. A review of relevant research in 1987 (INAC et al. 1988) indicated that a Dene mapping project was underway, which would provide a historical database of traditional land use by the Dene/Metis of the Mackenzie Valley. It was noted that this information could be particularly important to the Dene in the negotiation/settlement of possible future industry/harvester land use conflicts.

This hypothesis was not re-evaluated in 1991/92 as part of BREAM because socioeconomic issues were considered outside the scope of the program.

4.17 INCREASED HUNTING BY NON-LOCALS

4.17.1 Introduction

Based on the hydrocarbon development scenarios developed for BEMP and MEMP, it was anticipated that two types of influxes of non-local people would occur:

- large-scale and short-term influx during the construction phases of large projects (i.e., thousands of people for months); and
- smaller-scale and long-term influx during the operation and maintenance of oil and gas fields and transport facilities (hundreds of people for years) (INAC el al. 1986).

Non-locals would include native people from other areas within the Northwest Territories and Yukon, as well as non-native people throughout Canada.

Because of the importance of resource harvesting to native residents in the Beaufort/Mackenzie regions, there was concern that the influx of non-local people would result in increased demands for fish, game resources and fur, and competition among local residents for these resources. It was also recognized that local population growth would contribute to these effects (however, this was not examined as part of the MEMP or BREAM programs).

The potential impacts of increased harvesting by non-local people were addressed directly in regards to the white whale hunt (MEMP 20), and the general harvesting activities for fish, waterfowl, furbearers and large game (MEMP 25) (Table 4.17). Effects of increased human populations on waterfowl hunting and harvests of anadromous fish were also identified as a concern during the BEMP program (INAC and Environment Canada 1984, pages 291 and 292, respectively). Although impact hypotheses were developed, these were not evaluated as part of the BEMP program.

Effects of increased harvesting by non-local people were also addressed indirectly in a number of the impact hypotheses for MEMP and BEMP. For example, many of the impact hypotheses concerning the effects of increased access on resource populations and harvesting effort (see Section 4.13) implicitly included increased human populations (both non-local people and local population growth). MEMP 14 addressed the effects of increased access on the sport fish harvest One of the linkages predicted that increased human populations would result in increased numbers of sport fishers.

MEMP 14: Improved access and fishing pressure will decrease the abundance of fish and affect their distribution.

MEMP 20: Competition by non-locals will change the number of white whales landed and increase mortality in the population.

MEMP 25: Increases in hunting by non-locals will restrict harvest by local natives.

BEMP A2: A consequence of increased human populations in the Beaufort Sea region will be increases in recreational hunting of waterfowl (see Appendix III, INAC and Environment Canada 1984).

BEMP A3: Human population increases will cause an increase in the harvest of anadromous fishers which will lead to reduced populations of these species (see Appendix III, INAC and Environment Canada 1984).

Table 4.17
Increased Hunting by Non-Locals

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 14 Improved access and fishing pressure will decrease the abundance of fish and affect their distribution.			Detailed evaluation Concluded hypothesis to be valid. Participants agreed that development would result in increased numbers of sport fishers that will increase harvests of sport fish. Noted that regulations may be used to control harvest but are difficult to establish and enforce. Group identified need for harvest study to compare pre- and post-disturbance harvests, including composition, numbers, and location.	Review of research Review of research identified 7 relevant projects. Three studies involved baseline data on Arctic char stocks and data from domestic and commercial fisheries. Two studies involved stock identification in whitefish. Remaining two studies provided general information on fish populations.		Hypothesis review Requires re-evaluation during BREAM. Hypothesis valid; no changes in wording.	Brief Evaluation This hypothesis (designated BREAM R25) was only briefly examined during workshop. Group agreed that it would be more appropriate to evaluate this issue relative to community-based concerns. Given lack of information on fish stocks, not possible to evaluate the significance of the effects of increased access on fish abundance and distribution. Group noted that if scenario involved winter construction of pipeline, concerns re: increased access and fish would be reduced. Group identified need for information on basic biology and population size of important species.
MEMP 20 Competition by non-locals will change the number of white whales landed and increase mortality in the population.			Detailed evaluation Concluded hypothesis to be invalid. Participants agreed that it is unlikely that competition by non-local native people would occur. Even if some individuals did participate, it would not affect the level of harvest or the mortality of whales. No research or monitoring was recommended.	Review of research No relevant research identified.		Hypothesis review No re-evaluation necessary. Effects on harvest and population of white whales unlikely; no longer a concern due to the existence of the IFA structures. Now have to be a “beneficiary” to be able to harvest white whales.	

Table 4.17 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
MEMP 21 Increased or improved access associated with hydrocarbon development will increase the harvest of waterfowl, which will lead to a reduction in the number and alter the distribution of waterfowl.			Detailed evaluation Hypothesis is valid, but effects unlikely to occur given the present development scenario. As the Inuvik – Tuktoyaktuk roadway is unlikely to be built, other possible new access unlikely to provide improved access to important habitat for waterfowl. No research or monitoring programs recommended.	Review of research No relevant research identified.		Hypothesis review Requires re-evaluation. Hypothesis valid, but effects unlikely. No changes in wording necessary.	Overview Effects of improved access were addressed for fish, birds and mammals under one hypothesis by combining MEMP 21 and 23. It was suggested that direct effects of access on numbers and distributions of resources also be included in this hypothesis, rather than just through the domestic or sport harvest. Valid. Improved access would result in increased harvesting. Research and Monitoring: No new programs recommended.
MEMP 25 Increases in hunting by non-locals will restrict harvest by local natives.			Detailed evaluation Hypothesis valid. In absence of compensating legislation, it is likely that increased immigration of non-native people and native people would result in increased competition of fish, birds and large game animals. Not valid for trapping as must have license to trap. Group identified that baseline data is required on non-local harvesting activities (levels, location, effort harvest composition, etc.).	Review of research Two relevant research projects were identified dealing with resident hunter harvest surveys, and the other with socio-economic impacts associated with the Norman Wells pipeline project.		Hypothesis review Requires re-evaluation during BEMP. Hypothesis valid. No changes in wording necessary.	No evaluation. Considered during community-based concerns meeting in Yellowknife. Of note, the Inuvialuit, Gwich'in and Sahtu land claim agreements provide for mechanisms for regional regulation of hunting and fishing activities. Likelihood of increased numbers of non-local residents resulting in increased harvest levels is, therefore, reduced.

Table 4.17 (cont'd)

Hypothesis	1983/84 Initiation of BEMP	1984/85 BEMP	1985/86 BEMP/Initiation of MEMP	1986/87 BEMP & MEMP	1987/88 BEMP	1990/91 Initiation of BREAM	1991/92 BREAM
BEMP Appendix III-2 A consequence of increased human populations in the Beaufort Sea region will be increases in recreational hunting of waterfowl.	Flowchart development Due to a lack of appropriate expertise at the workshop, no evaluation was completed. Not considered further during BEMP.		Concerns embodied in this hypothesis were incorporated into MEMP 21 and 25 (see above).				
BEMP Appendix III-3 Human population increases will cause an increase in the harvest of anadromous fishes which will lead to reduced populations of these species.	Flowchart development Due to a lack of appropriate expertise at the workshop, no evaluation was completed. Not considered further during BEMP.		Concerns embodied in this hypothesis were incorporated into MEMP 14 and 25 (see above).				

4.17.2 Results of Evaluation

MEMP 20 addressed the potential for increased competition by non-local native people to change the number of landed white whales and to increase the mortality in the white whale population. Concerns were identified that non-local native employees would participate in the white whale hunt between workshifts. However, the workshop participants agreed that this would not likely occur given the close family ties in most northern families and other obligations. If individuals did remain in the area to participate in the hunt, it was likely that they would join existing harvesting groups rather than hunt on their own, particularly since whale hunting requires a specific set of skills and specialized equipment As a result, the working group concluded that competition by non-local hunters was unlikely, and that there would not be an increase in the level of harvest or the mortality of white whales.

MEMP 25 is similar to MEMP 20, except that it focussed on fish, waterfowl, furbearers and large game as VECs. Participants noted that the primary concern would be the smaller-scale, long-term influx of workers because they would eventually be able to qualify for hunting licenses and would likely have time or would make time to use them. There could also be a significant political pressure group that could lobby for increased quotas or other rights for non-native people (INAC et a/. 1986). In contrast, a large-scale, short-term influx of non-native employees was not expected to significantly increase the demand for fishing and hunting. This is because many of these individuals would not meet residence requirements, they may have little time for recreation, industrial policies may prevent or discourage them from hunting or fishing, and they may not be able to access suitable areas for recreational hunting and fishing. Immigration of non-local native people could result in a range of impacts on harvesting demands. Small-scale influxes would not likely cause any significant effects since they would be incorporated into the local community by traditional social methods. In contrast, large-scale increases may overwhelm the local community and could result in competition for country foods.

Increased demand from non-native and native immigrants was expected to be greatest for big game (e.g., moose, caribou), waterfowl and fish. Furbearers harvests are more strictly controlled by the local Hunters and Trappers Associations (HTAs). Non-local General Harvest License holders cannot trap without the permission of the HTAs.

Based on experience from other areas (i.e., Alaska, British Columbia), workshop participants concluded that substantial declines in local harvesting success could occur if regulations were not in place to control non-local harvesting activities. Such declines may reflect reductions in the availability of fish and wildlife, alienation of some harvesting areas by the presence of non-local hunters, and loss or alienation of some harvest sites due to industrial development (see also Section 4.17). The working group concluded that increased hunting by non-local people would have a significant effect on local residents unless compensating legislation or regulatory actions were put in place prior to significant new immigration. As a result of the enactment of the Inuvialuit Final Agreement in 1988, and land claim negotiations for the Gwich'in and Sahtu regions, such controls are now in place for all of the Beaufort Sea and Mackenzie Delta region, as well as most of the Mackenzie Valley.

MEMP 14 also addressed the effects of increased human populations on fishing effort and harvests (this hypothesis was discussed earlier in Section 4.12). Participants of the 1985/86 MEMP workshop concluded that, based on results from other areas, it was probable that Increased human populations and improved access would increase pressures and, in turn, result in the decline of some fish stocks. Arctic char and lake trout were identified as species that are particularly susceptible to overharvesting due to their restricted distribution and their slow recovery from overharvesting. Local populations of grayling may also be susceptible to overharvesting but are much more widespread throughout the study area. Participants noted that overfishing could be controlled by imposing quotas, catch limits and seasons on various types of fisheries, but that such regulations have proven to be difficult to establish and enforce.

5.0 CATASTROPHIC OIL SPILLS

Catastrophic oil spills and blowouts, while an important area of potential concern related to any hydrocarbon development, were not considered in BEMP and MEMP because of their infrequent and unpredictable occurrence and the associated difficulty in assigning research and monitoring priorities to such low-risk events. The Nestucca spill off the coast of Washington in December 1988 and the Exxon Valdez spill in Alaska in March 1989, however, changed this view. Questions related to the fate, effects and cleanup of a worst-case blowout in the Beaufort Sea dominated the EIRB review of Gulfs proposed 1990"1992 drilling programs from the Kulluk, and the Beaufort Sea Steering Committee and its associated Task Groups further examined various issues surrounding catastrophic oil spills. In light of these events, BREAM was compelled to deal with major oil spills, not only in terms of setting research and monitoring priorities but also from an environmental assessment perspective.

Phase II of BREAM (1991/92) was marked by the establishment of the Catastrophic Oil Spill Technical Working Group, which was charged with the responsibility of determining specific issues related to major oil spills and their cleanup that should be dealt with through the program. As part of this task, the Working Group developed six offshore and onshore oil spill scenarios (involving well blowouts and pipeline ruptures) and a list of Valued Ecosystem Components (VECs). This list of VECs included all of those originally selected for BEMP and MEMP as well as a number of new ones such as coastlines, non-harvested bird and fish populations, and air and groundwater quality.

In 1992/93, the primary focus of the Working Group was to build on progress made in 1991/92 in terms of developing two additional scenarios (involving barge diesel spills and refined fuel spills on winter roads), and formulating impact hypotheses relating the scenarios to the VEC species groups. Of the 18 oil spill hypotheses developed for BREAM, nine of these were selected for evaluation at the interdisciplinary workshop held in 1992/93 (Table 5-1). These hypotheses were considered most important based on known community and scientific concerns related to large oil spills in the region. The nine hypotheses involved four different spill scenarios where the timing and the location of the event represented a worst case, and considered the potential direct and indirect

Table 5-1
Catastrophic Oil Spill Impact Hypotheses

Hypothesis #	Hypothesis	Description of Hypothesis and Associated Linkages
C1	Offshore Blowout of Crude Oil in Summer – Marine Mammals	Direct effects of oil (surface contact and ingestion) on polar bear, arctic fox, seals and whales Indirect effects of noise and disturbance from well control and clean-up activities on marine mammals Indirect effect of clean-up activities (human interaction) on polar bear populations
C2	Offshore Blowout of Crude Oil – Terrestrial Mammals	Direct effects of stranded oil (fouling and ingestion) on populations and harvest of terrestrial mammals Direct effects of stranded oil on habitat Indirect effects of pipeline repair, clean-up, restoration and monitoring operations (noise, disturbances, human interaction) on populations and harvest of terrestrial mammals
C3	Pipeline River Spill of Crude Oil in Summer – Terrestrial Mammals	Direct effects of oil (ingestion and fouling) on populations and harvest of terrestrial mammals Indirect effects of repair, clean-up, restoration and monitoring operations (noise, disturbance) on populations and harvest of terrestrial mammals Indirect effects of repair, clean-up, restoration and monitoring operations (human interaction) on bear and fox populations and the harvest of same
C4	Pipeline River Spill of Condensate – Terrestrial Mammals	Direct effects of condensate (fouling and ingestion) on populations and harvest of terrestrial mammals Indirect effects of repair, clean-up, restoration and monitoring operations (noise and disturbance, human interaction) on populations and harvest of terrestrial mammals Indirect effects of repair, clean-up, restoration and monitoring operations (human interaction) no populations and ultimately the harvest of bears and foxes
C5	Offshore Well Blowout of Crude Oil – Semi-aquatic Mammals	Direct effects of stranded oil in Delta wetlands (fouling, ingestion, chronic irritation of mucous membranes) on populations and harvest of semi-aquatic mammals (primarily muskrat) Indirect effects of clean-up, restoration and monitoring activities on wetland habitat and semi-aquatic mammals (noise and disturbance) Direct effects of stranded oil on wetland habitat
C6	Pipeline River Spill of Crude Oil in Summer – Semi-Aquatic Mammals	Direct effects of oil (ingestion, fouling, chronic irritation of mucous membranes) on populations and harvest of semi-aquatic mammals (muskrat and beaver) Indirect effects of pipeline repair, oil clean-up, restoration and monitoring activities (noise and disturbance) on semi-aquatic mammals and ultimately their harvest Indirect effects of pipeline repair, oil clean-up, restoration and monitoring activities on habitat of semi-aquatic mammals
C7	Pipeline River Spill of Condensate – Semi-Aquatic Mammals	Direct effects of condensate (ingestion, fouling, chronic irritation of mucous membranes) on semi-aquatic mammals and the harvest of same Indirect effects of pipeline repair, clean-up activities and site restoration on habitat of semi-aquatic mammals Indirect effects of pipeline repair, clean-up activities and site restoration (noise and disturbance) on semi-aquatic mammals and the harvest of same
C8	Pipeline River Spill of Crude Oil under Ice – Birds	Effects of oil spill response (cleanup) activities on bird habitat, bird populations and the harvest of same Effects of oil on bird habitat and bird foods Effects of oiling of birds on their physiology and reproduction and thereby bird populations and their harvest

Table 5-1 (cont'd)
Catastrophic Oil Spill Impact Hypotheses

Hypothesis #	Hypothesis	Description of Hypothesis and Associated Linkages
C9	River Barge Spill of Diesel Fuel in Summer – Birds	Effects of oil spill response (cleanup) activities on bird habitat, bird populations and the harvest of same Effects of oil on bird habitat and bird foods Effects of oiling of birds on their physiology and reproduction and thereby bird populations and their harvest
C10	Oil/Condensate Spill, Leak or Blowout – Scavenging Birds	Effects of consumption of oiled birds by scavengers
C11	Island Platform Blowout in Summer – Birds	Effects of oil spill response (cleanup) activities on bird habitat, bird populations and the harvest of same Effects of oil on bird habitat and bird foods Effects of oiling of birds on their physiology and reproduction and thereby bird populations and their harvest
C12	Condensate Pipeline River Spill under Ice – Fish	Effects of dissolved oil-in-water on spawning and migration behaviour of arctic grayling and northern pike Sublethal and toxic effects of dissolved oil-in-water on newly emerging fry of fall-spawning species Effects of dissolved oil-in-water on quality of fish and harvest levels
C13	Condensate Pipeline River Spill in Summer – Fish	Sublethal and toxic effects of oil dissolved in water on fish Effects of dissolved oil-in-water on quality of fish and harvest levels Effects of surface oil on surface-feeding fish and their prey
C14	Oil Pipeline River Spill in Summer – Fish	Behavioural and sublethal effects of oil dissolved in water on fish Effects of dissolved oil-in-water on quality of fish and harvest levels Effects of surface oil on surface-feeding fish and their prey Effects of oil on nearshore bottom on prey of bottom feeders
C15	Oil Pipeline River Spill in Spring – Fish	Effects of oil dissolved in water on behaviour and migration of arctic grayling and northern pike Sublethal effects of oil dissolved in water on fish Effects of dissolved oil-in-water on quality of fish and harvest levels Effects of oil on the bottom on benthic invertebrates and bottom-feeding fish
C16	Offshore Sub-sea Blowout in Fall – Fish	Lethal, sublethal and food-chain effects of oil dissolved in water on fish Effects of dissolved oil-in-water on quality of broad whitefish and the harvest of broad whitefish Effects of oil/water emulsion and solid residues from countermeasures burning on benthic invertebrates and bottom-feeding fish
C17	Offshore Island Platform Blowout – Fish	Lethal, sublethal and food-chain effects of oil dissolved in water on fish Effects of dissolved oil-in-water on quality of broad whitefish and the harvest of broad whitefish Effects of oil/water emulsion and solid residues from countermeasures burning on benthic invertebrates and bottom-feeding fish
C18	River Barge Spill of Diesel Fuel in Summer – Fish	Effects of oil on prey of bottom feeders and subsequent effects on growth, population size and harvest of these fish Effects of tainting on fish harvest Effects of oil on spawning/migration behaviour of fish Sublethal effects of oil on growth and reproduction and thereby populations size

(i.e., spill response activities) impacts of:

- an offshore island platform blowout of crude oil in summer on marine mammals, birds, fish and semi-aquatic mammals and the harvest of these resources;
- a river barge spill of diesel fuel near Swimming Point on Richards Island during summer on fish and birds and their harvest;
- an under ice spill of crude oil at a pipeline river crossing near Norman Wells during spring on birds and their harvest; and
- a pipeline spill of crude oil just upriver of Fort Simpson during summer on terrestrial and semi-aquatic mammals and their harvest.

Evaluation of the impact hypotheses culminated in the identification of research and monitoring priorities related to large oil spills in the Beaufort and Mackenzie regions. Despite the fact that this workshop represented the first attempt by BREAM to address this complex issue, few research needs were identified. Most of the recommendations involved post-spill research and monitoring programs to assist in the assessment of impact and recovery/restoration of resources and resource uses after potential spills.

The following section of this report summarizes how issues surrounding each of the nine hypotheses were assessed, and the research and monitoring programs that were recommended to help resolve information gaps related to these concerns. The reader is referred to Section 4 of the 1992/93 BREAM report (INAC I'll a/. 1993) for more detailed information regarding the evaluations of these hypotheses.

5.1 OFFSHORE ISLAND PLATFORM BLOWOUT OF CRUDE OIL

Four impact hypotheses (BREAM C1, C5, C11 and C17) were developed to assess the potential impacts of an offshore island platform blowout of crude oil on marine mammals, semi-aquatic mammals, birds and fish and the harvest of these resources. The scenario used to evaluate these hypotheses involved the release of 77,400 bbls of crude oil over a 6-day period from an artificial island in the Beaufort Sea during the open-water season. The exact date of the spill varied for each of the species considered to ensure that it coincided with the timing of significant numbers of the population and harvest activities for that resource. Of the 77,400 bbls oil spilled, it was assumed that about 19,400 bbls would evaporate, 4000 bbls would naturally disperse into the water column, and 29,000 bbls would become stranded along the shoreline (some 60,000 bbls of emulsion along the Yukon coast between Kay Point and Whitefish Station, and another 56,000 bbls of emulsion between Whitefish Station and Avoknar Channel in the Mackenzie Delta). It was also assumed that the Beaufort Sea Co-op's Response Barge would be deployed within 24 hours of the blowout, and about 25,000 bbls of oil would be recovered from the sea surface near the blowout site (INAC et al. 1993).

BREAM C1: The effects of an island platform blowout of crude oil during summer on marine and marine-associated mammals and their harvest. (The VECs included white whales, bowhead whales, ringed seals, bearded seals and polar bears.)

BREAM C5: The effects of an island platform blowout of crude 011 during summer on semi-aquatic mammals and their harvest. (The VECs included muskrat and mink.)

BREAM C11: The effects of an island platform blowout of crude oil during summer on birds and their harvest. (The VECs included tundra swans, terrestrial geese, loons, brant, eider ducks, other ducks, alcids and shorebirds.)

BREAM C17: The effects of an island platform blowout of crude oil during summer on fish and their harvest. (The VECs included broad whitefish, lake whitefish, arctic cisco, least cisco, dolly varden, pacific herring.)

5.1.1 Direct and Indirect Oil Effects

Fouling

Evidence from past spills suggests that ringed and bearded seals would likely become oiled as a result of swimming or surfacing through oil slicks. Under normal arctic open-water conditions, it would be unlikely that this would have serious sublethal or lethal effects on oiled individuals. However, the presence of oil on the pelage of these seals could reduce the value of the skins and consequently affect the harvest of these species. Although there have been very few observations of oiled cetaceans, it was also considered possible that beluga and bowhead whales could become oiled. While there is no evidence to suggest that the whales would be negatively affected by this oil, perception of tainting could have significant effects on the cultural and/or market value of the beluga harvest and a potential bowhead harvest. The potential for contact with oil and subsequent sublethal and lethal effects was considered to be high for polar bears. Based on the results of past experiments with this species, it was considered unlikely that polar bear would avoid oil slicks and that contact of the skin or fur with oil would have both thermal and a range of sublethal effects on those affected individuals. Because the Beaufort Sea population of polar bears is already harvested at maximum sustainable yield, any mortality due to surface contact with oil would likely have long-term population effects and effects on the quota levels for this species. Contamination of fur could also reduce its value and, therefore, the quantity and quality of the polar bear harvest.

In a worst case, oil may be stranded within most wetlands and along channel shorelines within 5 km of the outer edge of the Delta. As most of this is high quality muskrat habitat, it is likely that fouling of some muskrat would occur. Fouling of this species during late summer and fall would be of concern because the summer moult would be largely complete and fouling could persist into the winter when thermal effects on muskrat would be most severe. However, because most of the prime habitat is in the southern portion of the Delta, the magnitude of this impact was expected to be small. Effects of fouling on the harvest of muskrat was considered to be more significant. If more than 10% of the regional population was affected, harvesting in the area would likely be suspended for a year or more. The perception of fouling may also extend beyond the predicted duration of direct effects of fouling. Mink that swim or forage in wetlands containing stranded oil would also likely contact oil films, sheens and mousses. However, because only a small portion of the regional mink population is expected to commonly utilize wetlands in the outer fringe of the Delta, it was concluded that the effects of fouling on mink populations and trapping of mink would be insignificant from a regional perspective.

It was considered unlikely that oil would reach areas where most terrestrial geese and tundra swans concentrate. However, significant numbers of these birds could encounter oil if a storm surge occurred during the spill. Larger proportions of loon, shorebird, brant, eider, alcid and other duck populations (I.e., those that occur in marine waters during at least part of the open-water season) would likely encounter oil. The likelihood of mortality from direct oiling was considered highest for thick billed murre, which engage in swimming migrations west across the Beaufort Sea in fall while migrating from their colony at Cape Parry. While there is abundant evidence that direct oiling of birds' feathers could result in mortality through loss of buoyancy and hypothermia, the extent to which this would occur as a result of the offshore blowout would depend highly on the date of the spill and wind conditions during the spill event. Birds with non-lethal doses of oil on their feathers could also transfer oil to their eggs, which may kill or deform the embryos. However, this linkage was thought to be invalid, as most of the VEC bird groups would be finished incubating their eggs at the time of the spill. Oiled birds that survive until the next breeding season would have moulted their oiled plumage.

In the Beaufort Sea, the spawning areas of most valued fish species would not be affected by an offshore island platform blowout. However, a zone of potentially lethal concentrations of oil dissolved in water (i.e., exceeding 1 ppm) would be created within 2 km of the platform. Depending on the duration of exposure, mortality of some young-of-the-year fish (least and arctic cisco, broad and lake whitefish and Pacific herring) could occur. Dissolved/dispersed oil was not expected to affect Dolly Varden, as their coastal range does not spatially overlap with this area. Some locally detectable effects of these high concentrations of dissolved oil may occur (e.g., where an abundance of larval or post-larval fish could be exposed to lethal concentrations for a number of days). However, it was considered unlikely that this would result in changes in population size. The zone of influence for sublethal effects (about 1 ppm) was expected to extend several kilometres landward from the platform. Populations most affected would likely be those species whose spawning activity or early larval development may be exposed to these concentrations (I.e., Dolly Varden returning to spawning streams along the Yukon coast, and eggs and larvae of the next seasons herring spawn). These effects would likely cause sufficient reductions in the local availability of Dolly Varden and Pacific herring to cause changes in harvest levels and harvest patterns for these populations.

Ingestion

Subadult bowhead whales appear to feed actively while in concentration areas along the Yukon coast and off the Mackenzie Estuary and, therefore, could ingest oil either directly from the water or through consumption of oiled prey. Although past studies provide some evidence that cetaceans may accumulate hydrocarbons from ingested oil, it was noted that they would have to consume very large amounts to demonstrate sublethal or lethal effects. Ingestion of such large amounts of oil was not considered possible given the scenario. The potential for ingestion of oil by ringed and bearded seals was considered much lower since they do not use this area extensively to feed, and therefore the potential for mortality or sublethal effects was considered to be low. Because white whales do not feed while in concentration areas within the Mackenzie Estuary, ingestion of oil by this species would not occur. However, polar bear would likely Ingest oil both through grooming of contaminated fur and consumption of oiled prey, which could cause a range of physiological and pathological effects as well as mortality. Any loss of individuals as a result of direct mortality or lower reproductive rates were expected to be significant given the current size of this population.

Recent evidence from post-spill monitoring of the Exxon Valdez spill suggests that contact of semi-aquatic mammals with oil and subsequent ingestion via contaminated prey and grooming would likely occur. Muskrat, in particular, would be at high risk because of their feeding habits (e.g., use of aquatic and emergent plants) and high reliance of water bodies for feeding, movements and protection from predators. Muskrat could potentially ingest oil through direct consumption of oiled vegetation, consumption of vegetation that has become contaminated through uptake of certain hydrocarbon compounds, and grooming of their own fur and conspecifics (including young of the year). Mink would likely ingest oil through ingestion of contaminated prey or oiled carrion. Although it was uncertain whether this would result in reduced survival and reproductive capacity of mink or muskrat populations in the Delta, it was concluded that impacts to the regional population of mink would likely be small due to fact that this species is very territorial and oiling of prey would be spotty. Tainting or perceived tainting of muskrat meat could have subsequent effects on the harvest of muskrat for food, which could persist for more than one year. However, taint is not an issue with mink since mink flesh is not commonly eaten. In addition, the loss of individuals due to ingestion of oil is unlikely to affect sufficient numbers to affect the local or regional mink harvest.

Contact of birds with oil slicks on the water surface, on shorelines and in adjacent terrestrial wetlands would likely result in the ingestion of oil through preening of oiled plumage and consumption of contaminated plant and animal foods. While a reduction in bird numbers as a result of physiological effects and reduced reproductive capacity could potentially occur, it was unknown whether birds would consume sufficient contaminated food to cause direct mortality. The effects of oil ingestion was considered to be an area of significant concern for most of the VEC bird groups, with the exception to eiders. Although it was unknown to what extent eiders consume food during their swimming migration through offshore waters in summer or fall, it was considered unlikely that their benthic food would be significantly contaminated with oil. For hunted waterfowl species, ingestion of non-lethal amounts of oil would likely change their palatibility and result in a reduction in the harvest of these birds.

Although it is likely that fish would consume oil-contaminated zooplankton and benthic invertebrates, effects on growth, development and reproductive success were expected to be limited because of the capacity of fish in this area to readily metabolize and depurate hydrocarbon contaminants. Sublethal effects would be most pronounced in larval and post-larval stages of coastal fish species, where enzyme systems responsible for degradation/metabolism of hydrocarbons may not be as well developed. With an oil spill of this magnitude, it is unlikely that population-levels effects would be detected as a result of the non-spawning adult portion of populations ingesting oil-contaminated prey.

Loss of Habitat

Mortality of wetland vegetation that provides important habitat for semi-aquatic mammals would likely result from direct contact with oil (suffocation), direct toxic effects and physical effects (e.g., dislodging, cleanup activities). However, the loss of habitat associated with the offshore oil blowout and subsequent stranding of oil in the Delta would be very small (i.e., < 1% of the available muskrat habitat in the Delta) and short term (Le., one year). The spill would affect mink habitat primarily through changes in the availability, quality and distribution of primary prey species (muskrat and fish). Although muskrat and fish would be affected by the spill, impacts to mink were expected to be insignificant given the restricted distribution of oil within the outer Delta, the low quality of mink habitat in the outer Delta, the availability of prey in adjacent areas, and the probable rapid response of prey through immigration and reproduction.

The offshore blowout would affect fish habitat primarily through changes in the availability and distribution of zooplankton. Lethal and sublethal effects of oil on zooplankton would be restricted to within an area of 1-2 km^2 of the platform, and therefore reductions in the abundance of zooplankton would be small, patchy and localized. Fish species potentially affected by this would be water-column feeders, pacific herring, arctic and least cisco and Dolly Varden. In some instances where a local fish population is dependent on feeding at a location where zooplankton recruitment is curtailed due to poor circulation and exchange, reduction in prey items may persist beyond the open-water season and affect the availability of zooplankton in the winter months. Potential loss of fish could occur in local populations of pacific herring, least cisco and arctic cisco, which overwinter in coastal embayments. Although its direct effect on the harvest of these populations was expected to be insignificant, tainting or the perception of tainting would likely significantly affect harvest levels and patterns for all the VEC fish species in the coastal and Delta area.

5.1.2 Effects of Spill Response Activities

Noise and disturbances associated with well control and cleanup activities could cause changes in the distribution of beluga and bowhead whales, and ringed and bearded seals. Because cleanup may be required in years following the spill event, effects on the distribution of these populations and, therefore, hunting activities of the Inuvialuit could be long term. The oil spill may also lead to a regulatory closure of the beluga hunt and seal hunts by either the Inuvialuit or Department of Fisheries and Oceans. While the potential effects of spill countermeasure and cleanup activities on the seal hunt were considered to be insignificant given the number of seals generally harvested in this area, the white whale is probably the most important marine mammal to Inuvialuit hunters in the region. Any effects on this hunt were considered to be significant.

It was also considered possible that noise and disturbance associated with oil spill response activities could cause reductions in the time available for foraging and an increase in the energy expenditures through increased avoidance behaviour in bowhead whales. Because the extent to which interference with feeding would occur was unknown, effects on the reproduction of individual bowheads Were also uncertain. However, it was noted that potential effects of disturbance from a single spill would probably be much less significant than those caused by long-term disturbances associated with offshore exploration and development activities. (This concern has been fully addressed in relation to routine aspects of development, BREAM Hypothesis R1). Little interference between cleanup activities and feeding activities of beluga whales and ringed and bearded seals was expected.

Noise and disturbance would not likely affect the energy balance of polar bears, but may cause some animals to be attracted to the area and result in the need to destroy some bears. The death of a few individuals would lead to compensatory reductions in bear quotas for that year and possibly future years, depending on the timing of the deaths and the age and sex classes of these animals.

Most of the containment and cleanup activities, habitat restoration and monitoring activities in coastal and terrestrial areas would be restricted to the outer shoreline of the Delta and perhaps the shorelines of the major channels in the Delta. In addition, the booms would likely be deployed along the outer coastline to prevent oil from entering major embayments. As a result, it was concluded that there would be little spatial overlap between these activities and muskrat and mink. However, noise and disturbance associated with these activities could cause birds to be stressed and result in sublethal effects on their physiological condition. The exception would be eider ducks, which fly west over the spill area in summer and fall. Cleanup activities could also cause degradation of bird habitat, particularly for those species that depend on the shoreline, adjacent nearshore waters and adjacent coastal lowlands seaward of the inland extent of storm surges. The exception to this would be loons (few nest seaward of the storm-tide line), eiders (the vast majority that occur in the area are migrants from breeding areas farther east), and alcids (thick-billed murre do not occur in coastal or terrestrial areas of the spill impact zone and black guillemots fly out to marine waters to feed). The effects of cleanup activities on the distribution of VEC bird species and subsequent effects on their harvest would only be valid for those waterfowl that are hunted.

5.1.3 Recommended Research and Monitoring

A number of research and monitoring recommendations were made in relation to assessing the validity of Hypotheses C1, C11, and C17. These included:

- review of the DFO sampling program for white whales to determine if adequate baseline data is available with which to assess the potential effects of an oil spill on beluga whales;
- post-spill monitoring of beluga and bowhead whales to examine their behaviour and determine their responses to oil and to well control and cleanup activities;
- pre-spill monitoring programs for some of the valued bird species occurring in the southeastern Beaufort Sea, in addition to the loon monitoring program already initiated by the Canadian Wildlife Service;
- determine the susceptibility of the Cape Parry thick-billed murre colony to oil spills by examining existing aerial-and boat-survey data on the temporal and spatial patterns of larger colonies in the Canadian High Arctic;
- in the event of a large oil spill, a number of field monitoring programs should be initiated, including: (1) systematic surveys to determine changes in the abundance of birds; (2) monitoring to determine the effectiveness of scare efforts; and (3) documentation of the effects of the spill and response on hunting activities and success;
- field tests of the effectiveness of selected bird scaring devices under Beaufort Sea conditions;
- research into the homing abilities of Dolly Varden; and

- monitoring of the condition of livers of harvested fish species as well as continued archiving of tissue samples.

5.2 RIVER BARGE SPILL OF DIESEL FUEL

Two impact hypotheses were developed to address the potential effects of a river barge spill of diesel fuel on fish and birds and their harvest (BREAM C9 and C8, respectively). While both hypotheses involve a release of 2300 bbls of diesel into the East Channel, the scenario was modified so as to affect a larger number of birds and fish. In the case of Hypothesis C9, the location of the spill was moved farther downstream to Lousy Point so that at least some diesel would reach Kittigazuit Bay. (Even under this revised scenario, it would be unlikely that the spilled diesel would move as far downstream as Hendrickson Island, Kidluit Bay or Mason Bay, where various birds tend to concentrate in mid summer.) For Hypothesis C18, the surface current was modified in the scenario such that oil would be more likely to reach the shores of Hendrickson Island and other coastline of Kugmallit Bay.

BREAM C9: The effects of diesel spill on the Mackenzie River from a barge on the number and harvest of birds. (Four VEC groups were selected: terrestrial geese, tundra swans, brant, and red-throated loons.)

BREAM C18: The effects of a diesel spill on the Mackenzie River from a barge on fish and their harvest. (The VECs included: broad whitefish, northern pike, burbot, and inconnu.)

5.2.1 Direct and Indirect Oil Effects

Fouling

Some snow, Canada and White-fronted geese could be killed as a result of loss of buoyancy or hypothermia due to oiling of their feathers. However, the risk of this and the proportion of the local population potentially affected would be low because it is unlikely that much diesel fuel would be Carried into the terrestrial areas where these waterfowl spend most of their time in summer. Recovery of these populations would likely occur within one generation. Brant would be more vulnerable to contact with oil and losses to the local population and the harvest of this population could be significant depending on the number of migrants that stop in the spill area. Although recovery is likely to occur, it may require more than one year depending on the extent of the losses to the population, While red-throated loons would be more likely to contact oil than the more terrestrial bird species, losses to this population would be small due to the small size and short duration of the spill and the low density of loons in this area of the river.

Young-of-the-year fish would be most susceptible to lethal effects of oil dissolved in water. However by the time of the spill (mid August), there would be very few Y-0-Y in the mainstem Mackenzie River. Broad whitefish and inconnu Y-O-Y are in nearshore coastal waters where very low concentrations of dissolved oil would occur, and northern pike and burbot fry are more likely to be found in creek mouths. In those circumstances where oil enters and persists in these creeks, some mortality of these species could occur. However, this effect was considered insignificant given the short-term duration of the oil, the age class of fish affected (fry), and the potential for recruitment from unaffected populations. Sublethal effects of oil in water on the spawning segment of broad whitefish and inconnu populations would be unlikely given that they are generally upstream of the spill area by mid August. Local populations of northern pike and burbot and subadult and non-spawning coregonids may be affected, but any toxicity-related effects would be of short duration and a localized nature,

Tainting as a result of exposure to high concentrations of oil dissolved in water (all VEC species), ingestion/contact with oil-contaminated bottom sediments and benthos (broad whitefish) would likely have a significant effect on the harvest of these fish species. Even in the absence of actual risk, the perception of taint would likely persist into the next year.

Ingestion

The likelihood of birds ingesting oil through preening of fouled plumage and consumption of contaminated prey would be greatest for brant concentrating and feeding along the coast and least for other geese and tundra swans feeding on land. However, whether any of these birds would ingest sufficient amounts of oil to cause mortality was unknown. While ingestion of nonlethal doses of oil could affect the physiological condition of the bird, it was considered unlikely that this would cause a decline in their reproductive capacity. Ingestion of oil could also cause a change in the palatability of hunted species (geese and swans) and subsequently their harvest, however, this would be unlikely given the number of geese and swans affected by the spill.

Given the lightness of the diesel, the small size of the spill and the transport potential of the oil due to the river current, there would be much less of a potential for oiling of bottom substrates, contamination of benthic invertebrates and subsequent ingestion of oil by bottom feeders (i.e., broad whitefish) than that associated with crude oil spills (see Section 5.1.1). There is also generally less potential for food chain effects because many of the VEC fish species rely on zooplankton, which are not abundant in the area of the spill.

Habitat Loss

The presence of spilled oil would lead to the degradation of bird habitat (e.g., water surface, benthic communities, shorelines, adjacent terrestrial wetlands). However, recovery of the habitat would probably occur in the short term. As mentioned above, the potential for oiling of bottom substrates and reductions in benthic invertebrate abundance is low given the nature and extent of the spill.

5.2.2 Effects of Spill Response Activities

While it is unlikely that oil spill cleanup activities would have any significant effects on bird habitat, these operations may cause disturbance and displacement of some terrestrial geese, Tundra Swans and Brant. Snow geese are particularly sensitive to disturbance during late summer and fall. Activities near shoreline areas would be expected to cause displacement of some waterfowl, which would result in limited energetic cost to these individuals and a reduction. in the harvest of these populations. Although it is uncertain how many brant may be affected by these activities (see effects of fouling; Section 5.2.1), the cumulative effects of disturbance/displacement, mortality through fouling, and perception of taint on the harvest may be significant depending on the number of brant in the area of the spill.

5.2.3 Research and Monitoring Recommendations

The highest priority research need in relation to Hypothesis C9 was to determine the stopover and turnover patterns of Brant migrating along the Beaufort Sea coast in late summer. Information gaps related to the various aspects of oil uptake by birds and bird use of the East Channel were also identified.

During the evaluation of Hypothesis C18, it became apparent that there is a need to develop a better understanding of the role that suspended sediments play in the fate of oil in the Mackenzie River, and the effect that suspended particulates have on the acquisition of taint and on bioaccumulation aspects of taint.

5.3 PIPELINE SPILL OF CRUDE OIL

Two impact hypotheses were developed for BREAM to address the potential effects of a pipeline spill in the Mackenzie River on terrestrial and semi-aquatic mammals (C3 and C6, respectively). Both hypotheses involve a scenario where a pipeline rupture causes up to 5000 bbls of crude oil to be released just upriver of Fort Simpson. For evaluation of Hypothesis C3, the timing of the spill was selected to be early June to July to coincide with the period immediately following the peak flood, when high but declining water levels would expose a large area of riparian habitats to released oil, and many terrestrial mammal species are utilizing riparian areas and islands for feeding and birthing. The timing of the scenario used to evaluate Hypothesis C6 was selected to be Mayas to coincide with the birthing periods of, and hunting activities for semi-aquatic mammals In this scenario, it was assumed that both shores of the river would be sporadically oiled along a 200 km stretch affected by the spill. It was estimated that 1000 bbis of oil would be stranded in widely-scattered areas within this affected zone and that 2500 bbls of oil would naturally dispersed within the water column.

BREAM C3: The effects of a pipeline spill of crude oil during summer on terrestrial mammals. (Three VEC groups were selected: moose, black and grizzly bear, and wolves and foxes.)

BREAM C6: The effects of a pipeline spill of crude oil during summer on semi-aquatic mammals. (The VECs included mink, muskrat and beaver.)

5.3.1 Direct and Indirect Oil Effects

Fouling

It was assumed that two hours after the spill, the diameter of the dispersed cloud would equal the width of the river. Therefore, any moose, bear, wolf, fox or mink swimming in the river or foraging along the river bank within the zone of influence of the spill would likely come in contact with the oil. While fouling of fur was not expected to result in energetic consequences to terrestrial mammals, it would result in the loss of insulation and buoyancy in mink fur that could lead to changes in the energy balance of affected individuals. Although the implications of this to the survival and reproductive capacity of the mink population was uncertain, it was estimated that less than 1% of the regional population would likely be affected through this pathway and recovery would, therefore, be short term. Because the main hunt for moose, bears, wolves and foxes and the trapping season for mink does not occur until much later in the year, it is unlikely that sufficient amounts of oil would still remain along the riverbanks or on the animal's fur to cause hunters/trappers to take fewer animals or to reduce the value of these harvests.

Oil would probably extend about one mile inland on both shores of the river. While this could affect 65-70% of the total area of suitable muskrat and beaver habitat, only 5-10% of this area would likely become oiled due to the small volume of oil that would reach the shoreline and its discontinuous distribution. While less than 10% of the regional populations of muskrat and beaver would likely come In contact with oil either while foraging for food or swimming in the river due to their widespread distribution and mobility, this could represent a large percentage of the total annual harvest for these species.

Ingestion

Although there was no evidence to suggest that moose have the capability of detecting and avoiding oil, it was thought unlikely that they would feed on contaminated vegetation when alternate uncontaminated food sources would be available in the area. However, they could ingest oil through grooming of fouled fur, particularly during the cleaning of calf fur by the mother. Due to a lack of information regarding the toxicological effects of oil on moose, it was uncertain whether ingestion of oil would lead to mortality in affected individuals. Some moose may ingest sufficient amounts of oil to cause a range of physiological and behavioural effects (increased grooming activity, shivering, vomiting) that would ultimately affect the energy balance of these animals. However, population-level effects were not expected.

Bears, wolves and foxes could potentially ingest oil through consumption of oiled prey, consumption of prey containing oil, or grooming of their fouled fur (and their young, in the case of bears). Because these species are scavengers and are known to utilize the river during the summer, it was concluded that some animals may ingest sufficient amounts of oil to cause mortality. The likelihood of black and grizzly bears ingesting sufficient amounts of oil to effect their survival and reproductive capacity was considered greater than for the other VEC species because they are particularly vulnerable to contact with oil. Because these species have very high mortality rates and low reproductive rates, a further reduction in the number of cubs born and the survival of subadult and adult bears would reduce the breeding population and cause a gradual decline in the size of the populations. Any reported losses of bears, wolves or foxes could affect quotas in subsequent years if present harvest levels are at the maximum sustainable yield for these populations.

Although it was concluded that muskrat, beaver and mink would also likely ingest oil through grooming of fouled fur and consumption of contaminated prey, the significance of this to the survival and reproductive capacity of these populations was unknown.

Habitat Loss

While the presence of spilled oil could lead to localized, direct toxic effects on vegetation and subsequent localized losses of muskrat and beaver habitat, these losses would probably represent less than 1% of the regional habitat of these species. Oil in the river and along the shoreline could also lead to a loss of habitat for mink (primarily prey species, muskrat and fish). However, this impact was not expected to be significant given the small volume of spilled oil, and the rapid recovery of these prey populations due to immigration of individuals from adjacent areas and high fecundity and reproductive rates of these species.

5.3.2 Effects of Spill Response Activities

Spill response activities such as pipeline repair, cleanup, habitat restoration and monitoring would be relatively localized and short term and, therefore, would not likely represent a source of major disturbance to terrestrial mammals (moose, bears, wolves or faxes). Given the nature of these activities and the relatively low abundance of wolves and foxes in the area, the potential for interactions with humans would be very low. However, there may be a need to destroy some bears that are attracted to these activities if they become a nuisance or safety hazard to cleanup or repair crews. As mortality in the regional grizzly bear population is believed to be high due to recreational and subsistence hunting, control of problem animals and natural causes, additional losses due to human/bear conflicts may exceed the sustainable limit for the population and a gradual decline in numbers may occur.

Cleanup and habitat restoration efforts would be focussed along the shoreline and lowland areas where there would be the potential for conflicts with muskrat, beaver and mink. The zone of influence of disturbances associated with spill response would be much smaller than that of oil and, therefore, very localized changes in the distribution and harvestability of these species would be expected. Because these activities would likely occur over a short time frame (i.e., 1,2 months), this impact would also be of short-term duration.

5.3.3 Research and Monitoring Recommendations

During the evaluation of BREAM Hypotheses C3 and C6, it was recommended that existing information related to the chronic and acute effects of oil on terrestrial and semi-aquatic mammals should be reviewed. Any information gaps in the database should be noted and opportunistic research conducted, with a priority on grizzly bear due to their low densities in the region and the economic value of this species.

5.4 UNDER-ICE SPILL OF CRUDE OIL

BREAM Hypothesis C8 was developed to assess the potential impacts of an under-ice spill of crude oil on birds and their harvest. The scenario used to evaluate this hypothesis involves a pipeline rupture at a crossing of the Great Bear River just upstream from its confluence with the Mackenzie River. To represent a worst case, it was assumed that the oil would leak from the submerged pipe at a rate of 100 bbl/day for 60 days (prior to detection). An additional 154 bbls of oil (from between the shut-off valves) would enter the river after detection. Prior to breakup, the oil would move into the Mackenzie River, where it would form a long narrow swath along the undersurface of river ice. Some oil might reach shorelines during breakup (probably in the form of a sheen), but would not be expected to reach the shorelines of islands located close to the west side of the Mackenzie River near and downstream of the mouth of the Great Bear River (e.g., Windy Island).

BREAM C8: The effects of an oil pipeline rupture and associated countermeasures at a river crossing in spring on birds and their harvest. (Three VEC groups were selected: dabbling ducks, geese & swans, and raptors.)

5.4.1 Direct and Indirect Oil Effects

Fouling

Given the spill scenario, it is unlikely that geese and swans that concentrate on islands on the west side of the Mackenzie River would become oiled. However, some ducks and raptors that land on the east side of the river where oil would be present could come in contact with oil and die as a result of a loss of buoyancy or hypothermia. With the exception to eagles, raptors would not likely enter oiled water but could become oiled by contact with oiled prey or oiled habitat. Ducks and raptors with non-lethal doses of oil on their feathers could transfer oil to their eggs, which could subsequently kill or deform the embryos and, thereby, reduce hatching success. Although the extent of losses through fouling was unknown, mortality of ducks and raptors was expected to be small and insignificant from a regional perspective. Recovery would likely occur within one generation, except in the case of peregrine falcons where losses would be more significant.

Ingestion

Evidence from past spills show that most heavily-oiled waterbirds die because of buoyancy and hypothermia problems. It was uncertain whether ducks and raptors that survive this would then die as a result of toxic effects of oil ingested through preening of their feathers. However, a range of physiological effects would be expected. It would be unlikely that ducks would ingest sufficient amounts of oil from contaminated food to cause mortality. Raptors often consume many feathers when eating avian prey and, therefore, may be more susceptible to ingesting lethal doses of oil.

Tainting or the perception of tainting may cause a reduction in the harvest for some ducks. However, the duration of this impact would likely be short term (i.e., one year).

Habitat Loss

The presence of spilled oil would lead to the degradation of habitat (e.g., water surface, benthic communities, shorelines, adjacent terrestrial wetlands) for some ducks and raptors. However, recovery of the habitat would probably occur in the short term (i.e., one year).

5.4.2 Effects of Spill Response Activities

Oil spill reconnaissance, bird deterrent efforts, and (if attempted) cleanup would involve intensive activity, noise and disturbance to feeding, resting, and/or migrating birds in the area. It was concluded that these disturbances could lead to physiological stress, particularly for snow geese and at least some raptors because these species are known to often react to noise caused by activities even at a considerable distance away. While disturbance effects would also have the potential to result in reduced local harvest of geese, effects on the harvest would probably last no more than one year. Because ducks are known to be less sensitive to disturbance than geese and because of their variable distribution, it would be unlikely that activity, noise and disturbance associated with spill response would affect the harvest of these birds.

5.4.3 Research and Monitoring Recommendations

A number of recommendations for pre-spill research were made during the evaluation of this hypothesis. However, a low priority was placed on this work as a result of the insignificant nature of most of predicted effects associated with this spill scenario. The group also recommended that several types of post-spill monitoring should be initiated after any spill in which a significant number of birds might be affected. These were also discussed in relation to the offshore platform blowout scenario.

6.0 COMMUNITY-BASED CONCERNS

6.1 COMMUNITY INVOLVEMENT AND INPUT TO BEMP, MEMP AND BREAM

With the exception to the initial planning years for BEMP (1983/84) and BREAM (1990/91), representatives of the major aboriginal organizations and communities within the Mackenzie Valley, Mackenzie Delta and the Canadian Beaufort Sea regions participated in all technical meetings and workshops (INAC 1992). Participation by community representatives provided opportunities to incorporate community concerns in the identification of issues and the development of impact. hypotheses, as well as to utilize community-based information in the evaluation of hypothesis linkages. Groups that participated in BEMP, MEMP and/or BREAM included the Inuvialuit Game Council, the Great Bear Development Impact Zone (DIZ) Society, the Dene Nation, the Sahtu, the Mackenzie Delta Regional Council, the Gwich'in, the Porcupine Caribou Management Board, the Fisheries Joint Management Commission, the Fort Liard Band, and the Deh Cho.

As noted in INAC (1991), there are a number of advantages to incorporating community-based concerns into processes such as BEMP, MEMP and BREAM:

- adds credibility to the program from the communities' perspective while also providing a focus for community input;
- fosters participation by communities in the program as well as subsequent recommended research programs;
- broadens the perspective of the programs;
- promotes the use of traditional knowledge;
- may assist in project reviews and approvals by resolving issues and ensuring that the communities are aware of and in *agreement* with background information, impact assessments and the importance of specific issues;
- increases mutual understanding of scientific, industry, government and community concerns; and
- may assist northern residents in developing trust in science and reducing the potential for confrontation.

Inclusion of community-based concerns may also constrain programs such as BEMP, MEMP and BREAM by:

- significantly widening the scope of the program in terms of time, space, and resources, and increasing the overall cost of the program;
- increasing the expectations of northerners in relation to hydrocarbon development, mitigation and compensation; and
- complicating the evaluation process through the identification of issues that are outside the scope of the program or the mandates of the supporting agencies (e.g., land claim settlements), or that can only be resolved by specific groups or industry (e.g., employment levels by industry).

Most of these disadvantages, however, relate strongly to program management, and can often be resolved by clearly defining the scope of the program, establishing criteria for identification of important issues, and developing a process for evaluation of issues and identification of research and monitoring needs. A number of these bounding principles were utilized during BEMP, MEMP and BREAM to assist in the identification of community-based environmental concerns, as opposed to community-based social concerns (Which were considered to be outside of the scope of all three programs).

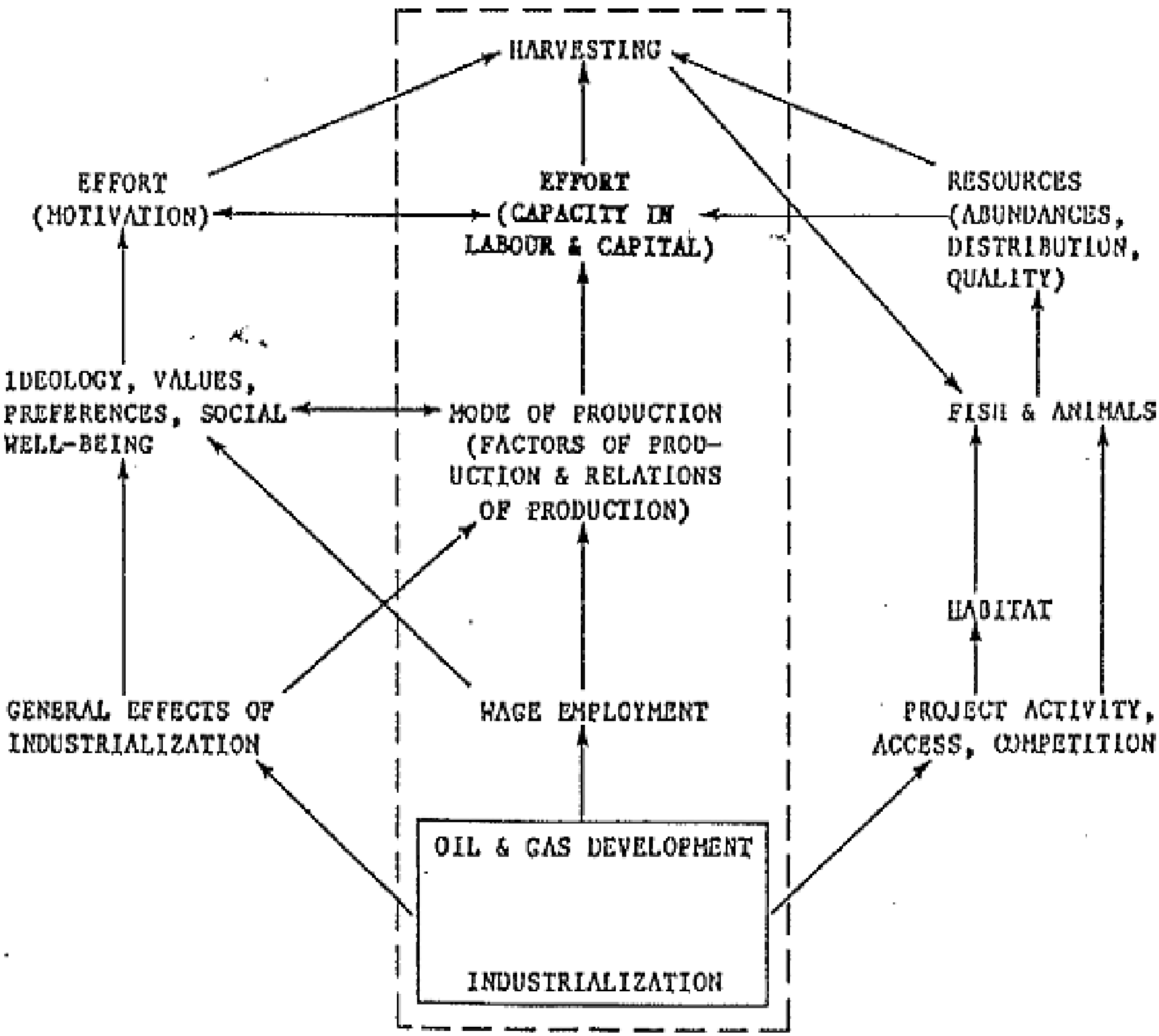
During BEMP, evaluation of community-based concerns was limited to potential effects of hydrocarbon activities on harvesting activities and the fish and wildlife populations (VECs) that are commonly harvested by northern residents. Several hypotheses involved the direct effects of hydrocarbon development on harvesting activities for white whales, polar bears and fish harvests. In addition, one impact hypothesis was developed to address effects of increased native wage employment on harvests, and two impact hypotheses were developed to address potential effects of increased human populations on the harvest success of native people. Most of the remaining impact hypotheses indirectly addressed effects on harvests through assessment of potential changes on resource abundance, distribution or quality (i.e., accumulation of heavy metals). Community concerns regarding changes in the quality or taste of fish partly lead to the development of Hypothesis 20 (i.e., effects of oil-based muds on anadromous fish), and the eventual expansion of this hypothesis to include marine mammals, waterfowl, and other fish.

Community-based concerns formed a very significant portion of the issues addressed through MEMP. Considerable effort was made to involve the Inuvialuit Game Council, the Great Bear DIZ Society, the Mackenzie Valley Regional Council, the Dene

Nation, the Métis Association and the Aklavik Hunters and Trappers Association. This likely reflected many factors, including the growing recognition of the importance of community involvement in environmental impact assessment, negotiations for and the settlement of native land claims (e.g., the Inuvialuit Land Claim Agreement), the desire of native organizations for greater involvement and recognition in processes such as MEMP, and increased interest in the integration of traditional environmental information with scientific data.

During the first year of MEMP, a conceptual model was developed to describe the possible interactions of hydrocarbon developments on resource harvesting (Figure 6-1). Participants agreed that direct effects of industrial activities on harvesting (the right hand side of Figure 6-1) should be considered as part of the MEMP program, whereas changes in social values and ideology (the left hand side of Figure 6-1) were outside the scope of MEMP (INAC €lt al. 1986). Direct effects on resource harvesting activities included potential impacts on harvesting effort and success, changes in the quality, abundance and distribution of the resource, as well as social, cultural and economic aspects such as the costs and benefits of harvesting.

Figure 6-1
Model of the Impact of Industrial Development on Native Resource Harvesting (taken from INAC *et al.* 1986)



Of the 17 environmental or resource-based impact hypotheses considered during MEMP, several directly addressed the effects of hydrocarbon development on caribou quality and abundance, waterfowl quality and harvests, fish quality and fishing success. As in BEMP, the majority of the remaining hypotheses indirectly assessed effects on harvests through assessment of potential changes on resource abundance and/or distribution (e.g., arctic fox and red fox, caribou, muskrat, moose, waterfowl, .fish and wolverine).

In addition, eight MEMP hypotheses were developed to address the effects of hydrocarbon development on the socio-economic process of resource harvesting by native people. Issues that were considered included:

- effects of wage employment on harvesting effort and success,
- effects of noise and mechanical disturbances on harvesting activities,
- increased competition for fish and wildlife as a result of increased human populations, and
- effects of increased access on harvest levels and distributions.

In the first year of BREAM, a Technical Working Group was established to address community-based environmental concerns. The Technical Working Group was tasked with identifying community-based concerns associated with hydrocarbon development and transportation in the Mackenzie Valley, Mackenzie Delta and Beaufort Sea region, and selecting those issues that could be most appropriately addressed by BREAM. It was concluded during the 1990/91 BREAM program that BREAM should address community-based environmental issues but not social concerns. The latter were recognized as being important, but more appropriately addressed through some other process.

During the subsequent two years of BREAM (1991/92 and 1992193), the Community based Concerns Technical Working Group focussed primarily on:

(1) identification of environmental concerns of northern residents, specifically in relation to large oil spills and their cleanup;

(2) development of processes for identifying community-based ecological issues and concerns, and incorporating local and traditional knowledge into the BREAM program;

(3) identification of community-based environmental issues and concerns, and incorporation of valid concerns into existing BREAM impact hypotheses; and

(4) identification and refinement of any outstanding community-based ecological concerns or issues.

Community-based environmental issues that were identified by this Technical Working Group during the 1991/92 and 1992/93 BREAM programs were:

1. need for better baseline data on resource populations, harvest locations, harvester effort, and habitat requirements for harvested populations;

2. need to consider cumulative effects of upstream development on fish quality (i.e., tainting, texture and appearance);

3. locations and toxic nature of solid waste disposal sites and associated contaminants;

4. potential impacts of a catastrophic oil spills' on harvestable resources and their habitat;

5. potential impacts of a refined oil spill as a result of increased winter road travel or barge traffic;

6. construction of an east-west pipeline route and subsequent feeder lines on beluga calving areas in Shallow Bay;

7. effects of increased ambient noise and traffic on harvestable resources;

8. cumulative effects of atmospheric contaminants, effluents and other industrial, municipal or agricultural contaminants on air and water quality and harvestable resources;

9. need to incorporate traditional knowledge into the evaluation of impact hypotheses, the design of research and monitoring programs, and the interpretation of data;

10. need to involve northern residents in all stages of research, monitoring and assessment, and to improve information sharing;

11. better use of existing sources of information on community-based environmental concerns; and

12. need to consider social and economic concerns as part of BREAM, or as a parallel process.

Based on the original BREAM hypotheses or on subsequent modifications to these hypotheses, participants concluded that BREAM had addressed all items except issues 3, 6, and 12. Concerns for solid waste disposal sites (#3) was dropped as an issue because of the recent program under the Arctic Environmental Strategy to clean up abandoned solid waste disposal sites. Potential effects of an east-west pipeline (#6) were also considered to be of minor importance since no pipeline is likely to be built in the short to moderate term (i.e., 15 to 25 years), and pipeline routing and environmental protection planning would minimize environmental impacts.

The single most important outstanding issue expressed by community representatives was that social and economic concerns related to northern oil and gas development are not being examined by BREAM or any other program. Community representatives strongly recommended that a program to investigate social and economic concerns be integrated with and be complimentary to BREAM. Others participants argued that integration of social and economic issues within the BREAM program is not only inappropriate, but could fail to adequately address the social and economic concerns of northerners since the tools employed by BREAM may be ineffective for evaluation of non-ecological questions (INAC et al. 1993). In reviewing the BEMP, MEMP and BREAM programs over the past decade, it is apparent that ecological and environmental considerations have far outweighed the social and economic investigations. To provide balance, a majority of participants in the 1991192 and 1992/93 BREAM programs recommended that a new initiative or process be undertaken to address the potential social, economic and cultural impacts of northern oil and gas initiatives.

6.2 COLLECTION AND USE OF TRADITIONAL ENVIRONMENTAL KNOWLEDGE

Almost from the beginning of the BEMP program, and throughout the MEMP and BREAM programs, traditional ecological knowledge was incorporated into the development and assessment of impact hypotheses and, more importantly, into the development and implementation of research and monitoring programs. MEMP was likely one of the first environmental impact assessment processes to explicitly recognize the value of traditional environmental knowledge as a source of important information on past and current environmental conditions, as well as actual (I.e., observed) or possible impacts to resources and resource harvesting.

The mechanisms that were used during the BEMP, MEMP and BREAM programs to identify and incorporate relevant traditional environmental knowledge were as follows.

- Community representatives were encouraged to participate in all workshops and most technical meetings. During all workshops and relevant technical meetings, community participants were encouraged to provide input on resource status and potential impacts.
- Community representatives played a major role in developing impact hypotheses related to environmental concerns of the communities, particularly in relation to potential effects on resource harvesting activities.
- Meetings to identify and evaluate community-based concerns were held during the 1991/92 and the 1992/93 BREAM programs. Results from these meetings were then used to modify existing impact hypotheses and information bases, as well as to develop new impact hypotheses (e.g., for the catastrophic oil spill scenarios).

Although the BEMP, MEMP and BREAM programs did foster the use of traditional environmental knowledge in most aspects of the evaluation and assessment processes, two issues arose in relation to the use and incorporation of this knowledge. First, it was apparent that some of the scientific participants in these programs did not view traditional environmental knowledge as a valuable source of baseline information, or impact response information to support impact hypotheses. This may reflect the lack of familiarity of these individuals with traditional environmental knowledge, as well as a distrust of information that has not been collected by strict scientific methods. In the past five years, however, there has been a growing recognition of the importance of traditional environmental knowledge, as well as the development of methods for systematically collecting and integrating traditional knowledge with scientific data bases (I.e., the Dene Cultural Institute Pilot Project in the Fort Good Hope and Colville lake areas [Johnson 1992], the Community Resource Mapping Projects by INAC [Herbert 1993]. community-based planning projects in the Inuvialuit Settlement Region [e.g., Community of Paulatuk 1990; Community of Sachs Harbour 1992], and the recently initiated traditional information program for the Northern Rivers Basin Project [L. Flett, pers. comm.]. By the completion of the BREAM program, it was clear that the value of traditional environmental knowledge was recognized by most participants.

The second issue related to traditional environmental knowledge was that recommendations for modification of existing harvest studies or the development of new study programs to systematically collect and summarize traditional environmental knowledge (e.g., INAC 1990, page 248; INAC 1991, page 32; INAC 1992, page 269) do not appear to be have been acted on, with the exception of harvest studies for white whales which were conducted by the Fisheries Joint Management Commission in the Mackenzie Delta. As an example, native concerns in the Canadian and Alaskan Beaufort Sea regions were the primary driving factor in supporting large research programs for bowhead whales, and the potential effects of hydrocarbon development and arctic shipping on this species. However, traditional information on this species did not appear to be used in the design of the research, collection of data, or the subsequent interpretation of the data,

6.3 COMMUNICATION OF PROGRAMS RESULTS TO THE COMMUNITIES

During the Community-Based Concerns meetings held in 1991/92 and 1992/93, community representatives expressed concerns that the results of the impact assessment process and the ongoing research and monitoring activities of BEMP and MEMP had not been clearly communicated back to the participating communities. Update newsletters were published regularly during the 199/92 and 1992/93 BREAM programs to address this concern. However, community representatives' felt that the newsletters were not widely available or well understood by the communities, particularly aboriginal residents. In future programs, it is recommended that a public consultation process be implemented to provide a broader forum for input of community concerns, as well as communication of information back to the communities.

7.0 RESEARCH AND MONITORING RECOMMENDATIONS

The fundamental role of BEMP, MEMP and BREAM was to identify the most important research and monitoring priorities related to future hydrocarbon development in the region. Throughout the 1970s and 1980s, there was a need for information relevant to assessing the potential impacts of development on the environmental and its resources. However, in many cases, acquisition of this information was not structured in a way that could be focussed on significant issues. A scientific framework was needed to focus on what needs to be known for assessment purposes and to make decisions through establishment of a prioritized list of necessary research, monitoring and assessment activities. The BEMP, MEMP and BREAM process provided that framework, and resulted in the initiation of new research and monitoring, focussing of some existing research, and the elimination of other programs that could not be defended in terms of their relevance to environmental assessment.

Through evaluation of the numerous BEMP, MEMP and BREAM impact hypotheses, several information deficiencies were identified and research and monitoring programs recommended to address these gaps. With time, many of these issues were resolved through research and monitoring activities and new issues arose as a result of changes in the development scenarios. This section of the report summarizes the research and monitoring recommendations made during each year of BEMP, MEMP and BREAM and reviews their status.

7.1 ROUTINE ASPECTS OF HYDROCARBON DEVELOPMENT

7.1.1 Offshore Structures and Marine Vessel Traffic

BEMP 1: Ship traffic, seismic programs and active offshore platforms and artificial islands will cause a reduction in the western Arctic population of bowhead whales.

During the BEMP and BREAM programs, this hypothesis generated the most interest, was the most controversial, and was the focus of much of the research related to the effects of offshore hydrocarbon development in the Beaufort Sea. While many of these programs provided information of relevance to one or more of the linkages of the hypothesis, several programs were the direct result of specific recommendations made by

BEMP participants (Table 7.1.1). The following summarizes those recommendations, and the research and monitoring programs subsequently funded.

During the 1983/84 BEMP workshop, it was concluded that each link of BEMP Hypothesis 1 could be supported with circumstantial evidence. In most cases, however, direct and quantitative data were lacking. The working group, therefore, concluded that this hypothesis should be tested with a monitoring program, and that further research was needed to support this proposed program. The most important information gaps related to the biology and energetics of bowheads, and the factors controlling the distribution of zooplankton in the Beaufort Sea.

(1) A monitoring program to examine both the short-term and long-term responses of bowheads to existing levels of industrial activity in the Beaufort Sea. This would include:

- *systematic aerial surveys in the southern Beaufort Sea and Amundsen Gulf to document the overall distribution of bowheads and ultimately allow determination of year-to-year variation in their distribution;*
- *quantification of short-term behavioural responses of bowheads to industrial activities; and*
- *use of aerial photographic techniques to Identify and measure individual bowheads.*

Table 7.1.1
Offshore Structures and Marine Vessel Traffic

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
BEMP 1/BREAM R1 Ship traffic, seismic programs and active offshore platforms and artificial island will cause a reduction in the western Arctic population of bowhead whales.	1983/84 BEMP • Monitoring of the short- and long-term responses of bowhead whales to existing levels of industrial activity in the region, including (1) aerial surveys to document overall bowhead distribution; (2) quantification of short-term behavioural responses to industrial activities; and (3) use of aerial photographic techniques to identify and measure individual bowheads. • Monitoring of the reproductive rate of bowheads, calf survival rates, and stability of adult social and feeding groups. • Monitoring of underwater ambient noise levels in the industrial zone throughout the year. • Examination of the stomachs of harvested bowheads to obtain information on capacity, anatomy and histology. • Comparisons of isotopic carbon in liver, muscle, blubber and other tissue from bowheads harvested in fall and spring to provide information on the extent (if any) of winter feeding. • Distribution of bowhead food (zooplankton) in the Beaufort Sea and factors controlling the distribution of zooplankton patches. 1984/85 BEMP • Priority should be placed on: (1) continuation of systematic surveys and studies of long-term behaviour through the aerial photography of individual whales; and (2) studies of food (zooplankton) distribution and availability in relation to oceanographic phenomena and bowhead distribution).	• Two studies (systematic surveys, ESRF/INAC; photographic component of long-term effects of industry study, ESRF) were initiated in response to this recommendation. • A study on the reproductive rate of the bowhead funded through various Alaskan industry sources • No program specifically designed with this purpose was initiated • While not initiated directly as a result of BEMP recommendations, an Alaskan research program involved examination of the stomachs of harvested bowheads. • A study initiated in Alaska focused on this research question. • Three studies conducted in 1984/85 provided information that related bowhead distributions to natural factors including zooplankton abundance. • The ESRF and NOGAP funded theses areas of recommended research in 1985/86.

Table 7.1.1 (cont'd)

Hypothesis	**Research and Monitoring Recommendations**	**Status of Recommendations**
BEMP 1/BREAM R1 (continued)	1985/86 BEMP An extensive list of research and monitoring recommendations evolved from discussions of practical measurement systems: A) Summer distribution of bowheads in the SE Beaufort Sea: • Aircraft-based surveys of bowhead whale distributions • Documentation of offshore industry activities • Ship-based study of food (zooplankton), within and outside areas of industry activity • Survey of hunters/trappers to obtain information on occurrence of bowheads at locations and times not covered by research and monitoring programs B) Behavioural studies: • Study of the medium-term responses of whales to industry activity • Study of the response of bowheads to food availability to determine minimum zooplankton densities in areas where bowheads feed • Development of satellite and radio tags for tracking of individual bowheads over extended periods C) Importance of summer feeding • Photographic measurements of the girth of bowheads • Collection of physiological and biochemical data from harvested whales	• Seventh consecutive year of systematic aerial and photogrammetric surveys conducted in 1986. • INAC and NOGAP funded the bowhead whale food availability study in 1986/87. • This research initiative was not undertaken. • Not acted upon • NOGAP and INAC funded a number of studies to address this research question. • A feasibility study of tagging bowheads for tracking by satellite was initiated by U.S. Minerals Management Service. • No known action • No known action
	1986/87 BEMP • There was not consensus among participants that there was no need for further research related to this hypothesis, but there was some support for: (1) research designed to determine the rate of use of zooplankton patches inside and outside the industry zone; and (2) development of hydroacoustic techniques that would allow distinction of biological targets from physical water quality gradients.	• DSS and NOGAP funded a study to test an acoustic system to measure zooplankton distributions along ships' tracks
	1991/92 BREAM • It was recommended that aerial surveys of bowhead distribution in conjunction with analyses of satellite data to determine Mackenzie River plume conditions be conducted for 1-2 years when there was no industry activity in the region to provide control data for the testing of Link 1a in this hypothesis (The cumulative effect of all offshore industrial activities will be to create a large-scale zone of bowhead whale exclusion encompassing the entire industrial zone).	• No known action

Table 7.1.1 (cont'd)

Hypothesis	**Research and Monitoring Recommendations**	**Status of Recommendations**
BEMP 2 (a) offshore structures will reduce the white whale harvest; (b) frequent icebreaker traffic in the landfast ice will increase harvest; (c) open-water ship traffic in the Mackenzie Estuary will alter the white whale distribution and lead to changes in harvest levels; and (d) Inuit employment in the industry will change the white whale harvest. BREAM R2 Various facilities and activities associated with offshore hydrocarbon development will affect the harvest of beluga whales.	1983/84 BEMP • Analysis of past survey results to determine factors influencing whale distribution in Niakunak and Kugmallit bays to allow separation of natural variability and industry-related effects. • Continuation of annual white whale monitoring program with components: (1) harvest levels and locations in the Mackenzie Estuary; (2) abundance and distribution of whales in the estuary; (3) intensified monitoring, including examination of behavioural responses of whales to industry operations, if a major increase in development activity is anticipated; and (4) continued monitoring of the effects of offshore structures on ice breakup patterns using remote sensing techniques. 1984/85 BEMP • It was suggested that the frequency of white whale monitoring program should be decreased to once every 2-3 years unless the level of industry activity in the estuary increases. 1991/92 BREAM • Workshop participants supported the need for four planned research initiatives: (1) Responses of belugas to industrial noise (2) Studies of the beluga harvest (3) Use of satellite tags on belugas (4) Estimation of the current population size through aerial surveys. • In addition, three other areas of research considered important were: (1) Expansion of research on regional climatic effects of global warming to effects on the fast and pack ice zones. (2) A measure of hunter effort be obtained so that changes in the availability of whales can be quantified. (3) Integration of the results of major beluga research initiatives sponsored by the FJMC.	• 1984/85 workshop participants did not support research on examining the natural factors influencing the distribution of white whales in the Mackenzie Estuary. No known action. • 1984/85 workshop participants did not support expansion of the white whale monitoring program unless industry activities in the estuary increased. The existing monitoring program continued to be funded by NOGAP and DFO until 1987 when the FJMC assumed the responsibility. • Daily SAR imagery of sea ice in vicinity of several active and abandoned artificial islands conducted as part of normal operational monitoring by petroleum industry. • ESRF, INAC and NOGAP funded systematic aerial surveys for white whales in the Mackenzie Estuary and offshore Beaufort each year between 1972 and 1980. In 1985, these surveys involved the use of both visual and photographic survey techniques. • These research initiatives were undertaken in 1991/92. • No known action • FJMC has attempted to collect CPUE data on the white whale harvest as part of the Inuvialuit Harvest Study. • No synthesis of results into a compendium.

Table 7.1.1 (cont'd)

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
BEMP 3/BREAM R3 Marine vessel activities, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of ringed and bearded seal populations.	1983/84 AND 1984/85 BEMP • There were no recommendations for research or monitoring.	• N/A
BEMP 7/BREAM R6 The presence of active facilities will result in increased polar bear mortality and reduced harvest levels.	1983/84 BEMP • The existing polar bear monitoring and deterrent programs should be improved, continued, and records summarized annually. 1984/85 BEMP • It was recommended that ongoing and new deterrent research programs receive a high level of support and priority, including the potential for linking detection and deterrent devices. • Potential sex- or age-specific variability in the attraction of bears should be examined if the number of offshore structures increases significantly in the future. • It was considered essential to obtain data on the size of the Alaskan harvest of polar bears.	• Considerable progress has been made in the development of detecting and deterring intruding bears since this early BEMP recommendation. • A variety of bear detection and deterrent research and education programs have been conducted by the Dept. Of Renewable Resources, GNWT with federal, territorial and industry funding. • A study completed by the CWS examined the issue of attraction of polar bears to offshore structures in some detail. • No information is available on the status of this recommendation, although it seems likely that the US Fish and Wildlife Service would have data on annual subsidence harvest levels.
BEMP 8/BREAM R7 Offshore hydrocarbon development activities will reduce the harvest of polar bears.	1983/84 BEMP • Data from the existing monitoring of the polar bear harvest should be analyzed in detail every 3-5 years to determine if changes in the program are necessary. • Data on bear kills should be supplemented with information on development activities in the region, ice conditions, and amounts and locations of open water. 1984/85 BEMP • No research or monitoring requirements for polar bears in the region were identified. However, participants reiterated the need for monitoring of the Alaskan subsistence harvest.	• The GNWT (Renewable Resources) maintains a database of polar bear harvest levels and locations as a necessary tool for management of this resource. • It is not known if this recommendation was acted upon. • See above discussion of BEMP 7 recommendations.

Table 7.1.1 (cont'd)

Hypothesis	**Research and Monitoring Recommendations**	**Status of Recommendations**
BEMP 21 Tanker traffic and minor oil spills associated with the westward transport of Canadian Beaufort oil will cause reductions in the Western Arctic population of bowhead whales and/or the harvest of this population by the Alaskan Inupiat.	1986/87 BEMP • While research or monitoring relative to this hypothesis per se were not considered justified, reanalysis of existing data was recommended to help determine the probability and significance of concerns identified in some links: (1) range from tankers where vocal contact between cows and calves would be lost; and (2) offshore displacement of westward bowhead migration by tanker traffic.	• Several studies of the potential effects of noise generated by marine vessel operations were completed between 1987 and 1991 and are relevant to this hypothesis. These two concerns were specifically addressed in a 1988 study funded by INAC.
BREAM R31 Development activities will change the harvest of bowhead whales.	1991/92 BREAM • No new research or monitoring was recommended, but it was considered important for DFO to continue to monitor the hunt, collect tissue samples and document areas used for the hunt and numbers of whaling crews involved.	• DFO has continued to monitor the bowhead harvest by the Inuvialuit.

In 1984, two projects were undertaken to examine the summer distribution of bowhead whales in the southeastern Beaufort Sea. These were the Bowhead Whale Monitoring Study funded by the ESRF and INAC, and the photographic component of the study on the long-term effects of offshore industrial activities. The purpose of the systematic aerial surveys was to determine the relative abundance and distribution of whales in August/September, and was the fifth consecutive year of such research. Although aerial surveys of bowhead whales in the Beaufort Sea had been conducted each year since 1980, the design of this program was the direct result of the above recommendation made by BEMP workshop participants.

(2) A monitoring program to determine the reproductive rates of bowheads, calf survival rates, and the stability of adult social and feeding groups.

Through funding from various Alaskan industry sources, a study on the reproductive parameters of the bowhead whale was completed in 1986. The objectives of this study were to estimate the gross annual recruitment rate for the western Arctic stock of bowheads, the proportions of yearlings in the population, the geographic segregation of age classes, and calving intervals. While a number of studies designed for other purposes provided estimates of the reproductive rate of western Arctic bowhead population, there was considerable variability in these estimates. This was the first study designed specifically to address this information gap.

(3) Monitoring of existing ambient noise levels in tile industrial zone throughout the year.

(4) Sampling of tissues of bowheads taken in the Alaskan harvest in fall and spring to provide information on the extent (if any) of winter feeding. This would include:

- ♦ *examination of stomach contents and observations of stomach musculature, histology, biochemistry and comparative anatomy to help determine bowhead feeding regimes and predict potential disruptions in feeding patterns; and*
- ♦ *comparisons of isotopic carbon in liver, muscle, blubber and other tissues.*

Although not initiated directly as a result of this BEMP recommendation, research projects conducted in Alaska provided information related to the feeding and energy balance of bowhead whales. These included studies on the digestive system of the bowhead whale; primary production in the Alaskan Beaufort Sea in relation to bowhead whale distribution; and carbon isotope studies on bowhead whales.

(5) Research on the distribution of bowhead food (zooplankton concentrations) in the Beaufort Sea and the factors controlling the distribution of zooplankton patchiness. It was proposed that this research program initially involve a feasibility study to provide essential information for the design of the main program, followed by a design phase, and conduct of the sampling program,

During 1984, three projects were undertaken to examine the distribution of bowhead whales in relation to the locations of available food sources (i.e., areas of high concentrations of zooplankton densities). These included a Satellite Imagery component of the 1984 aerial surveys mentioned above, the Bowhead Feasibility Study and a Remote Sensing Study.

During the 1984/85 BEMP workshop, participants supported continuation of the systematic aerial surveys and the photographic component of the study, as well as studies on the distribution and availability of bowhead food in relation to oceanographic phenomenon and bowhead distribution. In 1985, the sixth consecutive year of systematic surveys were completed. As in 1984, the monitoring program included a coincident satellite imagery component to allow comparison of bowhead distribution patterns with oceanographic features, as well as the photographic component to allow re-identification of whales and to obtain information on the age distribution of bowheads in different parts of the study area. During the same year, NOGAP and INAC funded a study to examine the importance of the Yukon nearshore and adjacent marine areas in the annual energy budget of the bowhead whale.

During the planning meetings and workshop for the 1985/86 BEMP program, considerable effort was focussed on formulating an overall approach that would result in the identification of research and monitoring to significantly accelerate the resolution of BEMP Hypothesis 1. During the workshop, an extensive list of recommendations evolved from discussions of a practical measurement system.

A. Summer Distribution of Bowheads In the Southeast Beaufort Sea

1 aircraft-based surveys of bowhead whale distributions;

2 documentation of offshore industry activities;

3 ship-based study of the availability of food within and outside the areas of industrial activity; and

4 survey of local hunters and trappers to obtain information on the occurrence of bowhead whales at locations and times outside of those covered by the research and monitoring programs.

In 1986, the seventh consecutive year of systematic aerial surveys was conducted in the summer range of the bowhead whale in the southeast Beaufort Sea. Unlike previous years, the monitoring program consisted of two separate studies. The first comprised of systematic aerial surveys and aerial photogrammetric surveys during the late August period, and was funded by the ESRF. The second consisted of systematic aerial surveys during September, and was funded jointly by the U.S. Minerals Management Service and INAC.

In 1986/87, INAC and NOGAP funded the bowhead whale food availability study. The primary objective of this study was to gain a better understanding of the importance of nearshore and adjacent marine waters between Cape Dalhousie and Herschel Island in the annual energy budget of the bowhead whale. It was designed to supplement the results of the 1985 study mentioned above.

(B) Behavioural Studies

1 study of the medium-term responses of whales to industry activity;

2 study of the response of bowheads to food availability to determine minimum zooplankton densities in areas where bowheads feed; and

3 development of satellite and radio tags for tracking of individual bowheads over extended periods.

NOGAP and INAC funded a number of studies from 1985 to 1987 to document the availability of bowhead food resources (zooplankton), the physical mechanisms influencing the distribution of these resources, and to document zooplankton biomass and assess the food value to bowheads. These included:

- Zooplankton of a Bowhead Whale Feeding Area off the Yukon coast in August 1985
- Zooplankton and Bowhead Whales Feeding in the Canadian Beaufort Sea, 1986
- Beaufort Sea Zooplankton Distributions, 1987
- Zooplankton Distributions in the Southeastern Beaufort Sea, Summer 1987

An ongoing feasibility study of tagging bowhead whales for tracking by satellite was initiated in 1979 by the U.S. Minerals Management Service. Although this study was not initiated as a result of the BEMP process, information from this long-term work is relevant to the evaluation of BEMP Hypothesis 1.

(C) Importance of Summer Feeding

1. *photographic measurements of the girth of bowhead whales; and*
2. *collection of physiological and biochemical data from harvested whales*

These recommendations were not acted upon.

During the 1986/87 BEMP workshop, there was not consensus among the working group in relation to the need for further research or monitoring related to BEMP Hypothesis 1 and the overall nature of the research. However, there was support from several of the participants for: (1) research designed to determine the rate of use of zooplankton patches inside and outside of the industry zone; and (2) development of hydro-acoustic measurement techniques that would allow distinction of biological targets from physical water quality gradients.

In 1989, DSS and NOGAP funded a study to examine the distributions of zooplankton in the Mackenzie Shelf region. This work was designed to supplement the results of research conducted in 1985 and 1986, as well as to test an acoustic system to measure zooplankton distributions along ship's transects.

During the 1991/92 BREAM workshop, it was noted that one of the major difficulties in interpreting the results of several years of study on the distribution of the bowhead whale was due to the lack of control data. Much of the research was initiated after industrial activities began in the Beaufort Sea region. It was, therefore, concluded that 1992 would provide a good opportunity to collect data on bowhead distribution since there was no industrial activity in the region at this time. The working group recommended that aerial surveys of bowhead distribution in conjunction with analyses of satellite data should be conducted for 1"2 years to determine the position of the Mackenzie River plume over the shelf and in and around the industrial zone and its effect on the distribution of bowheads.

BEMP 2: (a) Offshore structures will reduce the white whale harvest; (b) frequent icebreaker traffic in the landfast ice will increase harvest; (c) open-water ship traffic in the Mackenzie Estuary will alter the white whale distribution and lead to changes in harvest levels; and (d) Inuit employment in the industry will change the white whale harvest.

BREAM R2: Various facilities and activities associated with offshore hydrocarbon development will affect the harvest of beluga whales.

During the 1983/84 BEMP workshop, participants identified two areas where further research or continued monitoring were needed. Specifically, the group recommended the following.

(1) The results of the past eight years of surveys should be analyzed to determine the factors that influence the distribution of white whales within Niakunak and Kugmallit bays. This retrospective analysis of data will provide the basis for separation of natural variability and industry-related effects, and will identify the need for any subsequent field studies to address this uncertainty.

(2) The existing white whale monitoring program should be continued and expanded to include:

- *monitoring of harvest levels, timing and locations In the Mackenzie Estuary, (data collected by DFO);*
- *regular visits to whaling camps to collect Information on hunter effort, major changes In equipment and industry-hunter conflicts;*
- *aerial surveys to document the abundance, distribution and timing of entry of whales into the estuary;*

- *intensified monitoring, including examination of behaviour responses of whales to industry operations if increases in development activities are anticipated; and*
- *monitoring of effects of offshore structures on ice break-up using remote sensing techniques.*

In 1984/85, workshop participants confirmed that there was a major data gap in the understanding of natural factors influencing the distribution of white whales within the Mackenzie Estuary. However, no research to address this deficiency was supported by the group because: (1) there was an adequate data base on normal distribution patterns to allow detection of any large deviations that may be associated with industry activities; and (2) industry is already committed to the mitigation of any perceived concerns related to the effects of their operations on the white whale harvest. In addition, the 1984/85 working group did not support expansion of the white whale monitoring program unless the level of industry activity increased within the Mackenzie Estuary. They suggested that the frequency of aerial surveys could be reduced to once every two to three years rather than every year given the present data base related to use of the estuary by white whales. However, the group supported continuation of monitoring of break-up, harvest levels and possible interference of the hunt by industry activities,

As part of normal operational monitoring procedures by the petroleum industry, synthetic aperture radar (SAR) overflights were conducted over the Canadian Beaufort Sea on a daily basis from June to November, 1995 as well as over the Alaskan Beaufort Sea from July to October, 1995. The daily SAR imagery of sea ice in the vicinity of several active and abandoned artificial islands in the offshore Beaufort provided a good database for the examination of break-up patterns.

The Beaufort Sea white whale study, which was initiated in 1991 by NOGAP and DFO to obtain information on the population status, distribution and stock identity of white whales hunted in the Mackenzie Estuary, was continued in 1985 and 1986. While this program was initiated and is being conducted annually for reasons other than the BEMP process, this work is consistent with the recommendations made by the 1983/84 and 1984/85 BEMP participants. In 1987, the responsibility for conducting the monitoring program was assumed by the Fisheries Joint Management Committee. This project continues be conducted each year as part of the Inuvialuit Harvest Study.

ESRF, NOGAP and INAC funded systematic aerial surveys for white whales in the Mackenzie Estuary and in the offshore Beaufort Sea each year since 1972 and 1980, respectively. In 1985, these surveys involved simultaneously counting whales in the area using both visual and photographic aerial survey techniques.

Between 1985 and 1991, several research programs were funded by DFO, NOGAP and the petroleum industry to examine the effects of ship traffic and icebreaking on white whale behaviour and the timing of ice break-up. These studies are discussed further in Section 7.1.2 in relation to the effects of ice breaker traffic.

During the 1991/92 BREAM workshop, participant reviewed several research projects that were planned for 1992 and 1993 and identified some additional initiatives. While these planned project were designed and funded independently from BREAM, they were expected to provide information of relevance to examining BEMP 2 (renamed BREAM R2). These included:

1. a NOGAP-funded study to test the reactions of belugas to various recorded ship noises;

2. a FJMC study to analyze the biological samples collected from the hunt over the past few years, and obtain traditional knowledge regarding the numbers and movement of white whales in the delta; and

3. a two-year study funded by ESRF and DFO to monitor local movements of white whales between shallow estuaries and offshore feeding areas and movements between the two main summering areas in Kugmallit and Niakunak bays using satellite tags.

In addition to the above studies, the BREAM working group recommended the following research.

♦ *expansion of ongoing research by Environment Canada to include study of the effects of global warming on the fast ice and pack ice zone*

♦ *expansion of the ongoing monitoring program by the FJMC to include a measure of Catch Per Unit Effort (CPUE) to provide an early warning if industry activity is affecting the hunt*

- *integration of the results of major white whale research initiatives conducted by the FJMC*

As part of the Inuvialuit Harvest Study, the FJMC has attempted to collect data from hunters to determine some measure of CPUE in the white whale harvest. This includes numbers of whales landed, number of trips, and total number of days/hours of harvesting activities. However, because information related to hunter effort is for all harvesting activities and not specific to the beluga hunt, no CPUE data are available (M. Fabijan, FJMC, pers. comm.)

To date, results of beluga research conducted by the FJMC have not yet been analyzed and synthesized into a compendium (M. Stabler, FJMC, pers. comm.).

BEMP 3: Marine vessel activities, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of ringed and bearded seal populations.

No research or monitoring programs to address this hypothesis were recommended by the 1983/84 or 1984/85 BEMP workshop participants, Although the hypothesis itself was considered to valid, it was concluded that the cumulative effects of all links on both the ringed and bearded seal would be inconsequential. Moreover, it was noted that because of the naturally high variability in seals population levels in the region, population effects would either be unlikely or too difficult to detect

BEMP 7: The presence of active facilities will result in increased polar bear mortality and reduced harvest levels.

In response to the safety hazard associated with polar bear encounters at active offshore structures, monitoring and research programs were already designed and ongoing at the time of the first BEMP workshop. The working groups of both the 1983/84 and 1984/85 workshops supported continuation of these programs conducted by both industry and government, and recommended the continued support of research on methods of detecting and deterring polar bears.

Development of a bear deterrent and detection program initiated in 1981 continued to be supported by various government and industry sources. This included a training and education program, development of a "safety in bear country' manual, and development of several deterrent techniques (e.g., acoustic devices, portable electric fences, projectiles).

During the 1984/85 BEMP workshop, a number of important information gaps were identified by the working group. These focussed specifically on: (1) the uncertainty related to potential age-or sex-specific variability in the attraction or avoidance of polar bears to offshore structures; and (2) the status of the Alaskan Beaufort polar bear harvest Although the group did not recommend that new research initiatives be undertaken in the immediate future to address these information requirements, they did identify the need to examine potential age-or sex-variability if the number of offshore structures increase significantly in the future, and the need for future BEMP workshops to address gaps in our understanding polar bear harvest levels.

BEMP 8: Offshore hydrocarbon development activities will reduce the harvest of polar bear.

Participants of the 1983/84 and 1984/85 BEMP workshops concluded that this hypothesis was unlikely and, therefore, did not warrant any specific research or monitoring at the present level of industrial activity in the region. However, the groups suggested that data from the existing NWT Wildlife Service monitoring program on polar bear harvests be analyzed every 3-5 years to determine whether changes in the program are necessary, and that these data be supplemented with information on development activities occurring in the region, ice conditions and amounts/locations of open water. The groups also reiterated the need for monitoring of the Alaskan subsistence harvest.

Although it is not known if data on bear kills has been supplemented with this additional information, the GNWT (Renewable Resources) continues to maintain a database of polar bear harvest levels and locations as a necessary tool for management of this resource.

BEMP 21 Tanker traffic and minor oil spills associated with the westward transport of Canadian Beaufort oil will cause reductions in the Western Arctic population of bowhead whales and/or the harvest of this population by the Alaskan Inupiat.

BEMP Hypothesis 21 was developed and evaluated during the 1986/87 workshop. While workshop participants agreed that this new hypothesis was valid, most of its linkages were unlikely to occur given the anticipated level of shipping activity in the region. Consequently, further research or monitoring programs related to this hypothesis were considered unjustified. The group did, however, support the need to reanalyze existing data to determine the probability and possible significance of concerns embodied in this hypothesis. Specifically, these issues included: (1) the range from tankers where vocal contact between cows and calves could be lost; and (2) offshore displacement of westward bowhead migration by tanker traffic.

In 1987, INAC funded a study to evaluate the effects that tanker traffic could potentially have' on bowhead whales in the Beaufort Sea. This study addressed many of the issues identified during the 1986/87 workshop, particularly those related to cow-calf separation and seaward displacement of the bowhead migration.

BREAM R31: Development activities will change the harvest of bowhead whales.

In response to resumption of bowhead whaling off the Yukon coast, this new hypothesis was evaluated during the 1991/92 BREAM workshop. While it was concluded that changes in bowhead distribution as a result of development-related activities and offshore structures could affect the bowhead harvest, these effects were thought to be mitigable with known techniques at the level of development envisaged for the region. Consequently, the group did not recommend any research or monitoring initiatives related to this impact hypothesis. However, they did support continuation of monitoring the hunt, sampling the hunt, and documenting areas used for the hunt and the number of whaling crews involved. Since this time, DFO has continued to monitor the bowhead harvest by the Inuvialuit.

7.1.2 Icebreaker Traffic

BEMP 2: Various facilities and activities associated with Offshore hydrocarbon development will affect the white whale harvest.

BREAM R2: Various facilities and activities associated with offshore hydrocarbon development will affect the harvest of beluga whales.

Participants in the 1983/84 BEMP program made no specific recommendations for research or monitoring related to interactions between icebreaking and the beluga whale and its harvest. It was concluded that the studies recommended in relation to other activities associated with offshore hydrocarbon development (Table 7.1.1) would address key concerns regarding belugas and their harvest by the Inuvialuit. As indicated in Table 7.1.2, however, other investigations conducted in the Beaufort Sea (SAR ice imagery) and eastern Arctic (icebreaking effects on hunter travel, ice breakup and behaviour of belugas) provided data useful to the assessment of BEMP Hypothesis 2.

In 1984/85, workshop participants recommended continuation of ongoing monitoring and evaluation of potential conflicts with the annual harvest of beluga. As in the previous year, no studies directed specifically at the effects of icebreaking on this population or the beluga hunt were considered necessary.

BEMP 4: Increased frequency of icebreaker traffic through the landfast ice and through Amundsen Gulf will reduce ringed seal pup production and have subsequent effects on population levels.

BREAM R4: Increased frequency of icebreaker traffic through the landfast ice will reduce ringed seal pup production and population levels.

The potential for destabilization of the ice cover in Amundsen Gulf due to icebreaking activities and the subsequent implications of this perturbation on the ringed seal population were among the most significant concerns raised during the first year of BEMP. As indicated in Table 7.1.2, several research recommendations were formulated to address these questions. A NOGAP-funded program on the effects of icebreaking by the MV Arctic in Admiralty Inlet provided important information on the potential for ice stabilization associated with icebreaker operations. Over a decade of research conducted by the Arctic Biological Station (Tom Smith) and summarized in 1987 has provided information on the status, dynamics and habitat requirements of ringed seals in Amundsen Gulf. This and other information collected by Canadian and Alaskan researchers in various parts of the Beaufort Sea can be used to evaluate the sensitivity of ringed seal pup production to variations in the ice regime.

Table 7.1.2
Icebreaker Traffic

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
BEMP 2 Various facilities and activities associated with offshore hydrocarbon development will affect the white whale harvest. BREAM R2 Various facilities and activities associated with offshore hydrocarbon development will affect the harvest of beluga whales.	1983/84 BEMP • Table 7.1.1 describes recommended research and monitoring related to the effects of most aspects of offshore hydrocarbon development and associated activities on the beluga whale and its harvest. There were no specific recommendations regarding icebreaking operations in the region. 1984/85 BEMP • As above – other than continuation of existing monitoring program and evaluation of possible conflicts with the annual harvest, no research/monitoring needs specific to icebreaking were identified. 1991/92 BREAM • No research or monitoring recommended	• No action required; several studies have, however, produced information of direct and indirect relevance to this hypothesis including routine SAR ice imagery conducted by the petroleum industry, and research in the eastern Arctic on the effects of icebreaking and ship tracks on hunter travel, ice breakup and the behaviour of beluga whales. • No action required • No action required
BEMP 4 Increased frequency of icebreaker traffic through the landfast ice and through Amundsen Gulf will reduce ringed seal pup production and have subsequent effects on population levels. BREAM R4 Increased frequency of icebreaker traffic through the landfast ice will reduce ringed seal pup production and population levels.	1983/84 BEMP • Research on the potential for large-scale ice destabilization processes in Amundsen Gulf to determine both the need for and design of any future monitoring program. • Analysis of ringed seal samples collected between 1971 and 1982 (Holman, NWT) to determine if significant differences in population parameters exist and sensitivity of pup production to variations in the ice regime. The results of this analysis may trigger other research needs. • Monitoring through aerial photography in icebreaking activity in Amundsen Gulf to address uncertainties related to the destabilization issue. 1984/85 BEMP • If Amundsen Gulf is used as a transportation corridor, research should include: (1) examination of ice processes in Amundsen Gulf; (2) investigation of the relationship between ice conditions in the Gulf and ringed seal pup production; and (3) direct measurement of the transmission of pressure waves from icebreakers. 1991/92 BREAM • No further research or monitoring recommended.	• Eastern Arctic (Admiralty Inlet) NOGAP-funded research on the effects of the <u>MV Arctic</u> on ice breakup provided information relevant to the ice destabilization issue. • The results of this research by T. Smith (Arctic Biological Station) were published in 1987. • Research conducted in Alaska, while not initiated as a result of BEMP recommendations, provided information on use of lairs by ringed seals. • Other Canadian research indirectly relevant by providing a baseline on population levels, dynamics, and distribution. • Monitoring in Amundsen Gulf not initiated nor required because of change in development scenario. • No action required for reason indicated above. • No action required.

Table 7.1.2 (cont'd)

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
BEMP 5/BREAM R5 Icebreaker traffic in the transition (shear) zone will reduce bearded seal pup production.	1983/84 BEMP • Research on bearded seal vocalization rates in control and disturbed areas was considered useful but not a high priority. 1984/85 BEMP • The above research on vocalization was recommended only if icebreaker traffic in the shear zone increased substantially for existing levels.	• No research on this subject has been initiated. • No research on this subject was initiated, nor considered necessary given the intensity of icebreaking activities in the transition (shear) zone.
BEMP 6 Icebreaker traffic in Amundsen Gulf will affect the ringed seal and polar bear populations.	1983/84 BEMP • Two areas of research were proposed: (1) examination of available data on survival of ringed seal pups and productivity of young in years after destabilization of the ice (1971, 1978, 1981); and 92) analysis of reproductive parameters (e.g., pregnancy rates) and feeding habits in years following destabilization. • 1984/85 BEMP • Increased effort to ensure collection analysis and cataloguing of sea ice data to the extent required for the interpretation of biological studies.	• No specific research was initiated to address these information requirements, although a detailed analysis of existing data collected by DFO (T. Smith) contributed to general knowledge of relationships between ringed seals and the ice environment. • No new research required – ice data available from a variety of sources including SAR overflights conducted routinely by the petroleum industry when operating in the region.

BEMP participants in 1984/85 identified other research and monitoring priorities to address uncertainties related to the destabilization issue and potential direct impacts of icebreaking operations on ringed seals. However, the need for these studies diminished in the following year when the development scenario for the region no longer involved transport of hydrocarbons out of the region by tanker along an eastern route through Amundsen Gulf and Parry Channel.

Participants of the 1991/92 BREAM workshop did not recommend any further research or monitoring related to this hypothesis (R4).

BEMP 5: Icebreaker traffic in the transition (shear) zone will reduce bearded seal pup production.

While participants in the first two years of BEMP identified data gaps on bearded seal vocalization that could be addressed by additional research, such studies were never considered justifiable given the anticipated levels of icebreaker traffic in the shear (transition) ice zone in the Beaufort Sea. No further recommendations were made during the 1991/92 BREAM workshop when this hypothesis (renamed BREAM R6) was reviewed.

BEMP 6: Icebreaker traffic in Amundsen Gulf will affect the ringed seal and polar bear populations.

Like BEMP Hypothesis 4, destabilization of the ice cover in Amundsen Gulf as a consequence of icebreaking activities was the focus of this hypothesis. Research recommendations in the first year of BEMP (1983/84) involved analysis of existing data to examine survival of ringed seal pups, productivity of young, reproductive parameters and feeding habits of seals in years after historic destabilization (1971,1978 and 1981). No new research programs were initiated to address these information requirements, although detailed analysis of existing data collected by DFO contributed to our present understanding of the relationships between ringed seals and their physical environment, including the seasonal ice cover.

In 1984/85, workshop participants identified two general areas of concern related to the availability of ice cover data for the Beaufort Sea and Amundsen Gulf. Firstly, it was believed that limited communication between life science specialists and ice specialists was limiting the value of existing research programs, and that increased efforts should be made to improve communication between these two groups, It was recommended that a quasi-formal or informal working group be established to increase cross-disciplinary contact. Secondly, the group noted that no effort was being made to ensure continued collection and analyses of sea ice data needed for interpreting the results of biological studies, It was recommended that low-cost ice data such as daily, full resolution NOAA satellite imagery should be catalogued for future use by researchers in the Beaufort region.

Although no new research programs were initiated in response to these recommendations, ice data has been available from a variety of sources such as SAR overflights, which are conducted routinely by the petroleum industry when operating in the region,

7.1.3 Nearshore Structures

BEMP 14: Nearshore structures will disrupt the nearshore band of warm brackish water and reduce broad whitefish populations.

During the 1983/84 and 1984/85 BEMP workshops, the working group recommended that research should be conducted in view of increasing indirect evidence that causeways are affecting fish distributions in the Alaskan Beaufort Sea, and the possibility that some form of shoreline alteration may be associated with the construction of a shorebase on the Yukon coast (INAC and Environment Canada 1984, 1985). Specifically, the group recommended that:

1. if causeways are envisaged, research on nearshore oceanography and fish distribution/movement near proposed structures should be initiated as soon as possible; and

2. a brief, broadly-based study should be initiated to summarize the available/e information regarding oceanographic conditions of the nearshore Beaufort Sea.

During the BEMP and BREAM programs, development of nearshore structures was not included within the hydrocarbon development scenarios for the region. As such, there was no immediate need to address recommendation #1. However, in response to a recommendation made during the 1985/86 MEMP workshop in relation to MEMP Hypothesis 14, research was initiated by the Freshwater Institute (DFO) on stock differentiation of broad whitefish in terms of movements, locations of rearing/overwintering/spawning areas and other critical life history events (NOGAP Project B.12). The information that has been gained through this research is particularly useful in addressing any BEMP, MEMP or BREAM impact hypothesis that considers the direct and indirect effects of industrial development on this species. Specific studies undertaken as part of Project B.12 that are of relevance to BEMP 14 include the following.

- Spawning, migration, overwintering and dispersal of broad whitefish
- Mackenzie Shelf coregonid young-of-the-year distribution study
- Salinity tolerance of whitefish
- Broad whitefish stock description
- Identification of coregonids
- Hybridization of coregonids
- External scarring of whitefish from the western Northwest Territories
- Broad whitefish population dynamics
- Investigation of food chains and fish migration using the stable isotopes of sulphur, carbon and nitrogen

To date, a low-level study to summarize coastal oceanographic conditions and examine regional differences in the Vulnerability to disruptions in current, salinity and temperature regimes (recommendation #2) has not been conducted. However, numerous NOGAP/DFO-funded projects were initiated by the Institute of Ocean Science's to improve knowledge regarding general oceanic dynamics over the Beaufort Continental Shelf. As part of the NOGAP D.1 and B.6 projects, several studies' conducted in the southern Beaufort Sea involved the collection of nearshore temperature, salinity, current and wave measurements. In addition, seasonal CTD data were collected from 1980 to 1988 in two embayments (Tuktoyaktuk Harbour and Mason Bay) along the south east Beaufort Sea as part of the NOGAP B.2 Project. Although this additional information is limited to specific sites and seasons, it is of value because of the lack of existing TUS data for the nearshore. Studies focussed on local coastal processes will still be required to address the issue of potential impacts of nearshore structures along the Yukon coast on anadromous fish if and when such structures are envisaged for future hydrocarbon development in the region.

Table 7.1.3
Nearshore Structures

Hypothesis	**Research and Monitoring Recommendations**	**Status of Recommendations**
BEMP 14 Nearshore structures will disrupt the nearshore band of warm brackish water and reduce broad whitefish populations.	1983/84 BEMP • No new research or monitoring was recommended. However, the group identified the need for research on nearshore oceanography, and fish distribution and movements if future development plans change to include major nearshore structures with the potential to interfere with fish movements. 1984/85 BEMP • The group recommended a brief broadly-based study to summarize available information on the range of coastal oceanographic conditions present in the Beaufort Sea to examine regional differences in vulnerability to disruptions in temperature, salinity and current regimes.	• Numerous studies related to broad whitefish movements, salinity tolerances and stock separation have been conducted over the past 8 years by the Freshwater Institute (DFO) as part of NOGAP Project B.12. • Although a low-level study of this nature was not initiated, the Institute of Ocean Sciences (DFO) initiated a long-term investigation of circulation and water mass characteristics of the Beaufort Continental Shelf (NOGAP Project B.6 – Beaufort Sea Oceanography), which provides some nearshore CTD data.
BEMP 15 Nearshore structures will disrupt the nearshore band of warm brackish water and reduce Alaskan population of Arctic cisco.	1983/84 BEMP • The group recommended research on: (1) oceanographic (wind and current) conditions in the nearshore zone along the Yukon coast (2) spatial variability in temperature and salinity within the surface layer of the nearshore zone (3) arctic cisco movements along the coast including possible controlling environmental stimuli and number of migrants. If causeway development is proposed, a number of monitoring programs would be required. 1984/85 BEMP • The group confirmed the need for a low-level oceanographic study recommended in relation to BEMP 14. The group also stressed the importance of an ongoing monitoring program on the Colville River fishery to determine if the existing causeway in Prudhoe Bay is adversely affecting arctic cisco movements.	• INAC sponsored a study to assess the potential effects of coastal structures along the Yukon coast on fish using information available from causeway sin Alaska. This project was undertaken as part of NOGAP Project D.7. • A five-year study was initiated by the Freshwater Institute to assess fish habitat along the Yukon North Slope. This NOGAP/DFO-funded project was undertaken as part of NOGAP project B.2. • See 1984/85 recommendation for BEMP 14

BEMP 15: Nearshore structures will disrupt the nearshore band of warm brackish water and reduce Alaskan population of Arctic cisco.

During the 1983/84 and 1984/85 BEMP workshops, it was concluded that BEMP 15 could not be proved or disproved on the basis of existing information (INAC and Environment Canada 1984, 1985). It was apparent that the lack of temperature/salinity data within a few hundred meters of the coastline was a serious information deficiency, and that there was no conclusive evidence for the underlying assumption that Alaskan stocks of arctic cisco originate from the Mackenzie River system. The group, therefore, recommended research in the following areas.

(1) oceanographic/biological research along the Yukon coast. The oceanographic component of the study should include direct wind and current measurements, a small-scale CTD survey in the vicinity of a proposed causeway site, landsat imagery of the thermal band, and measurement of local river discharges. The biological research should be conducted simultaneously with the oceanographic investigation and include arctic cisco movements along the coast in relation to time, location and stage of development as well as possible controlling environmental stimuli.

(2) review of results from an ongoing monitoring program of the Colville River fishery, which is being conducted to determine if the ARCO causeway in Prudhoe Bay is adversely affecting arctic cisco movements

(3) a low-level research program to assess the vulnerability of different areas along the coast to disruptions in current, temperature and salinity regimes from causeway construction (discussed above in relation to BEMP 14)

As part of a NOGAP-funded program to assess critical estuarine and marine habitats of the Canadian Arctic continental shelf (Project B.2), a five-year study was initiated by the Freshwater Institute (DFO) to examine the significance of Yukon nearshore habitats of marine and anadromous fish. The primary objectives of this study address many of the information gaps identified by research recommendation #1 of BEMP 15. These include: (1) describing the alongshore migration patterns of anadromous fish during the open-water period; (2) identifying specific areas within Phillips Bay that may be important feeding, spawning or nursery habitat; and (3) characterizing inshore habitats (to the 5 m isobath) in relation to temperature and salinity and relating these variables to fish distribution and movement patterns. The results of this study and other research conducted in the Alaskan Beaufort Sea ("Wind-aided recruitment of Canadian arctic cisco into Alaskan waters') lended support to the assumption that Alaskan arctic cisco do spawn in the Mackenzie River, migrate as juveniles along the Yukon coast to spend a number of years in Alaskan waters, and return to the Mackenzie to spawn. This was also supported by fish tagging surveys conducted in conjunction with the 1981-1984 Waterflood, 1983-1984 Lisburne and 1982 Endicott fish monitoring studies funded by the U.S. Army Corps of Engineering (INAC 1989).

Under NOGAP Project A.7 (Offshore environmental ecosystems monitoring), INAC sponsored a study to examine the potential impacts of nearshore structures along the Yukon coast on population levels of anadromous fish that use the coast as a migration route and summer feeding habitat (Griffiths et al. 1988). Relevant information on the effects of causeways in Alaska on the distribution, movement and population levels of anadromous fish was synthesized and combined with available data for two potential development sites on the coast (King Point and Stokes Point). While it was concluded that causeways at these sites would not likely affect large arctic and least cisco given their swimming capabilities and the relatively small size of the structures, effects on smaller fish could not be determined. There was insufficient data on the distribution and movement pattern of small Arctic and least cisco to determine the potential impacts of development on these groups. Two key unknowns were identified: what percentage of the Mackenzie stocks utilize the Yukon coast?; and are arctic and least cisco from single or mixed stocks?

Additional NOGAP/DFO-funded work was initiated in 1988 to further examine the potential effects of development on arctic cisco stocks. The objectives of this research were to determine the discreteness and number of stocks in the lower Mackenzie River, and to determine their distribution east and west of the river.

7.1.4 Dredging Operations

BEMP 19: Dredging and deposition of spoils will reduce the bearded seal population.

On the basis of worldwide experience regarding the effects of dredging and the estimated levels of dredging activity identified in the Beaufort Sea hydrocarbon development scenario, it was concluded by the *1983/84* and *1984/85* BEMP workshop participants that BEMP 19 was unlikely and not worth testing (INAC and Environment Canada 1984, 1985). Consequently, no research or monitoring programs related to this hypothesis were recommended (Table 7.1.4). However, it was noted that the need for specific research and monitoring programs should be evaluated on a site-specific basis for dredging operations that have the potential to cause significant impacts. These include dredging programs in areas with very low water exchange rates, high densities of important demersal or benthic biota, or feeding areas of bearded seals. The working group agreed that bioaccumulation of heavy metals could occur in the livers of bearded seals if they fed in areas of active dredging for extended periods of time. It was, therefore, suggested that samples of bearded seal liver be collected on an opportunistic basis because of the possible link to human health.

In 1990/91, DFO arranged with the Fisheries Joint Management Committee (FJMC) to collect and analyze tissue samples from ringed seals and beluga whales for heavy metal accumulation (R. Allen, DFO, pers. comm.). The sampling program was initiated in 1991, and has focussed each year on harvests from the communities of Paulatuk, Holman Island and Sachs Harbour. The 1994 sampling program involved the collection of tissue samples from Pauiatuk and Holman Island, Organ, fat and muscle tissues have been analyzed (with particular emphasis on mercury), and the results of these analyses are currently available in draft form. It is expected that the final results will be published in the fall of 1994. To date, tissue samples have not been collected from bearded seals because harvests from these communities have been too small to allow adequate sample sizes (R. Allen, pers. comm.).

BREAM R12: The construction of shorebases, pipeline landfalls, and development of shallow-water production fields will result in a decrease in the populations of Arctic cisco and broad whitefish.

No research or monitoring needs were identified in relation to this hypothesis.

BREAM R32: Dredging to facilitate barge access to the Parsons Lake Gas field will result in a decline in the Husky Lakes lake trout population.

During the 1991/92 BREAM workshop, evaluation of BREAM 32 was not completed because it became apparent to the working group that the dredging required to facilitate barge access to the Parson Lake field would be of a magnitude to warrant DFO approval (INAC 1992). It was noted that approval would not likely be granted, and the project would be referred to an EIRB and, possibly, an EARP review. Although no research or monitoring programs were recommended by the group to a.id in the evaluation of this hypothesis, this does not preclude the possible need for specific research programs as part of the assessment or approvals process if and when there is interest in development of the Parsons Lake gas field.

Table 7.1.4
Dredging Operations

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
BEMP 19/BREAM R14 Dredging and deposition of spoils will reduce the bearded seal population	1983/84 BEMP • No general research or monitoring needs were identified. However, the group recommended that site-specific programs be designed in situations where dredging has the potential to result in significant impacts (i.e., areas of very low water exchange, high densities of important benthic/demersal biota, large concentrations of fish or feeding habitat of bearded seals). 1984/85 BEMP • The working group recommended measurement of heavy metal accumulation in bearded seal livers on an opportunistic basis because of possible link to human health. 1991/92 BREAM • Hypothesis not evaluated. Therefore, no research or monitoring was recommended.	• N/A • In 1990/91, DFO began collecting and analyzing tissue samples from ringed seals and beluga whales harvested by the communities of Paulatuk, Holman Island and Sachs Harbour. This program is being funded by the Fisheries Joint Management Committee through the Implementation Funding for Land Claims. • N/A
BREAM R12 The construction of shorebases, pipeline landfalls, and development of shallow-water production fields will result in a decrease in the populations of Arctic cisco and broad whitefish.	1991/92 BREAM • The working group did not identify any research or monitoring needs related to this hypothesis.	• N/A
BREAM R32 Dredging to facilitate barge access to the Parsons Lake Gas field will result in a decline in the Husky Lakes lake trout population.	1991/92 BREAM • Evaluation of hypothesis not completed. No research or monitoring programs recommended.	• N/A

7.1.5 Chronic Marine Oil Spills

BEMP 9: Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of polar bears.

BREAM R8: Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of polar bears and reduced harvest levels.

During the 1983/84 BEMP workshop, participants concluded that while mortality of polar bears as a result of oil exposure or ingestion of contaminated prey from chronic/episodic spills was possible, the extent of this was unknown. The most significant information gap related to this hypothesis related to the responses of polar bears to oil-covered waters and oil-contaminated prey. The working group suggested that specific experiments could be undertaken to address this issue, however, studies of this nature would very likely receive extreme public and political opposition. It was noted that additional information could be obtained by conducting in vivo experiments (I.e., polar bear pelts) and hydrocarbon body burden studies on bears harvested by Inuit hunters, as well as through incidental observations made by oil spill personnel. The group supported opportunistic studies in situations where bears contact oil anywhere in the Canadian Arctic, and reporting of these incidents to regulatory agencies.

By the 1984/85 BEMP workshop, no further research involving oiling of captive bears was initiated and recommendations related to in vivo experiments and body burden studies were not acted upon. However, the GNWT initiated an "Action Plan for the Protection of Polar Bears in the Event of a Major Oil Spill". While this was not prepared in direct response to the above recommendations, this plan does partially satisfy the requirement for opportunistic study.

Participants of the 1984/85 BEMP workshop did not recommend any further research specifically directed at oil-bear interactions. However, they did support the following ongoing programs.

(1) continuation of research on polar bear deterrent methods

Table 7.1.5
Chronic (Episodic) Oil Spills

Hypothesis	**Research and Monitoring Recommendations**	**Status of Recommendations**
BEMP 9 Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of polar bears. BREAM R8 Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of polar bears and reduced harvest levels.	1983/84 BEMP • While research designed to obtain better information on the behavioural responses of polar bears to oil-covered water and oil-contaminated prey was considered important, it was recognized that the public and political opposition to such experiments would likely make it untenable. • In vivo experiments with polar bear pelts. • Determination of hydrocarbon burdens in animals harvested by Inuvialuit hunters. • Opportunistic studies in situations where bears contact oil anywhere in the Canadian Arctic, and reporting of such incidents to regulatory agencies. 1984/85 BEMP • Continued research on polar bear deterrent methods. • Effects monitoring of spills of opportunity and potential expansion of the Polar Bear Protection Action Plan to include effects monitoring on an opportunistic basis. 1991/92 BREAM • It was concluded that adequate information exists and no further work required.	• No further research involving experimental oiling of captive polar bears has been initiated. • No known action • No known action • While not prepared in direct response to this recommendation, the GNWT "Action Plan for Protection of Polar Bears in the Event of a Major Oil Spill" partly satisfies the recommendation (see below). • Further research on deterrent and detection methods supported by various government and industry sources. • To date, the Action Plan has not been updated to reflect the BEMP recommendation. However, the US Marine Mammal Commission funded another workshop in 1990 dealing with oil industry/polar bear interactions, where the importance of oil spill contingency and response team plans was reinforces. • No action required.

Table 7.1.5 (cont'd)

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
BEMP 10 Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within an adjacent to the marine environment will result in localized mortality of certain bird species.	1983/84 BEMP • Opportunistic monitoring of short- and long-term impacts of chronic oil spills.	• Documentation of effects of chronic spills is currently an integral part of response plans in the Beaufort region and its conducted by on-site industry personnel. Reporting procedures by one operator (Dome) were revised as a direct result of this recommendation. No further action is warranted.
MEMP 10 Chronic/episodic spills of crude oil and diesel fuel near staging and moulting areas of nesting colonies will reduce the abundance of waterfowl.	1984/85 BEMP • Following discussion of the value of incidental observations, it was concluded that a more systematic approach to effects monitoring may be necessary if chronic spills increase in frequency and/or volume.	• No action required.
BREAM R9 Chronic (episodic) oil spills resulting from normal hydrocarbon development activities within and adjacent to the aquatic environment will result in mortality and decreased productivity of certain species of waterbirds.	1985/86 MEMP • Reinforcement of BEMP recommendations related to documentation of oiled wildlife settings in oil spill reports produced following incidents involving spillage of oil.	• No action required; a review of the potential impacts of dispersants and dispersed oil by the CWS in 1987 provided information of value related to assessment of this hypothesis, while another CWS document (1988) described key areas for birds in the coastal region of the Beaufort Sea of value in response plans.
	1990/91 BREAM • No recommendations during research evaluation phase	• Large number of studies initiated after the Exxon Valdez oil spill in Alaska provided information relevant to the Canadian Beaufort.
	1991/92 BREAM • No recommended research related specifically to chronic oil spill effects.	• No action required

Development of a bear deterrent and detection program initiated in 1981 continued to be supported by various government and industry sources. This included a training and education program, development of a "safety in bear country' manual, and development of several deterrent techniques (e.g., acoustic devices, portable electric fences, projectiles).

(2) publication and implementation of the "Action Plan for the Protection of Polar Bears" and expansion of this plan to include an effects monitoring component

To date, the Action Plan has not been updated to reflect the BEMP recommendation related to the inclusion of effects monitoring. However, the US Marine Mammal Commission funded a workshop in 1990 to deal With oil industry/polar bear interactions, where the importance of oil spill contingency and response team plans was reinforced.

(3) effects monitoring of spills of opportunity in general

In 1986, the CWS initiated a study to compare the size, distribution and demographic and reproductive parameters of the Beaufort population of polar bears in 1986-88 to the results of a previous study conducted in 1971-79. While this program was not directed at satisfying the information gaps identified by BEMP participants, it would entail maintaining records of any oiled bears encountered during the study.

During the 1991/92 BREAM workshop, participants concluded that adequate information existed with which to evaluate BEMP 9 (renamed BREAM R8) and that further research related to this hypothesis was not required.

BEMP 10: Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of certain bird species.

MEMP 10: Chronic/episodic spills of crude oil and diesel fuel near staging and moulting areas of nesting colonies will reduce the abundance of waterfowl.

BREAM R9: Chronic (episodic) oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in mortality and decreased productivity of certain species of waterbirds.

Participants of the 1983/84 BEMP and 1985/86 MEMP workshops concluded that there was sufficient information to accept the hypotheses that chronic/episodic 011 spill would cause mortality of birds under some circumstances (BEMP 10 and MEMP 10). However, due to the high degree of uncertainty regarding the casual circumstances, nature and extent of potential impacts of these events on bird populations, the group recommended that opportunistic monitoring of the short-term and long-term effects of chronic spills in the Beaufort Sea be undertaken. It was suggested that monitoring should be conducted as part of existing oil spill response plans for the region by experienced observers or by members of the Beaufort Sea Oil spill Cleanup Cooperative.

As a result of the above recommendation, Dome Petroleum Limited revised its oil spill response reporting form to include information on the occurrence of oil-contaminated wildlife.

During subsequent BEMP and MEMP workshops, the working groups agreed that recording of incidental sightings of oiled birds on spill reporting forms should continue by the petroleum industry. While there was much discussion as to the value of conducting a detailed monitoring program to document effects of incidental oil spills, it was concluded that implementation of a systematic monitoring program would only be justified if the frequency and volume of chronic oil spills increased in the future.

A review of all BEMP and MEMP hypotheses during the 1990/91 BREAM program found both MEMP 10 and BEMP 10 to be valid and identified a substantial body of new information related to these hypotheses. Specifically, a number of studies conducted following the Exxon Valdez oil spill provided information that was directly applicable to the Canadian Beaufort and to the evaluation of the hypothesis linkages. However, because this information supported earlier conclusions regarding their validity, the working group of the 1991/92 BREAM workshop did not complete an evaluation of BEMP and MEMP 10 (which were combined to form a new hypothesis-BREAM R9). No further research or monitoring specifically related to BREAM R9 was considered necessary.

7.1.6 Contaminants

BEMP 13: Shorebases and shallow-water production facilities will release hydrocarbons and heavy metals at sufficient levels such that fish harvest will be reduced through tainting and heavy metal accumulation.

Due to concerns related to the potential for hydrocarbon contamination and subsequent decreases in fish harvests, participants of the 1983/84 and 1984/85 BEMP workshops recommended a number of research and monitoring initiatives (Table 7.1.6). Specifically, they recommended that time series measurements of hydrocarbon concentrations in fish flesh should initiated in Tuktoyaktuk Harbour. Further, it was noted that if these measurements indicate that significant concentrations of hydrocarbons exist or complaints of tainting occur, complimentary programs should be undertaken. These could include a taste testing program, and a study to determine the size of the area where tainting was occurring. During the 1984/85 workshop, recommendations related to the monitoring program were refined to include the selection of species (Le., arctic flounder and broad whitefish) and an indicator of hydrocarbon exposure (MFO induction).

Over the following year, a number of studies of direct relevance to the above recommendations were initiated.

- In 1985, NOGAP funded a monitoring program to assess the potential biological effects of chronic chemical contaminant inputs into Tuktoyaktuk Harbour on the benthic fishes arctic flounder and starry flounder. Measurements were made of: (1) polyaromatic and lakane hydrocarbons in flounder liver, bile and flesh; (2) mixed function oxidase enzyme activity in flounder liver; (3) PAH metabolites in bile; (4) mercury in flounder flesh; and (5) the incidence of idiopathic liver lesions. Measurements were also made of hydrocarbon concentrations within the sediments and water column of the harbour.

- In 1985, ESRF funded a study to evaluate the real or potential concerns associated with tainting of fish resources due to oil spills or hydrocarbon development activities, assess the effectiveness of various methods used to detect tainting (e.g., taste panels, analytical techniques), and identify research and monitoring strategies related to tainting. This study was initiated at least in part because of the recommendations made in relation to BEMP Hypothesis 13.

Table 7.1.6
Contaminants

Hypothesis	**Research and Monitoring Recommendations**	**Status of Recommendations**
BEMP 13/BREAM R11 Shorebases and shallow-water production facilities will release hydrocarbons and heavy metals at sufficient levels such that fish harvest will be reduced through tainting and heavy metal accumulation.	1983/84 BEMP • Recommended monitoring: time series measurement of hydrocarbon concentrations in fish collected from Tuktoyaktuk Harbour. • If the above monitoring shows significant hydrocarbon concentrations in fish flesh, or if complaints of tainting occur, then it was recommended that complimentary programs be considered: taste testing and/or research with caged fish. 1984/85 BEMP • Above recommendations refined in terms of selection of species to monitor (Arctic flounder, broad whitefish) and indicator of hydrocarbon exposure (MFO induction). 1991/92 BREAM • Recommended research/monitoring of metal levels in fish and marine mammals in the western Arctic. • A taste testing program was also recommended.	• An ESRF-funded review of available information on tainting of fishery resources was initiated at least in part because of this BEMP recommendation. • Background information on hydrocarbon levels in fish (including Tuktoyaktuk Harbour) provided by DFO study of contaminants in arctic fish. • Recommended monitoring was conducted in 1986 and 1987 as part of NOGAP, and indicated that hydrocarbons were accumulated by flounder. • Complimentary taste testing and caged fish studies were not initiated. • Several broad-based Beaufort Sea oceanography studies funded by DFO and NOGAP (B.6) provided important information on the nature and fate of hydrocarbon inputs to this region. • A variety of PERD-funded research programs and reviews completed in 1991/92 provided substantial data relevant to tainting of fish by hydrocarbons. • Numerous research programs related to contaminants in Arctic biota funded by the Arctic Environmental Strategy's Northern Contaminants Program. • This recommendation has not been acted upon.
BEMP 16 The construction of shorebases and shallow production fields will result in a decrease in the populations of Arctic cisco and broad whitefish. BREAM R12 The construction of shorebases, pipeline landfalls, and development of shallow production fields will result in a decrease in the populations of Arctic cisco and broad whitefish.	1983/84 BEMP • No recommendations for research or monitoring (other than compliance monitoring) if wastes discharged into waters >5 m deep. 1984/85 BEMP • No recommended research or monitoring 1991/92 BREAM • No recommended research or monitoring	• No action required • No action required • No action required

Table 7.1.6 (cont'd)

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
BEMP 20 The discharge of cuttings contaminated with oil-based drilling muds during development of shallow-water production facilities will reduce populations of Arctic cisco, broad whitefish and lake whitefish, and will also decrease the harvest of these species due to hydrocarbon accumulation. BREAM R15 The discharge of cuttings contaminated with oil-based drilling muds during hydrocarbon exploration or production will reduce populations of fish, birds or mammals, or decrease the harvest of these resources due to hydrocarbon accumulation in tissues.	1984/85 BEMP • No recommendations for research or monitoring; review of an ESRF-funded tainting study. 1986/87 BEMP • Five areas of required research or monitoring were identified: 1. Fate of discharged oil-contaminated cuttings 2. Establishment of a hydrocarbon baseline against which to judge effects of offshore development 3. Identification of critical habitats 4. Oxygen demand of oiled cuttings 5. Downhole generation of PAHs 1991/92 BREAM • No recommended research or monitoring	• No action required • ESRF-funded study conducted at two artificial island sites in 1987/88 • Several NOGAP-funded studies conducted in subsequent years have provided this hydrocarbon b baseline. • DFO (Freshwater Institute) have conducted several studies of prominent fish species in coastal regions of the Beaufort Sea and Mackenzie Delta that satisfy this recommendation • In 1985/86, NOGAP funded a study to investigate the oxygen demand of oiled drill cuttings. • A study designed specifically to address the issue of downhole generation of PAHs was funded by INAC in 1987/88.

Table 7.1.6 (cont'd)

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 15 Water discharges and accidental oil/chemical spills will lead to unpotable water and decreased acceptability of fish as a food source. BREAM R26 Contaminants from local and distant sources will lead to decreased acceptability and availability of fish as a food source.	1987 MEMP • A study of the mobility of contaminants in the vicinity of an abandoned drilling waste sump was recommended. • Continuation of time-series measurements of hydrocarbons and metals in burbot and whitefish, as well as associated morphological abnormalities. • Substantiation of background hydrocarbon levels in the Mackenzie River 1991/92 BREAM • The relative importance of local and LRTAP sources of the major contaminants (metals, petroleum hydrocarbons, PAH and organochlorines) in the region, including information on: (1) the standing stock of contaminants in and flux of contaminants to air, water, sediment and biota; (2) temporal trends; and spatial trends. • Further research to identify the contaminant pathways most relevant to each harvest group in the area.	• INAC and NOGAP funded a study to assess the performance of eight abandoned sumps in the Mackenzie River Valley region. • DFO (Freshwater Institute) and NOGAP funded a multi-year study of the effects of refinery operations at Norman Wells on fish quality in the Mackenzie River Basin. • Comprehensive data on the chemical properties of the lower Mackenzie River (including hydrocarbons) were collected in a study funded by INAC and completed in 1986. • Broad-based oceanographic studies conducted by IOS and others have also provided relevant data on the geochemistry and fluxes of hydrocarbons to the Beaufort Sea Shelf. • Numerous research programs of direct relevance funded through the Arctic Environmental Strategy's Northern Contaminant Program.

- ♦ A sampling program was undertaken by DFO to determine the level of potentially toxic contaminants in fish that might be used for human consumption. Several species of marine fish (arctic cod, whitefish, sculpins, herring and flounder) were collected from Tuktoyaktuk Harbour and Kugmallit Bay as well as five other locations within the Arctic. Samples of liver, kidney, gonad and muscle tissue were obtained and analysed for concentrations of hydrocarbons, heavy metals, mixed function oxidases and organochlorines.

Several other broader-based studies were funded by PERD, NOGAP and DFO over the next six years that provided information on the nature and fate of hydrocarbon inputs to the Beaufort region; and tainting of fish by hydrocarbons (INAC 1991).

During the 1991/92 BREAM workshop, BEMP Hypothesis 13 (renamed BREAM R11) was re-examined and further research and monitoring needs were identified. The workshop subgroup identified two areas where additional information related to fish tasting was required. These included: (1) examination of metal levels in fish and marine mammals of the western Arctic; and (2) a taste testing program. Although this latter recommendation was not acted upon, numerous research activities related to examining hydrocarbon and metal contamination in arctic marine biota have been funded through the Arctic Environmental Strategy's Northern Contaminants Program (INAC 1994). The following is a list of activities undertaken during 1993/94 fiscal year that are directly relevant to recommendations made in relation to BREAM R11.

- ♦ Sources and sinks of organochlorines in the Arctic marine food web. B. Hargrave, Bedford Institute of Oceanography, Fisheries and Oceans Canada.
- ♦ Identification of toxaphene components in Arctic air, marine mammals and human milk samples. D. Muir, Freshwater Institute, Fisheries and Oceans Canada.
- ♦ Spatial and temporal trends of organochlorines in Arctic marine mammals. D. Muir, Freshwater Institute, Fisheries and Oceans Canada.
- ♦ Long-term trends in organochlorine residues in eastern and western Arctic seal blubber. R. F. Addison, Institute of Ocean Sciences, Fisheries and Oceans Canada.
- ♦ Modelling and evaluation of contaminant accumulation and effects in marine mammals. M. Kingsley, Institut Maurice-Lamontagne, Fisheries and Oceans Canada.

- ♦ Planar PCBs, chlorinated dioxins/furans and related compounds in Arctic marine mammals and fish. D. Muir and C. Ford, Freshwater Institute, Fisheries and Oceans Canada.
- ♦ Mercury and other inorganic contaminants in country foods in eastern Hudson Bay. M. Kingsley. Institut Maurice-Lamontagne, Fisheries and Oceans Canada.
- ♦ Methylmercury and heavy metals in tissues of narwhal. beluga and ringed seals. R. Wagemann, Freshwater Institute, Fisheries and Oceans Canada.
- ♦ Biomarkers and stress effects in Arctic marine mammals. W. L. Lockhart and 8. Fergusson, Fisheries and Oceans Canada.
- ♦ Potential for effects on reproduction, carcinogenesis, mutagenesis and teratogenesis in Arctic marine mammals: Status of biomarkers in Arctic seals and whales. J. Payne, Fisheries and Oceans Canada.
- ♦ Metallothionein in Arctic marine mammals and fish. R. Wagemann, Freshwater Institute, Fisheries and Oceans Canada.
- ♦ Contaminant trends in freshwater and marine fish. D. Muir and W. L. Lockhart, Freshwater Institute, Fisheries and Oceans Canada.
- ♦ Sources, pathways and levels of contaminants in fish from Yukon waters. M. Palmer, Yukon Technical Committee on Contaminants in Northern Ecosystems and Native Diets.

BEMP 16: The construction of shorebases and shallow production fields will result in a decrease 'in the populations of Arctic cisco and broad whitefish.

BREAM R12: The construction of shorebases, pipeline landfalls, and development of shallow production fields will result in a decrease in the populations of Arctic cisco and broad whitefish.

Given the hydrocarbon development scenario used for the 1983/84 BEMP program, workshop participants concluded that produced water discharge from production platforms in waters greater than 5 m deep would not likely have any effects on arctic cisco or broad whitefish populations. It was agreed that no research or monitoring (other than compliance monitoring of shorebase and offshore waste streams) was warranted. However, if the scenario changed to include the development of shallow (i.e., < 5 m) production fields where temperature-sensitive species or life history stages are present and a solid ice cover simultaneously results in reduced mixing and dispersal, additional research would be required to examine the potential impacts on fish populations and necessary mitigative measures.

Due to the possibility of production from the ADGO field (located in water depths less than 3 m), this issue was re-addressed during the 1984/85 BEMP workshop and again during the 1991/92 BREAM workshop. Because of the unlikely nature of any impacts on fish populations as a result of the small volume of effluent expected from this field, the group did not make any specific recommendations for further research or monitoring. They did, however, identify some key information gaps related to this impact hypothesis that should be addressed if the estimated amounts of produced water from the ADGO field increase significantly.

BEMP 20: The discharge of cuttings contaminated with oil-based drilling muds during development of shallow-water production facilities will reduce populations of Arctic cisco, broad whitefish and lake Whitefish, and will also decrease the harvest of these species due to hydrocarbon accumulation.

BREAM R15: The discharge of cuttings contaminated with oil-based drilling muds during hydrocarbon exploration or production will reduce populations of fish, birds or mammals, or decrease the harvest of these resources due to hydrocarbon accumulation in tissues.

During the first evaluation of BEMP Hypothesis 20 in 1984/85, it was concluded that effects on regional populations of arctic cisco, broad whitefish and lake whitefish as a result of reduced prey availability caused by oxygen depletion and toxicity of petroleum hydrocarbons in drilling muds was highly improbable. It was, therefore, agreed that testing of this impact pathway through a monitoring program was not justified. The main cause of tainting and the reduction of these fish populations would be through the ingestion of benthic epifauna that accumulate hydrocarbons associated with cuttings piles. No research or monitoring related to this pathway was recommended due to the absence of a site-specific case upon which to test the hypothesis. However, the working group suggested that the results of an ongoing ESRF tainting study should be reviewed when available.

A substantial body of new information was available with which to re-evaluate BEMP Hypothesis 20 in 1986/87. Most of this information related to the use, disposal and possible fate and effects of oil-based muds. Participants of the 1986/87 workshop confirmed the validity of this hypothesis, which was expanded to include anadromous fish, birds and marine mammals, and identified five areas of required research and monitoring.

(1) Fate of discharged oil-contaminated cuttings

In 1985, ESRF funded a study to determine the areal distribution and dispersal of base oil from drilling mud contaminated cuttings discharged from two drilling rigs near Sable Island. The two drill sites studies provided Substantially different physical and oceanographic regimes -the Mobile West Venture C-62 site was located in about 16 m of water in an area where bottom sediments are well mixed by wind and wave action; and the Shell South Des Barres 0-76 site was located in about 70 m of water. The results of this study not only provided good information related to the fate of oil-base mud cuttings in two depositional environments, but also provided data for comparison with the results of a companion ESRF-funded study conducted in the Beaufort Sea. This latter study involved monitoring the distribution of base oil hydrocarbon concentrations in the vicinity of two well (Minuk I-53 and Kaubvik 1-43) and determining the aeral extent of discharged cuttings at the sites.

(2) Establishment of a hydrocarbon baseline against which to judge the effects of offshore hydrocarbon development

As part of NOGAP Project B.6 (Beaufort Sea Oceanography), NOGAP and DFO funded a study to investigate the distribution of hydrocarbons across the Beaufort Sea shelf. The specific objectives of this study were to characterize hydrocarbon concentrations in various compartments (water, particulates, plankton and sediments) across the shelf from 10m to out beyond the shelf break at 200 m water depth. The results of this study provided a well-defined baseline and source identification for hydrocarbons in all compartments of the Beaufort Sea against which any anthropogenic inputs can be measured.

(3) Identification of critical habitats

DFO and NOGAP funded research on fisheries habitat within the Mackenzie shelf area. The objectives of this investigation were to: (1) identify, both spatially and temporally, the areas of the shelf from Demarcation Point to Cape Bathurst that are of significance to estuarine and marine fish; (2) characterize areas of important or critical marine habitats in terms of their physical-chemical environment, biotic community structure or production; and (3) describe the feeding habits of selected pelagic and demersal fish of the shelf in relation to habitat and season.

In 1987/88, a review of published and unpublished information on overwintering fish habitat in the nearshore Beaufort and Mackenzie Della region was completed. This study involved documenting and mapping areas of known importance in the nearshore zone «10m isobath) from the U.S./Yukon border east to Anderson River, including Tuktoyaktuk Peninsula, Eskimo lakes, Liverpool Bay, the Mackenzie River and tributaries downstream of Arctic Red River, as well as freshwater overwintering areas along the Yukon North Slope.

(4) Oxygen demand of Oiled cuttings

In 1985/86, NOGAP funded a study to determine the oxygen demand of oiled drill cuttings layered on the sea floor. Sub-objectives of this study were to: (1) evaluate the influence of underlying substrate type and cuttings thickness on the oxygen demand of the cuttings; (2) observe the change in redox potential of cuttings and sediments covered by seawater; and (3) compare the pore water metal concentrations at the beginning and end of 30-day flow-through experiments.

(5) Downhole generation of PAHs

To address concerns raised during the 1986 BEMP workshop, INAC funded a literature review to investigate the generation and occurrence of in·situ downhole production of polyaromalic hydrocarbons (PAHs) during oil and gas drilling. The findings of this review presented evidence that downhole generation of PAHs is an unlikely source of PAH in rotary drilling operations.

MEMP 15: Water discharges and accidental oil/chemical spills will lead to unpotable water and decreased acceptability of fish as a food source.

BREAM R26: Contaminants from local and distant sources will lead to decreased acceptability and availability of fish as a food source.

During evaluation of MEMP 15 in 1985/86, the following recommendations for research and monitoring were made:

♦ *A study of the mobility of contaminants in the vicinity of an abandoned drilling waste sump*

Of direct relevance to the above recommendation is an INAC/NOGAP-funded study which was completed in 1987. The objectives of this study were to assess the performance of waste drilling fluid contaminant sites in the Mackenzie River Valley region. The assessment was conducted on eight abandoned sumps, which were located in a range of permafrost conditions and geological locations. The results of this work suggested that leakage at six of the eight sumps occurred. Although the possible areal extent of movement of the sump fluids from the containment sumps (I.e., mobility) was not determined, the results of this study provides supporting evidence of the hypothesis linkage that contaminants can migrate away from a drilling waste fluid containment sump and potentially lead to increased contaminant concentrations in subsurface waters.

♦ *Continuation of time-series measurements of hydrocarbons and metals in burbot and whitefish as well as associated morphological abnormalities*

Environment Canada and NOGAP funded a multi-year study to assess the freshwater impacts from the Norman Wells Oilfield development. Phase I of this work involved characterizing the crude oil and refinery effluent, while Phase II involved determining the Chemical characterization of the natural hydrocarbons from seeps in the Mackenzie River. The objectives of Phase III were to develop a water quality model based on hydrocarbon concentrations measured in the Mackenzie River at locations around Norman Wells and to determine whether a relationship exists between the health of burbot or arctic grayling and the location of collection or the Chemical contaminants in the bile, liver and dorsal muscle of the fish. Although extreme differences in the quality of burbot livers were evident, no parameter examined could be implicated as contributing to these differences.

In response to complaints from northern residents related to the quality of fish from the Mackenzie River, DFO (Freshwater Institute) conducted a study to determine whether deterioration of fish quality was caused by contamination from the Norman Wells Oilfield Expansion. This work involved: (1) comparing the quality of burbot livers from fish collected from several northern communities and eastern lakes; (2) conducting starvation experiments on burbot to determine the effects on liver quality; (3) conducting oil exposure experiments on trout to determine the effects on fish growth; (4) conducting oil exposure experiments on burbot to monitor the induction of microsomal exodase enzymes; and (5) comparing the levels of several low-boiling hydrocarbons in fish from Norman Wells and other communities.

♦ *Substantiation of background hydrocarbon levels in the Mackenzie River*

In 1986, INAC funded a study on the flux of suspended particulates, petroleum-related hydrocarbons, trace metals and nutrients from the Mackenzie River during the winter season. The results of this study provide a comprehensive data set of winter chemical water properties in the lower Mackenzie River, with which to better estimate natural levels of hydrocarbons in the Mackenzie and evaluate the relative scales of possible development/industrial inputs.

In addition to the INAC-funded study, several broad-based studies have been completed that have provided relevant information on the geochemistry and fluxes of hydrocarbons to the Beaufort Sea shelf (NOGAP Project B.6; see above in relation to BEMP 20).

During evaluation of BEMP 16 (renamed BREAM R26) in 1991/92, further recommendations for research and monitoring were made in relation to determining the relative importance of local and LRTAP sources for the major contaminants (metals, petroleum hydrocarbons, PAH and organochlorines) in the region. Specifically, the working group recommended that information be collected on: (1) the standing stock of contaminants in and flux of contaminants to air, water, sediment and biota of the region; (2) temporal trends; and (3) spatial trends. The group also suggested further research to identify the contaminant pathways most relevant to each harvest group in the area.

Under NOGAP Project A.12, the pathways of chlorinated and non-chlorinated hydrocarbon contaminants in the Mackenzie River and Beaufort Sea Shelf were examined, and a synthesis of studies was undertaken to determine the relative importance of hydrocarbons on the overall health of the area. Funding was provided to DFO/Institute of Ocean Sciences to conduct a sampling program in the Canadian Basin. This involved the collection of sediment, air, water and biota samples (in conjunction with concurrent measurements of other oceanographic properties) for analysis of chlorinated and non-chlorinated hydrocarbons.

Through the Arctic Environmental Strategy's Northern Contaminants Program numerous research programs of relevance to the above recommendations have also been initiated. In addition to those studies listed above in relation to BEMP Hypothesis 13 that have addressed contaminant uptake and effects in biota, several other studies were completed in 1993/94 in relation to contaminant :>sources, pathways and fate. These include:

- Atmospheric emissions of toxic substances. E. Voider, Atmospheric Service, Environment Canada
- International emissions inventory activities. E. Voider, Atmospheric Services, Environment Canada
- Study of the transport of persistent organic pollutants with special emphasis on Arctic regions. J. Pudykiewicz, Atmospheric Service, Environment Canada
- Northern contaminants air monitoring. LA Barrie, Atmospheric Service, Environment Canada
- Atmospheric mercury measurements at Alert. W.H. Schroeder, Atmospheric Environment Service, Environment Canada
- Modelling global-scale transport of hexachlorocyclohexanes; review and preparation of supporting data. T.F. Bidleman, Atmospheric Environment Service, Environment Canada
- Toxaphene in the Arctic: Atmospheric delivery and transformation in the lower food chain. T.F. Bidleman, Atmospheric Environment Service, Environment Canada
- Development of models describing the distribution of organic Chemicals into cold ecosystems. D. Mackay, Institute for Environmental Studies, University of Toronto.
- Past and present concentration of contaminants in the Russian and Canadian High Arctic. R.M. Koerner, Geological Survey of Canada.
- The historical record of persistent organic pollutants and trace metals in glacial snow/ice. D.J. Gregor, Centre for Groundwater Research, University of Waterloo.
- Current contaminant deposition measurements in Arctic precipitation (snow). M Swyripa, Indian and Northern Affairs Canada, and W.M.J. Strachan, National Water Research Institute, Environment Canada.
- Current contaminant deposition in snow in the Yukon Territory. M. Palmer, Indian and Northern Affairs Canada.
- Long-range transport of contaminants to the Canadian Basin. R.W. Macdonald and E.C. Carmack, Institute of Ocean Sciences, Fisheries and Oceans Canada.
- Measurements of radioactive contaminants in the Arctic Ocean. J.N. Smith, Bedford Institute of Oceanography, Fisheries and Oceans Canada.

- Polychlorinated dibenzo dioxins and furans in the Arctic environment. M. Alaee, National Water Research Institute, Environment Canada.

- Riverine inputs of contaminants. D. Jeffries and J. Carey, National Water Research Institute, Environment Canada, and M. Swyripa, Indian and Northern Affairs Canada.

- Modelling inorganic and organic contaminants in Arctic freshwater lakes. M.L. Diamond, Department of Geography, University of Toronto.

- Depositional trends ~ lake and marine sediments. W.L. Lockhart, Freshwater Institute, Fisheries and Oceans Canada.

- A study of the sources and fate of organochlorine contaminants in the Yukon River basin. M. Alaee, National Water Research Institute, Environment Canada, and D. Gregor, Centre for Groundwater Research, University of Waterloo.

- Processes and fluxes of contaminants in aquatic systems. R. Semkin, National Water Research Institute, Environment Canada.

7.1.7 Marine and Freshwater Withdrawal

BEMP 17: Marine water intakes will reduce populations of broad whitefish and arctic cisco.

BREAM R13: Water withdrawal from freshwater lakes for use in land-based production facilities will result in a reduced population of broad whitefish.

BEMP 17 was considered to be extremely unlikely because the potential waterflood requirements of Canadian nearshore fields would be considerably smaller than those typical of larger Alaskan fields, where losses of small anadromous fish were expected to result in only limited, if any, declines in population levels. This hypothesis was not considered worth testing and, therefore, no research or monitoring recommendations were made by the working group (INAC and Environment Canada 1984, 1985).

Studies on the effects of water intake structures associated with waterflooding projects in Alaska were initiated in 1984. It was agreed that the results of these monitoring programs would provide further information related to BEMP 17 and would help to determine the need for re-evaluation of this hypothesis at some future time, The hypothesis did not undergo any further evaluation as part of BEMP or BREAM because marine water use was not included within the hydrocarbon development scenario for the region.

As part of the 1991/92 BREAM program, a new hypothesis (BREAM R13) was developed to address concerns regarding the possible effects of water withdrawal for field flooding and other uses from lakes on Tuktoyaktuk Peninsula and Richards Island. Evaluation of this hypothesis was somewhat hampered by the lack of specific volume and flow requirement data for field flooding and processing, and an insufficient understanding of the hydrologic characteristics of some of the Peninsula lake systems (INAC 1992). Information from ongoing research activities sponsored by DFO on Peninsula watershed hydrology and by the National Hydrologic Research Institute on modelling of the hydrometeorology of selected watersheds was considered essential to scoping the magnitude and importance of this potential source of impact. As such, the working group supported continuation of these studies, and recommended the implementation of hydrologic/fish utilization monitoring programs should specific development scenarios involve water withdrawal from these lake systems.

Table 7.1.7
Marine and Freshwater Withdrawal

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
BEMP 17 Marine water intakes will reduce populations of broad whitefish and arctic cisco.	1983/84 & 1984/85 BEMP • No research or monitoring needs were identified. However, the group recommended that the results of monitoring studies conducted under the auspices of the U.S. EPA, Army Corps of engineers and the National Marine Fisheries Service be reviewed when available to determine need for re-evaluation of hypothesis in the future.	• N/A
MEMP 4 Oil and gas development activities will alter the water regime and decrease muskrat populations.	1985/86 MEMP • No research or monitoring studies were recommended.	• N/A
BREAM R13 Water withdrawal from freshwater lakes for use in land-based production facilities will result in a reduced population of broad whitefish.	1991/92 BREAM • Ongoing studies of Tuktoyaktuk Peninsula watershed hydrology as it relates to fish utilization (Wedel and Lawrence, in prep) should be completed as well as efforts to model the hydrometeorology of selected watersheds. • The group identified the need for hydrologic/fish utilization monitoring studies if and when specific development scenarios include a requirement for water withdrawal from lakes on Tuktoyaktuk Peninsula and Richards Island.	• The Tuk Peninsula hydrology study has not been completed due to lack of funding in the second year of the project. (M. Lawrence, North/South Consultants, pers. comm.) • N/A
BREAM R19 Water withdrawal from hydrocarbon development and land subsidence and drainage barriers resulting from linear corridors will change the population characteristics of birds, semi-aquatic furbearers and fish.	1991/92 BREAM • No research or monitoring programs related to the effects of water withdrawal on birds, fish and semi-aquatic furbearers were recommended. (Recommendations related to monitoring land subsidence/drainage barriers resulting from linear corridors is discussed in Section 7.1.12.)	• N/A

Due to a lack of funding for the second year of the Tuktoyaktuk Peninsula hydrology study, only an incomplete draft report has been prepared to date (M. Lawrence, pers. comm.). However, efforts by the National Hydrologic Research Institute to model the hydrometeorology of selected watersheds in the region are ongoing (P. Marsh, NHRI, pers. comm.) and are currently focussed on developing a model for snowmelt runoff, snow accumulation and snow chemistry. Field work has concentrated on two areas: Inuvik and an area between Inuvik and Tuktoyaktuk.

MEMP 4: Oil and gas development activities will alter the water regime and decrease muskrat populations.

BREAM R19: Water withdrawal from hydrocarbon development and land subsidence and drainage barriers resulting from linear corridors will change the population characteristics of birds, semi-aquatic furbearers and fish.

No research or monitoring recommendations were made in relation to MEMP 4 because this hypothesis was considered invalid and not worth testing (i.e., significant decreases in the Mackenzie Delta muskrat population were not expected as a result of water withdrawal and drainage disruptions; see Section 4.7).

The focus of MEMP 4 was expanded during the 1991192 BREAM program, when many of its linkages were revised to include: (1) the effects of water withdrawal and physical drainage barriers on fish and waterfowl; and (2) the impact of local land subsidence along pipelines and roads within the Mackenzie Delta and Valley. Despite the expanded scope of the impact hypothesis (renamed BREAM R19), no additional research or monitoring programs related to the effects of water withdrawal on birds, fish and semi-aquatic furbearers were recommended. However, a number of information needs related to evaluating the effects of linear corridors in the Delta on shorebirds and their habitat were identified by the working group (see Section 7.1.12.)

7.1.8 Aircraft Overflights

BEMP 3: Marine vessel traffic, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of the Beaufort Sea populations of ringed and bearded seals.

No research or monitoring programs to address this hypothesis were recommended by the 1983/84 or 1984/85 BEMP workshop participants. Although the hypothesis itself was considered to valid, it was concluded that the cumulative effects of all links on both the ringed and bearded seal would be inconsequential. Moreover, it was noted that because of the naturally high variability in seals population levels in the region, population effects would either be unlikely or too difficult to detect.

The original BEMP Hypothesis 3 was adopted by BREAM in 1991/92 (renamed BREAM R3), however, re-evaluation of this hypothesis was not considered necessary at that time. Consequently, no research or monitoring needs were identified by workshop participants.

As indicated in Table 7.1.8, other investigations have been conducted in the Beaufort Sea region that provide useful data for the assessment of BEMP 3/BREAM R3. These have included:

- Changes in the population dynamics of ringed seals in the Amundsen Gulf;
- Environmental and ecological factors influencing ringed seal distribution in the southeast Beaufort Region during late summer/fall; and
- Patterns of aggregation in ringed seals, bearded seals and bowhead whales in the Beaufort Sea during late summer.

Table 7.1.8
Aircraft Overflights

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
BEEP 3/BREAM R3 Marine vessel traffic, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of the Beaufort Sea populations of ringed and bearded seals.	• 1983/84 and 1984/85 BEEP • The group concluded that all links in the hypothesis were valid. However, no specific research or monitoring recommendations were made because the group determined that effects would either be inconsequential or too difficult to detect.	• Although no specific research or monitoring was initiated as a direct result of the BEEP/BREAM programs, participants of the 1985 workshop identified various research/monitoring projects that are of relevance to this hypothesis.
BEEP 12 Frequent low altitude aircraft flights over staging brant will cause increased overwinter mortality. BREAM R10 Activities associated with hydrocarbon development will affect eh abundance and distribution of aggregations of staging, moulting and nesting birds.	1983/84 BEEP • No specific research or monitoring was recommended 1984/85 BEEP • The 1984 workshop concluded that this hypothesis was invalid. Consequently, it was not re-evaluated in the BEEP program 1991/92 BREAM • The hypothesis was not re-evaluated during this year's workshop because adequate information exists to support eh validity of the hypothesis and potential impacts of industry disturbances are well documented in the literature; therefore, further research was not considered necessary.	• N/A
MEMP 8/BREAM R22 Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.	1985/86 MEMP • No new research or monitoring was recommended. However, the subgroup did support the continuation of routine monitoring of raptor populations being conducted by federal and territorial governments. 1991/92 BREAM • No research or monitoring was recommended	• No new studies were recommended by MEMP or BREAM, but several related research programs were completed over the six years.

BEMP 12: Frequent low altitude aircraft flights over staging brant will cause increased overwinter mortality.

BREAM R10: Activities associated with hydrocarbon development will affect the abundance and distribution of aggregations of staging, moulting and nesting birds.

Participants of the 1983/84 workshop concluded that BEMP Hypothesis 12 was invalid. Consequently, this hypothesis was not re-evaluated as part of BEMP and no research or monitoring needs were identified by the working group. However, a number of projects have been undertaken that are of direct relevance to this hypothesis. These include studies on the impact of hydrocarbon development on populations of snow geese and other waterfowl, the identification of key areas for birds in coastal regions of the Canadian Beaufort, the impact of low-level overflights on waterfowl populations, and the spring bird migration along offshore leads in the Beaufort Sea.

As part of the BREAM program, BEMP Hypothesis 12 was merged with MEMP 7 to form a new hypothesis (R10). During the 1991/92 workshop, this hypothesis did not undergo a full evaluation because it was felt that adequate information existed to support the validity of the hypothesis, and potential impacts of industry disturbances are well documented in the literature. No research or monitoring was not considered necessary.

MEMP 8: Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.

During the 1985/86 MEMP workshop, no research or monitoring recommendations were made in relation to this hypothesis. However, the subgroup did support the continuation of existing raptor monitoring programs being conducted by the federal and territorial governments.

- Through funding from Interprovincial Pipelines Ltd. and the GNWT, a raptor monitoring program of the Norman Wells Pipeline was completed in 1988. This project documented the distribution and abundance of falcons, eagles, hawks, raven and owls in the vicinity of the pipeline.

- The GNWT funded a study to collect occupancy and productivity data on peregrines in the Mackenzie Valley to estimate the reproductive success of the population and to monitor its long-term success. As a secondary objective, nestlings were also banded and blood samples were taken for DNA analysis.

- Rankin Inlet's peregrine population has been monitored since 1981 and GNWT intends to continue this monitoring indefinitely. The objectives of this study are to: (1) monitor the production of young, population turnover and recruitment; (2) determine diet; (3) measure pesticide contamination; and (4) study behaviour.

- Gyrafalcons populations have been monitored since 1982. The purpose of this program is two-fold: to collect baseline information on which to base harvest quotas and to detect any unexpected changes in raptor populations, as they are considered indicators of ecological health.

During the 1991/92 BREAM workshop, no research or monitoring specifically related to the effects of hydrocarbon development activities on staging, nesting and moulting birds was recommended by the subgroup.

7.1.9 Air Emissions

BEMP 18: Air emissions resulting from the operation of aircraft, marine vessels, drill rigs, offshore platforms and shorebases will adversely affect air quality.

MEMP 12: Air emissions resulting from oil and gas development and operation will adversely affect air quality.

During evaluation of BEMP 18 and MEMP 12, workshop participants concluded that air quality would not be affected to an extent to warrant the design and implementation of a monitoring program. It was noted, however, that this should not preclude the possible need to monitor air quality near major emission sources as part of required operating permits (INAC and Environment Canada 1984, (INAC *et al.* 1986).

Table 7.1.9
Air Emissions

Hypothesis	**Research and Monitoring Recommendations**	**Status of Recommendations**
BEMP 18 Air emissions resulting from the operation of aircraft, marine vessels, drill rigs, offshore platforms and shorebases will adversely affect air quality.	1983/84 BEMP • The group concluded that air quality would not be affected to an extent to warrant the design and implementation of a monitoring program.	• N/A
MEMP 12 Air emissions resulting from oil and gas development and operation will adversely affect air quality.	1985/86 MEMP • As above	• N/A

7.1.10 Increased Road Traffic

MEMP 2: Increased traffic on the Dempster Highway and on roads on the North Slope will decrease the number of caribou and alter their distribution.

BREAM R17: Hydrocarbon development in the Beaufort Region and roadway development to the Yukon North Slope will alter the number of Barren Ground Caribou and their distribution.

During the 1985/86 MEMP workshop, the working group supported continuation of research on the use of insect-relief habitat by caribou but concluded that initiation of any new research should be contingent on the results of this program. Through funding from NOGAP, this work was carried out by the Canadian Wildlife Service, with the Objective of defining and identifying critical caribou habitat in northern Yukon. While the effect of insect activity was one component of this investigation, researchers also collected data on vegetation complexes and regional weather patterns, assessed caribou efforts to minimize insect harassment, and documented activity budgets, habitat selection and food habits.

Participants of the MEMP workshop also identified the need for further monitoring:

(1) Aerial surveys of caribou movements in the North Slope area should be conducted if the proposed roads are constructed. This would provide the information needed to select appropriate mitigative measures to minimize interference with caribou migrations.

(2) Documentation on caribou road kills along the Dempster highway should be compiled so that mitigative measures could be employed if the number of caribou lost on the highway significantly increases.

Several studies of the Porcupine herd in relation to the highway were conducted during the mid 1970s to mid 1980s. During the winter of 1979 -1980 to 1981-1982, potential disruptions to winter activity patterns were measured by daily activity patterns, cratering activity, and short-term disruption by vehicles.

Table 7.1.10
Increased Road Traffic

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 2 Increased traffic on the Dempster Highway and on roads on the North Slope will decrease the number of caribou and alter their distribution. BREAM R17 Hydrocarbon development in the Beaufort Region and roadway development to the Yukon North Slope will alter the number of Barren Ground Caribou and their distribution.	1985/86 MEMP • Continued research on the use of insect-relief habitat by caribou was recommended by the workshop group. The group also identified the need for aerial surveys of caribou movements on the proposed North Slope roads; and documentation on road kills • The group also recommended a monitoring program to examine the effects of traffic on caribou distributions, information would have to be collected on 1) traffic levels in September/October and 2) the number and location of caribou harvested. In order to complete this traffic monitoring program, continued monitoring (by CWS) of the Porcupine caribou herd was recommended. 1991/92 BREAM • Eight research requirements were identified with respect to this hypothesis: 1) effects of hunting pressure on caribou responses to roads; 2) information on the factors that influence the distribution and abundance of parasitic insects, and the degree of insect harassment on caribou; 3) quantification of the effects of insect harassment on the body condition of caribou; 4) assessment of habitat quality and caribou habitat use on a regional scale; 5) assessment of long-term responses of caribou to roadways; 6) assessment and monitoring of pollution levels in the Beaufort Sea region; 7) establish a permanent, long-term monitoring program to assess the changes in range quality for caribou; and 8) establish a program to monitor levels of potential contaminants and to develop transport/fate modelling to determine how uptake of these contaminants by caribou may occur.	• Numerous studies were conducted to examine caribou population movements and distribution and the effects of increased traffic on caribou activity.

Table 7.1.10 (cont'd)

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 5 Oil and gas development, construction and, clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose.	1985/86 MEMP • No specific research was recommended, but basic research on the numbers, movements, recruitment and energetic of moose should be continued. The need to monitor road kills was identified. • A program to monitor the regeneration of woody browse was recommended. • If above-ground pipeline sections of more than 3–5 km are built, it was recommended that moose movements along the pipeline be monitored to determine if movements are restricted.	• A number of research projects have been initiated related to moose responses to oil pipeline crossings, browse use and digestibility, moose energy budgets, winter activity patterns, and revegetation monitoring.
BREAM R20 Oil and gas development, construction and clearing activities and the presence of an above-ground pipeline and gathering system will change the abundance and distribution of moose.	• No research specific to BREAM R20 was recommended.	• N/A

(3) *Effects of traffic on the distribution of caribou during fall migration should be monitored. This would require information on traffic levels in September and October, numbers of animals harvested and location of harvest, and seasonal movements of the Porcupine herd. It was noted that data on traffic levels could be obtained from ferry records, while harvest data could be obtained through the existing hunter survey system. The group supported continuation of a program being conducted by The Yukon territorial government and The CWS 10 monitor the distribution of/he Porcupine herd.*

Substantial research was undertaken to assess the movements, behaviour and energetics of the Porcupine caribou herd. A large amount of information on responses of barren ground caribou to roadways was also provided by studies conducted in the Prudhoe Bay oil field area in Alaska.

During evaluation of BEMP 2 in the 1991/92 BREAM workshop (renamed BREAM R17), the working group identified eight research needs in relation to caribou. These included the following.

(1) *Effects of insect harassment on the body condition of caribou, and The ultimate effect of these changes on production*

A study of the Central Arctic caribou herd in the vicinity of the Prudhoe Bay development area was initiated in the summer of 1992. This involved live capture and radio tagging of individuals within the herd to measure body size and condition prior to and after the insect season, and to assess calf survival throughout the season. Through NOGAP funding, a similar study of animals in the Porcupine herd was also undertaken to provide comparative data on caribou not exposed to hydrocarbon development. Under NOGAP Project A.13, CWS has undertaken a monitoring program to relate changes in range quality to changes in the physical condition of the Porcupine herd, and in turn population dynamics of the herd. In 1992/93, this involved:

- identifying high value habitats for calving on the coastal plain of the Arctic National Wildlife Refuge by determining daily weight gain;
- determining the relationship between abiotic factors which influence insect harassment (snow depths, timing of spring snowmelt, summer temperature and wind) and the fall body condition of caribou;

- determining the energy cost of lactation and the relationship between maternal condition and calf growth;
- predicting pregnancy rate from body condition scores; and
- studying body composition and growth of juvenile caribou in relation to maternal body condition.

(2) Factors influencing the distribution and abundance of parasitic insects, and the degree of insect harassment on caribou

Although some related research on group dynamics and behaviour of the Porcupine herd during the insect season was undertaken earlier through the University of Alaska (Nixon 1991), research specifically related to this recommendation was not funded through NOGAP.

(3) Effects of hunting pressure on caribou responses to roads

Through NOGAP funding, the Yukon Department of Renewable Resources completed a harvest study of the Porcupine caribou herd in 1987. This study reports the estimated semi-annual harvest of these caribou by all Canadian users. Measurements include species killed, sex and general age class, kill date and time, and location of the kill in relation to the Dempster Highway. Hunter data were collected from voluntary recall and hunter check stops.

(4) Assessment of winter habitat quality and caribou habitat use on a regional scale

As mentioned previously in relation to research recommendation # 1, CWS has undertaken this research as part of NOGAP Project A.13.

(5) Assessment of the long-term responses of caribou to the construction and operation of the Dempster Highway

Although this information was considered important by the BREAM working group in assessing the impacts of hydrocarbon development on caribou, it was agreed that this type of research is not practical due to the difficulties in separating the effects of environmental factors from man-caused disturbances. No studies have been initiated in relation to this research question.

(6) Effects of sulphur oxides and other pollutants on plant growth and distributions, and assessment of changes in quality and availability of caribou ranges

(7) Assessment of changes in range quality for caribou associated with cumulative effects of global climate change and long range transport of contaminants

It was agreed by the BREAM working group that while range monitoring is an important baseline study, this was outside the scope of the BREAM program. An international program has been initiated in Alaska and Russia to establish a long-term range monitoring network.

(8) Monitor levels of potential contaminants and to develop transport/fate modelling to determine how uptake by caribou may occur

Although the working group identified the need for this type of research, it was agreed that this was outside the scope of BREAM. No research has been initiated to address this information gap specifically related to caribou. However, contaminant pathway modelling of chlorinated and non-chlorinated hydrocarbons in the Mackenzie River and Beaufort Sea Shelf was funded through NOGAP Project A.12.

MEMP 5: Oil and gas development, construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose.

BREAM R20: Oil and gas development, construction and clearing activities and the presence of an above-ground pipeline and gathering system will change the abundance and distribution of moose.

During the 1985/86 BEMP workshop, participants did not recommend any research specifically related to the effects of hydrocarbon development on moose populations. However, the group did recognize the importance of moose to the native harvest and, therefore, supported the continuation and expansion of basic research on the numbers, movements, recruitment and energetics of moose populations in the NWT. Over the next year, several relevant studies were undertaken.

- ♦ In 1986, research was completed on the winter activity patterns of moose in interior Alaska (K.L. Risenhoover, Michigan Technological University). Data was collected on moose activity patterns, energy budget, and movements within Denali National Park and Preserve.

- ♦ Interprovincial Pipeline Ltd. sponsored a 3-year wildlife monitoring program to study the effects of pipeline construction and operations on the abundance, distribution, and local movements of wildlife within the pipeline corridor.
- ♦ GNWT conducted an aerial census of moose in the Fort Good Hope area. Primary objective of the study was to obtain an early winter population estimate of moose within a 100 km radius of Fort Good Hope. In 1992, GNWT was considering a similar survey of the Fort Norman area as no moose inventory has ever been completed in this area.
- ♦ GNWT, under NOGAP funding, initiated a grizzly bear and moose habitat identification and mapping study within the Mackenzie Delta.

Workshop participants also identified the need for a monitor program to determine the regeneration of woody browse on areas cleared for wood-chip production during construction of the IPL pipeline and to document the suitability of the woody browse for consumption by moose, Two studies related to this recommendation were undertaken over next year. IPL funded a monitoring program to assess revegetation success and vegetation recovery on seismic lines, areas of wood-chip operations, temporary roads and the pipeline right-of-way, IPL, in conjunction with INAC and Energy, Mines and Resources, also supported a long-term evaluation of revegetation and restoration associated with construction of the pipeline.

Of relevance to the above recommendation, the GNWT initiated a monitoring program to determine the recovery of furbearer and moose populations after forest fires. This study monitored browse regeneration and the length of time required for recovery of wildlife populations. It appears that the program was in effect during 1991 and GNWT intends on continuing the research program until at least December 1995,

No further research or monitoring programs were recommended in relation to BEMP Hypothesis 5 through either the BEMP or BREAM programs.

7.1.11 Onshore Development Activities

MEMP 1: The presence of offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a decrease in the number of Arctic and red foxes.

BREAM R16: The presence of offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a change in the number of Arctic and red foxes.

During the 1985186 MEMP workshop, participants concluded that hydrocarbon development will not significantly affect Arctic and red fox populations. However, the following research were recommended for the purpose of population management and to verify that the hypothesis is indeed invalid.

(1) Information is required on fox travel rates and movement patterns along sea ice and on tile relationship of foxes on the sea ice to the breeding populations.

- ♦ In 1986, a NOGAP-funded survey of Arctic fox dens on Herschel Island was completed. The results of this work include information on den activity and their prey.
- ♦ NOGAP and the Yukon Department of Renewable Resources funded two studies related to Arctic fox denning. The first involved examination of the physical and soil characteristics of Arctic fox dens on Herschel Island and the Yukon Coastal Plain. The second study involved conducting aerial surveys between 1984 and 1988 to document the distribution and occupancy rate of Arctic and red fox dens on the Yukon North Slope.

(2) A tagging program at drill sites should be implemented to establish whether a) Individual foxes remain at camps for extended periods, or b) if foxes observed at camps are from a continuously moving population.

(3) Catch per unit effort should be determined. A coordinated effort would be required. Data should be collected through a literature review, and a harvest study of the northern fox populations.

This recommendation has not been acted upon.

During the 1991/92 BREAM workshop, participants identified the need for assessing the use of abandoned gravel extraction sites, artificial gravel sources and undisturbed fluvial landforms by wildlife for the purpose of developing guidelines for maximizing wildlife use of reclaimed gravel extraction sites. It is unknown whether a study to address this recommendation has been initiated.

Table 7.1.11
Onshore Development Activities

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 1 The presence of offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a decrease in the number of Arctic and red foxes. BREAM R16 The presence of offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a change in the number of Arctic and red foxes.	1986/87 BEMP • Identified the need; for a radio-telemetry study of Arctic foxes to determine travel rates, and patterns of movement; collection of catch per unit effort data through harvest surveys; and initiation of a tagging program at drilling sites. 1991/92 BREAM • Recommend assessment of wildlife use of abandoned gravel extraction sites, artificial gravel sources and undisturbed fluvial landforms to develop reclamation guidelines to maximize wildlife use of reclaimed sites.	• Observational studies have been conducted on Arctic fox and red fox. Observational data was collected on fox and den sightings in an effort to collect information on their distribution and movements. Funding sources: CWS, the University of British Columbia and NOGAP. • Study conducted by the Yukon Department of Renewable Resources, and funded by NOGAP, was conducted to help determine the extent of denning habitat loss suffered by Arctic foxes, and terrain and soil requirements for Arctic fox dens. From these studies, further monitoring of breeding Arctic fox performance and harvest is proposed. • No known action
MEMP 3/BREAM R18 Gravel extraction, construction, seismic exploration and other development activities, and the presence of camps and garbage will decrease the number of grizzly bears and alter their distribution.	1985/86 MEMP • The subgroup supported continuation of a reporting system of grizzly bears observed or killed at or near camps to determine the population size and mortality rates; bear deterrent/detection research by the NWT Wildlife Service; and NWT Wildlife Service's ongoing radio-telemetry study of bears on Richards Island. 1991/92 BREAM • Research on aversive conditioning in the Prudhoe Bay area should be continued.	• GNWT has initiated projects related to this hypothesis: development of a manual on safety in grizzly bear habitat and a program to determine the effectiveness of a solar-powered electric fence and a disposal program using portable incinerators. • Through NOGAP funding, grizzly bears on Richards Island have been radio-collared and monitored.

Table 7.1.11 (cont'd)

Hypothesis	**Research and Monitoring Recommendations**	**Status of Recommendations**
MEMP 5 Oil and gas development, construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose. BREAM R20 Oil and gas development, construction, and clearing activities and the presence of an above-ground pipeline and gathering system will change the abundance and distribution of moose.	1985/86 MEMP • Refer to Table 7.1.10	• Refer to Table 7.1.10
MEMP 6/BREAM R21 Oil and gas exploration and development activities that alter habitat permanently or temporarily will influence the distribution and abundance of marten.	1985/86 MEMP • No specific research or monitoring is recommended. However, the size of marten's home ranges in the NWT is presently unknown. 1991/92 BREAM • No new research or monitoring recommended for the BREAM study area.	• N/A

Table 7.1.11 (cont'd)

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 7 Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl. BREAM R10 Activities associated with hydrocarbon development will affect the abundance and distribution of aggregations of staging, moulting and nesting birds.	1985/86 MEMP • The subgroup concluded that MEMP 7 was valid, but the localized effects would of disturbance would be small and impossible to detect. The subgroup acknowledged that evaluation of the effects of increased human access on specific breeding colonies was desirable; however, they concluded that a research program to determine cause and effects was not warranted. 1991/92 BREAM • The hypothesis was not re-evaluated during this year's workshop because adequate information exists to support the validity of the hypothesis, and potential impacts from industry disturbances are well documented in the literature. Therefore, further research was not considered necessary.	• N/A
MEMP 8/BREAM R22 Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.	1985/86 MEMP • Refer to Table 7.1.8	• Refer to Table 7.1.8

Table 7.1.11 (cont'd)

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 9 The presence of camps and garbage disposal will attract predators that will lead to changes in the local abundance and distribution of waterfowl. BREAM R23 The presence of camps and garbage disposal will attract predators that will lead to changes in the abundance and distribution of birds.	1985/86 MEMP • The workshop participants concluded that the hypothesis was valid; however, no recommendations were made regarding research and monitoring. Efforts would best be utilized if preventative measure were taken to eliminate problems associated with the attraction of wildlife to garbage. 1991/92 BREAM • Recommended research on the effects of camps and disposal sites on local densities of foxes and their associated predation rates on waterfowl; and on modifications of home ranges of foxes by camps and garbage.	• N/A • No known action
MEMP 17 Wolverines that are attracted to camps and garbage will be killed as nuisance animals, thus reducing the population.	1985/86 MEMP • Hypothesis considered invalid, therefore, no research or monitoring was recommended.	• N/A
MEMP 24 Industrial activities in harvesting areas will reduce the harvest of mammals, birds and fish because of conflicts between industry and harvesters over land use.	1985/86 MEMP • Group identified the need to establish negotiation, mitigation and compensation processes. The need for further information as part of these processes included: (1) location of proposed or probably developments and knowledge of native land use; (2) traditional knowledge related to land use; and (3) effectiveness of existing negotiation, mitigation and compensation mechanisms.	• Dene mapping project undertaken to obtain traditional knowledge related to land use of the Mackenzie Valley. • Department of Renewable Resources undertook evaluation of department's participation in the Norman Wells expansion project. As part of this review, information related to harvest impacts and success of compensation process examined.

MEMP 3: Gravel extraction, construction, seismic exploration and other development activities, and the presence of camps and garbage will decrease the number of grizzly bears and alter their distribution.

Due to concerns related to the impact of hydrocarbon development on the northern Mackenzie Valley grizzly bear population, participants of the 1985186 MEMP workshop recommended continued support for the following research.

(1) a reporting system for grizzly bears observed or killed at or near camps in order to determine population sizes and mortality rates

(2) bear awareness programs and deterrent/detection research being conducted by NWT Wildlife Service

A reference manual was prepared by the GNWT Department of Renewable Resources on safely in bear country. This manual summarizes information on human-bear conflicts (polar, grizzly and black bears) and recommends techniques, products and practices to reduce the chances of injury or property damage resulting from confrontations with bears. The manual is intended for use by industry, government agencies and local residents in training staff or residents to minimize human-bear encounters.

In 1991, GNWT's Wildlife Management Branch began monitoring the effectiveness of a solar-powered electric fence that was constructed around the Norman Wells dump site. The fence was monitored for a short time during the summer of 1991 and 1992 to determine its effectiveness in deterring bears from the area.

In 1991, the Alaska Department of Fish and Game initiated a three-year study on the use of aversive conditioning to reduce grizzly bear/human conflicts in the North Slope Oilfield. Although this work was not initiated as a direct result of any BEMP, MEMP or BREAM recommendation, it does provide detailed information on the responses and effectiveness of deterrants.

In 1992, the GNWT Department of Renewable Resources initiated a study to determine the effectiveness of portable incinerators to dispose of garbage and reduce the incidents of bear problems in camps in the Mackenzie Delta. During the winter of 1992, 15 incinerators were distributed to camps. Participants in the program will be interviewed in the fall of 1993/94 to determine the effectiveness of the incinerators, and a report summarizing the results of this study will be prepared sometime in 1994/95.

(3) an ongoing monitoring program to update population estimates and investigate movements and feeding patterns of grizzly bears on Richards Island, which is being conducted by the NWT Wildlife Service

Through funding by NOGAP, grizzly bears on Richards island were radio-collared and monitored in relation to industrial development activities in the area until 1988. Denning habitat and den emergence were assessed, and industrial related mortalities were documented.

During the 1991/92 BREAM workshop, recommendations for research in relation to MEMP 3 (renamed BREAM R18) were limited to continued research on aversive conditioning in the Prudhoe Bay development area.

MEMP 5: Oil and gas development, construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose.

BREAM R20: Oil and gas development, construction and clearing activities and the presence of an above-ground pipeline and gathering system will change the abundance and distribution of moose.

Recommendations for research and monitoring to address this impact hypothesis were discussed earlier in Section 7.1.10 in relation in increased road traffic.

MEMP 6: Oil and gas exploration and development activities that alter habitat permanently or temporarily will influence the distribution and abundance of marten.

During the 1985/86 MEMP workshop, participants concluded that no impacts to marten populations would likely occur provided that habitat alterations resulting from oil and gas development activities do not affect the majority of a marten home range. Although no recommendations for monitoring or research were made by the group, it was noted that the size of marten's home ranges in the NWT is still unknown.

Between 1984 and 1987, the Yukon Department of Renewable Resources studied the movements and habitat use by transplanted marten in the Yukon Territory. For those transplanted animals that became resident in the area, estimates of home range size were determined.

In the fall of 1989, the GNWT Department of Renewable Resources undertook a three-year study of marten in an area west of Norman Wells. The objectives of this research program were to: (1) determine summer and winter home range sizes; (2) document the pattern and timing of dispersal of animals into and out of the area; (3) assess the abundance of major foods; and (4) evaluate the distribution and abundance of habitat in terms of vegetation cover, deadfall, overhead cover, and snow depth.

During evaluation of MEMP 6 in the 1991/92 BREAM workshop, no further research or monitoring needs were identified in relation to this impact hypothesis.

MEMP 7: Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.

BREAM R10: Activities associated with hydrocarbon development will affect the abundance and distribution of aggregations of staging, moulting and nesting birds.

Participants of the 1985186 MEMP workshop concluded although evaluation of the effects of increased access on specific breeding colonies of waterfowl was desirable, research to determine cause-effect relationships was not warranted. The CWS was presently conducting a study of the effects of aircraft disturbance on nesting geese at the Anderson River colony, and several other studies provided qualitative evidence in support of this impact hypothesis.

During the 1991/92 BREAM workshop, MEMP 7 and BEMP 12 were merged to form a new BREAM hypothesis (R10). This hypothesis was not re-evaluated during the workshop because the working group concluded that adequate information existed to support the conclusion regarding its validity. No further research was considered necessary.

MEMP 8: Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.

Recommendations for research and monitoring to address this impact hypothesis were discussed earlier in Section 7.1.8 in relation to aircraft overflights.

MEMP 9: The presence of camps and garbage disposal will attract predators that will lead to changes in the local abundance and distribution of waterfowl.

BREAM R23: The presence of camps and garbage disposal will attract predators that change the abundance and distribution of birds.

Participants of the 1985/86 MEMP workshop concluded that although MEMP Hypothesis 9 is valid, camps and garbage disposal sites would not likely affect the number of waterfowl lost through increased predation if proper handling procedures for domestic wastes were undertaken. The group did not consider further research or monitoring to be justified, and noted that preventive and remedial actions to eliminate problems associated with the attraction of wildlife to garbage were the most practical approach.

During the 1991/92 BREAM workshop, two areas of research were recommended by the working group. These included: (1) studies on the effects of camps and disposal sites on local densities of fox and in turn its effects on predation rates to local waterfowl populations; and (2) modification of home ranges by foxes due to attraction to disposal sites. It is unknown whether either of these recommendations have been acted upon.

MEMP 17: Wolverines that are attracted to camps and garbage will be killed as nuisance animals, thus reducing the population.

No research or monitoring was recommended to address this impact hypothesis because it was concluded to be invalid by participants of the 1985/86 MEMP workshop.

MEMP 24: Industrial activities in harvesting areas will reduce the harvest of mammals, birds and fish because of conflicts between industry and harvester over land use.

Participants of the 1985/86 MEMP workshop concluded that based on the development scenario, it was possible that harvests could be reduced as a result of industrial development and land use conflicts. It was recommended that further study would be required to determine if impacts on the harvest were occurring and how significant these changes were. The group suggested that the following Information would be required as part of existing or future processes dealing with negotiation, mitigation and compensation. These include:

(1) *the location of proposed or probable industrial developments and a knowledge of existing land use by native harvesters;*

(2) *collection of data by community residents for determining actual effects of land use conflicts on harvests; and*

(3) *assessment of the effectiveness of existing negotiation, mitigation and compensation mechanisms.*

Specifically, the group noted that it would be important to determine effective means of measuring level of harvest effort on an individual or community basis to assess whether industry activity is directly or indirectly affecting level of effort.

For the purposes of the Dene/Metis land claim settlement, the Dene/Metis Negotiating Secretariat initiated a mapping project to obtain traditional knowledge related to land use of the Mackenzie Valley. An historical database was developed, and computerized maps summarizing information such as locations of trails, hunting areas, traplines, fishing areas and extent of traditional land between 1885 and 1979 were prepared.

In 1987, the Department of Renewable Resources undertook an evaluation of the Norman Wells project to assess the effectiveness of the department's participation in the public and regulatory review processes and project and impact management; to provide recommendations for the Department's participation in future large-scale developments; and to provide recommendations on improving public and regulatory review processes. The report indicates that during the oilfield expansion project, hunting pressure in the area experienced a marked increase. The number of resident sport hunting licenses doubled during the construction years (1983 and 1984) from the three previous years, and the resident hunter moose harvest experienced a two-fold increase. Three compensation claims were filed and, in two other situations, individuals met with IPL to discuss hunting and trapping concerns. All claims were settled in a timely manner to the satisfaction of parties involved.

7.1.12 Land Subsidence

MEMP 11: Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat.

There was considerable uncertainty related to the evaluation of MEMP Hypothesis 11, Much of this was due to the fact that there was no accurate method of predicting reservoir compaction and direct subsidence, and the potential for subsidence caused by changes in permafrost and ground ice was uncertain (INAC et al. 1986). For these reasons, the working group recommended that the following research be conducted to better our understanding of the potential for subsidence as a result of hydrocarbon development in the Delta region.

(1) *examine the reservoir geology of the Niglintgak area for comparison with other areas of known subsidence*

(2) *examine the importance of permafrost on mechanical properties of reservoir rock and the potential for direct subsidence*

(3) *determine the vertical and horizontal distribution of permafrost in the area of hydrocarbon reservoirs*

Results of research conducted since the 1985/86 MEMP workshop have provided additional information with which to more accurately assess the impacts of induced land subsidence.

- ♦ Through funding by the Department of Energy, Mines and Resources, the Geological Survey of Canada has investigated permafrost characteristics along the southern Beaufort Sea and massive ground ice associated With glaciofluvial sediments on Richards Island. NWT. The results of these investigations provide evidence for substantial variability in geothermal and ground ice conditions in both the nearshore and onshore, suggesting that similar spatial variations in thaw consolidation and thermokarst activity resulting from induced land subsidence should be expected.

- ♦ As part of the NOGAP C.20 Project, Environment Canada and the Department of Agriculture sponsored a study to evaluate and quantify the short-term physical and thermal changes in the permafrost-active layer as a result of human disturbance. This study has shown that degradation of the near-surface permafrost leading to subsidence and erosion of the terrain can be considerable within the first two years following disturbance.

Table 7.1.12
Land Subsidence

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 11 Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat.	1985/86 MEMP • The group recommended the following research to help determine the accuracy of predictions made concerning potential subsidence in the Niglintgak area. (1) review reservoir geology of the Niglintgak area and compare with areas of known subsidence (2) examine the importance of permafrost on mechanical properties of reservoir rock and the potential for direct subsidence (3) determine the vertical and horizontal distribution of permafrost in the area of hydrocarbon reservoirs.	• The Geological Survey of Canada has undertaken research to examine permafrost characteristics along the southeastern Beaufort Sea and to investigate massive ground ice associated with glaciofluvial sediments on Richards Island NWT. • AS part of the NOGAP c.20 Project, Environment Canada and the Department of Agriculture sponsored a study to define, evaluate and quantify the short-term physical and thermal changes in the permafrost-active layer as a result of human disturbance. • N/A
BREAM $24 The cumulative effects of natural land subsidence, induced land subsidence (from hydrocarbon withdrawal) and increasing sea levels due to global climate change will alter wetland and aquatic habitats in the Mackenzie Delta and result in changes in the distribution and abundance of waterfowl, fish and muskrat.	1991/92 BREAM • Research Need 1: Quantification of the potential for land inundation (1) the rate and distribution of natural subsidence in the Mackenzie Delta and the Beaufort coast (2) the potential rate and distribution of induced subsidence resulting from hydrocarbon activities (i.e., site-specific assessment of potential risk) (3) the potential rate of increase in sea level as a result of global warming (4) net effect of delta deposition on subsidence and sea level change • Research Need 2: Effects on wildlife and fish If the cumulative effects of subsidence and sea level changes on land inundation are significant, an assessment should be initiated to determine the effects of habitat loss on fish, waterbirds and muskrat.	• Research has been conducted as part of NOGAP Project D1 (Coastal Zone Geotechnics, Beaufort Sea) by the Atlantic Geoscience Centre, Geological Survey of Canada on thaw of permafrost, coastal and nearshore processes, coastal erosion and coastal impacts of climate change. • Under NOGAP Project C11 (Sediment-related aspects of northern hydrocarbon development) Inland Waters Directorate has undertaken research to investigate and model delta sediment flux, and develop a hydrologic information database for the Mackenzie Delta. • CWS is presently conducting a study on the impacts of climate change on migratory birds.

Table 7.1.12 (cont'd)

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
BREAM R19 Water withdrawals from hydrocarbon development, and land subsidence and drainage barriers resulting from linear corridors will change the population characteristics of birds, semi-aquatic furbearers and fish.	1991/92 BREAM • The group identified two area where further research was needed to properly assess the degree of impact of pipeline/road construction on the Delta on shorebird populations and their habitat. (1) examine the pattern of surface flows across shorebird nesting habitat on the Delta (2) determine the distribution of shorebird habitat on the Delta	• A NOGAP/IWD project has been undertaken to develop a delta flow distribution model. • CWS has been conducting aerial and ground surveys of breeding and migrating shorebirds on the Mackenzie Delta to determine their densities in various habitats and to identify the most important staging and breeding sites.
	• The group also recommended that the following monitoring programs be implemented in the event that roads/pipelines are constructed on the Delta. (1) monitoring/maintenance of the pipeline to identify and correct erosion and subsidence problems as they occur. (It was assumed that a program of this type would be part of standard operating procedure as has been undertaken by IPL along their Norman Wells pipeline.) (2) monitor changes in water levels and distribution of shorebird habitat (3) monitor the distribution of nesting shorebirds on the Delta (4) monitor productivity of shorebirds on the Delta to determine implications of changing water levels and distribution patterns	• N/A

BREAM R24: The cumulative effects of natural land subsidence, induced land subsidence (from hydrocarbon withdrawal) and increasing sea levels due to global climate change will alter wetland and aquatic habitats in the Mackenzie Delta and result in changes in the distribution and abundance of waterfowl, fish and muskrat

During the 1991/92 BREAM program, the original MEMP Hypothesis 11 underwent major revisions to address the cumulative impacts of natural land subsidence, induced land subsidence and increasing sea levels due to global warming. Evaluation of this new hypothesis (BREAM R24) highlighted a number of information deficiencies that would need to be addressed in order to assess the hypothesis properly. The working group concluded that "it was necessary to determine:

(1) the rate and distribution of natural subsidence in the Mackenzie Delta and the Beaufort coast;

(2) the potential rate and distribution of induced subsidence resulting from hydrocarbon activities (i.e., a site-specific assessment of potential risk);

(3) the potential rate of increase in sea level as a result of global warming; and

(4) the net effect of delta deposition on subsidence and sea level changes" (INAC 1992).

As natural subsidence, global climate Change and delta deposition are occurring over a geological time scale, the working group agreed that the associated research needs would have to be conducted over the long term and, therefore, were outside the scope of the BREAM program. Nevertheless, many of these factors have been investigated as part of ongoing NOGAP-funded projects. Under the NOGAP 01 Project (Coastal Zone Geotechnics, Beaufort Sea) the Atlantic Geoscience Centre, Geological Survey of Canada has conducted research on thaw of permafrost, coastal and nearshore processes, coastal erosion and coastal impacts of climate change. The main summary document is currently in preparation (S. Solomon, pers. comm.). Under NOGAP Project C11 (Sediment-related aspects of northern hydrocarbon development) Inland Waters Directorate, Environment Canada has undertaken research to investigate sediment source and deposition areas, delta sedimentation and delta channel stability. This project was completed in 1993/94, and reports prepared during that fiscal year will be available by mid 1994 (J. Jasper, pers. comm.).

During the evaluation of BREAM R24, the working group agreed that if the cumulative effects of subsidence and sea level changes on land inundation are significant, an assessment should be initiated to determine the effects of habitat loss on fish, waterbirds and muskrat. It was noted that quantitative modelling of existing baseline habitat conditions and potential future changes in habitat availability and quality will be required. Although a research program to address this recommendation has not been initiated, research currently being conducted by CWS will provide information relevant to assessing habitat loss of migratory birds. Through funding by the Atmospheric Environment Service and the National Institute for Ecological Research, Denmark, CWS is conducting an ongoing investigation of the impacts of climate change on arctic-nesting waterfowl and shorebirds. The objectives of this study are to determine the sensitivity of these birds to variations in weather and climate in their breeding, migration-staging and wintering areas, and to identify those species and habitats that may be at risk from global warming.

BREAM R19: Water withdrawals from hydrocarbon development, and land subsidence and drainage barriers resulting from linear corridors will change the population characteristics of birds, semi-aquatic furbearers and fish.

While BREAM R24 deals with the cumulative effects of regional land subsidence induced by hydrocarbon withdrawal and occurring naturally within the Mackenzie Delta, BREAM R19 specifically addresses the effects of local land subsidence along pipelines and roads on the Delta. Research conducted in association with the IPL pipeline from Norman Wells (Ground thermal regimes and terrain stability; NOGAP Project A.17) has provided considerable information regarding permafrost, terrain and terrain stability, soil climates in the Mackenzie Valley, and slope stability and landslide processes in permafrost soils. However, because the IPL line is located in the valley where the topography is variable and the effects on drainage are very localized and limited due to this natural variability, there is still uncertainty related to the effects of pipeline construction on terrain in an area of continuous permafrost. A three-year NOGAP-funded program of the Inland Waters Directorate (Project C.11.6) on channel stability in the Mackenzie Delta, with particular emphasis on proposed pipeline crossings, may provide useful information related to stability of the permafrost table and stability of the drainage network of the Delta.

During evaluation of BREAM R19, it was noted that construction of a pipeline on the Delta would follow a firm set of design criteria to minimize effects on terrain (e.g., avoidance of sensitive areas, insulation of the pipe) (INAC 1992). Nevertheless, land subsidence and creation of drainage barriers would occur, at least temporarily, until remedial actions are taken by the proponent. Due to the lack of information on natural waterflow patterns across the Delta, it was unknown to what extent this would affect surface flows and wetland habitat. Because of the importance of this habitat for nesting shorebirds, the working group recommended that the following research be conducted.

(1) Examine the pattern of surface flow across shorebird nesting habitat on the Delta

As part of the NOGAP C.10 Project (Hydrologic/hydraulic aspects of northern hydrocarbon development 1991/92,1993/94), Inland Waters Directorate continued research into developing a flow distribution model for the Mackenzie Delta. A one-dimensional hydraulic model involving 85 reaches was developed to simulate flow velocity and levels. While further work on this project related to evaluating the effects of lake storage on delta hydrology is expected to begin in the fall of 1994 (J. Kerr, IWD, pers. comm.), reports prepared during the final year of NOGAP funding are expected to be available by mid 1994.

(2) Continue research by CWS to determine the distribution of shorebird habitat on the Delta

From 1991 to 1994, CWS has been conducting aerial and ground surveys of breeding and migrating shorebirds on the Mackenzie Delta to determine their densities in different habitats and to identify the most important staging and breeding sites. Vegetation communities and priority shorebird habitat will be mapped for the entire outer Delta using digital analysis methods employed in an earlier CWS study (Dickson et al. 1989) to determine the distribution, abundance and habitat requirements of selected species of arctic-nesting shorebirds on the outer delta and Richards Island (NOGAP Project C.7.3). This research has been co-funded by NOGAP and the Polar Continental Shelf Project.

7.1.13 Improved Access

MEMP 7: Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.

BREAM R10: Activities associated with hydrocarbon development will affect the abundance and distribution of aggregations of staging, moulting and nesting birds.

Participants of the 1985/86 MEMP workshop concluded although evaluation of the effects of increased access on specific breeding colonies of waterfowl was desirable, research to determine cause-effect relationships was not warranted. The CWS was presently conducting a study of the effects of aircraft disturbance on nesting geese at the Anderson River colony, and several other studies had provided qualitative evidence in support of this impact hypothesis.

During the 1991/92 BREAM workshop, MEMP 7 and BEMP 12 *were* merged to form a new BREAM hypothesis (R10). This hypothesis was not re-evaluated during the workshop because the working group concluded that adequate information existed to support the conclusion regarding its validity. No further research was considered necessary.

MEMP 8: Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.

During the 1985/86 MEMP workshop, no research or monitoring programs to address this hypothesis were recommended by the working group. However, the group did support the continuation of routine monitoring programs being conducted by the federal and territorial government, and suggested that specific regulations to mitigate potential development disturbances should continue to be enforced by government agencies.

Over the next six years, several new studies on raptors in the Mackenzie region had been conducted. Although this new information provided data to better assess the effects of disturbances on raptors, it did not alter the conclusions of the MEMP or BREAM working groups related to the validity of the hypothesis. No research or monitoring needs related to MEMP 8/BREAM R22 were identified.

Table 7.1.13
Improved Access

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 7 Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl. BREAM R10 Activities associated with hydrocarbon development will affect the abundance and distribution of aggregations of staging, moulting and nesting birds.	1985/86 MEMP • Refer to Table 7.1.11	• Refer to Table 7.1.11
MEMP 8/BREAM R22 Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.	1985/86 MEMP • Refer to Table 7.1.8	• Refer to Table 7.1.8
MEMP 14/BREAM R25 Improved access and fishing pressure will decrease the abundance of fish and affect their distribution.	1985/86 MEMP • Group identified need for monitoring of catch data for major fish species in the sport, domestic and commercial fisheries; and index monitoring of catch and fish populations. • Several research initiatives recommended for target fish species (arctic char, whitefish, arctic grayling, lake trout) 1991/92 BREAM • New information available but there still exists the need for further study on basic biology and population size of harvested fish species.	• Over the past 6 years, DFO has initiated several studies to improve our knowledge related to population sizes and characteristics, and existing pressures of the domestic, sport and commercial harvests on key target fish species (particularly arctic char and broad whitefish).

Table 7.1.13 (cont'd)

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 21 Increased or improved access associated with hydrocarbon development will increase the harvest of waterfowl, which will lead to a reduction in the number and alter the distribution of waterfowl. BREAM R29 Changes in access will affect the harvest of birds, fish and mammals, which will lead to a reduction in the abundance and later the distribution of these populations.	1985/86 MEMP • Hypothesis is valid, but effects are unlikely to occur given the development scenario. No new research or monitoring was recommended. 1991/92 BREAM • No new research or monitoring was recommended.	• N/A
MEMP 23 Changes in access will alter the harvest of birds, fish and mammals.	1985/86 MEMP • The group identified the need for an ongoing harvest study 1991/92 BREAM • No new research or monitoring was recommended.	• N/A

MEMP 14: Improved access and fishing pressure will decrease the abundance of fish and affect their distribution.

BREAM R25: Improved access and fishing pressure will decrease the abundance of fish and affect their distribution.

During evaluation of this hypothesis in the 1985/86 MEMP and the 1991/92 BREAM workshops, it was concluded that increased fishing pressure on fish populations could be significant as a result of improved access. While it was noted that overfishing could be controlled to a certain extent by imposing quotas, catch limits and seasonal openings on various fisheries, it was recognized that enforcing these type of regulations, particularly in the Arctic, is difficult. A number of monitoring and research programs were recommended by the 1985/86 MEMP working group (Table 7.1.13). Despite much work in these areas over the following six years, the need for further study on the basic biology and population size of the species captured was identified by the BREAM working group.

During the MEMP workshop, the following monitoring was recommended:

(1) *Collection of total annual catch data for major fish species in the sport, domestic and commercial fisheries for each waterbody to allow more accurate predictions of the effects of future increases in catch.*

(2) *Index monitoring of catch and fish populations through length/age frequencies from catches or population samples and evaluation of catch per unit effort in domestic and commercial fisheries or experimental studies involving sampling gillnets. This would aid in identifying trends in population sizes caused by harvesting activities.*

The working group also identified a number of research needs related to management of important target species.

(1) ***Arctic char*** *- data on the response of populations of western arctic char to exploitation in various fishing is lacking. However, it was noted that given the limited number and size of these populations in Canada, further disturbances through scientific study may not be justified.*

In 1983, DFO undertook a sampling program to collect biological data (age, length, weight, sex, maturity, fecundity, condition) on arctic char that were captured by a fish weir and trap on the Rat River. This report provides baseline data on the characteristics and abundance of a population that is subjected to a domestic fishery by residents of Aklavik and Fort MacPherson.

In 1984, DFO conducted population studies of arctic char in the Big Fish River as well as surveys of 19 rivers from the Yukon to Victoria Island. The objectives of this work were two-fold: (1) to provide an assessment of total harvest taken by the domestic fishery in the Big Fish River and examine the distribution and movement of this population; and (2) to assess arctic char habitat, potential spawning and overwintering areas and potential sites for fish weirs in the region. This baseline data was considered essential to assessing any changes in harvest levels in the domestic fishery and providing information necessary for management of these populations.

Monitoring of the domestic/commercial fisheries for arctic char in both the Big Fish River and Rat River areas continued in 1986 and provided further baseline information on the annual harvests. Monitoring of the fishery in the Big Fish River/Cache Creek area was considered to be particularly important to assessing the potential effects of improved access on fish populations since in recent years access to this river in early winter (i.e., a time when arctic char are concentrated in small areas and are vulnerable to over-fishing) was improved by use of snowmobiles.

In 1986, DFO and NOGAP funded a study to examine the discreteness and number of char stocks in the western Arctic using morphometric, meristic and electrophoretic techniques, and to establish the relatedness of these stocks. In 1990, a supplementary project was initiated to investigate the population dynamics of early life history stages. Char were sampled from sites on Joe and Cache creeks and on the Firth, Babbage, Canoe and Rat rivers. Results of these studies indicated that char in this region are structured into genetic stocks and that these stocks retain their fidelty to at least some rivers during all life history stages.

(2) ***Lake trout*** *- compilation of available records and knowledge on the distribution of lake trout is required. Limited field sampling should be undertaken to address data gaps.*

(3) ***Whitefishes*** *- while research is required on all species of whitefish, particular emphasis was placed on broad whitefish d(le to its importance in the*

domestic fisheries and its abundance in the region. Specifically, continuation of research on differentiation of broad whitefish stocks in terms of movements, rearing locations, overwintering and spawning areas and other critical fife history events was recommended.

In addition to the ongoing DFO/NOGAP-funded study on broad whitefish stock differentiation, DFO initiated a number of sampling programs specifically related to whitefish populations in the western Arctic. These included:

- ♦ A long-term study to examine the external scarring of whitefish from the western Northwest Territories and its possible implications to development of fisheries. Results of this study indicated that the frequency of scarred individuals varied geographically from the Mackenzie mainstem and tributaries and, further, that fish from mainstem locations had approximately twice the frequency of scarring than fish from tributary locations. Smaller scars were restricted to fish from locations With connections to the Arctic Ocean and therefore were attributed to marine parasitic copepods or arctic lampreys. Larger scarring was attributed to attacks by lamprey or previous gillnetting capture. These results indicated that increased fishing pressure could decrease the quality of fish and, thus, their saleability.

- ♦ A study to collect data on key diagnostic characters of coregonids that define and identify fish of different ages and sizes to species. The ability to identify all stages of fish development to a species level was considered essential to obtaining knowledge on the size of regional populations of coregonids and to assessing the risk of populations to exploitation and development activities.

- ♦ A study to examine the extent of hybridization in coregonids of the western Arctic. Field collections in the Wood Bay area indicated that most coregonids in the region hybridize freely and the rates of hybridization are very high.

(4) **Arctic grayling** - experimental harvest study would provide some data to assess the effects of increased fishing pressure on grayling. To determine the vulnerability of this species to overfishing, it was also recommended that research be initiated to determine whether grayling form discrete populations (or stocks) and spawn in their natal streams.

No research programs were initiated in response to this recommendation.

MEMP 21: Increased or improved access associated with hydrocarbon development will increase the harvest of waterfowl, which will lead to a reduction in the number and alter the distribution of waterfowl.

BREAM R29: Changes in access will affect the harvest of birds, fish and mammals, which will lead to a reduction in the abundance and alter the distribution of these populations.

No new research or monitoring was recommended by either the MEMP or BREAM working groups during evaluation of this hypothesis.

MEMP 23: Changes in access will alter the harvest of birds, fish and mammals.

During the 1985/86 MEMP workshop, the working group identified the need for implementation of an ongoing harvest study to provide information on changes in trends in the composition of the harvest and the locations from which animals are taken.

These data are collected, in part, by the FJMC as part of the Inuvialuit Harvest Study, which was initiated in 1987 to provide a continuous, long-term record of the harvest of 69 species of birds, terrestrial mammals and marine mammals from the Mackenzie Delta and Beaufort Sea region. A resident harvest study is also conducted annually by the GNWT Department of Renewable Resources. This study was initiated to determine the level of harvest for all species taken during hunting, trapping and fishing activities within the NWT.

7.1.14 Linear Corridors

MEMP 2: Increase traffic on the Dempster Highway and on roads on the North Slope will decrease the number of caribou and alter their distribution.

BREAM R17: Hydrocarbon development in the Beaufort Region and roadway development to the Yukon North Slope will alter the number of Barren Ground Caribou and their distribution.

MEMP 5: Oil and gas development, construction and clearing activities, and the presence of an above-ground pipeline will change the abundance and distribution of moose.

BREAM R20: Oil and gas development, construction and clearing activities, and the presence of an above-ground pipeline and gathering system will change the abundance and distribution of moose.

Recommendations for research and monitoring programs to address to these impact hypotheses were discussed earlier in Section 7.1.10 in relation to increased road traffic. The reader is referred to this earlier section for a detailed discussion.

MEMP 16: The construction and presence of linear corridors will affect the number, distribution and quality of fish, and fishing success.

BREAM R27: The construction and presence of linear corridors will affect the number, distribution and quality of fish, and fishing success.

Participants of the 1985/86 MEMP workshop discussed the need for specific research and monitoring initiatives in relation to this impact hypothesis. These included:

(1) studies 10 improve the design of culverts to allow fish passage during icy conditions;

(2) studies on the distribution, movements and critical habitats of whitefishes and grayling;

(3) systematic monitoring of fish and selected indicator species; and

(4) expansion of the existing hydrometric network 10 provide baseline data for engineering and biological studies.

Consensus regarding the need for any particular research or monitoring program could not be reached among the workshop participants, although it was generally agreed that the present knowledge related to affects of linear corridors and potential mitigation would allow for development of linear facilities within the Mackenzie Delta and Valley. Despite this, a number of studies of relevance to the above suggestions were funded over the following six years.

- Through funding by DFO and NOGAP, the Freshwater Institute undertook an investigation on the movement of broad whitefish in Mackenzie River streams on Tuktoyaktuk Peninsula and in the Mackenzie Estuary. This study provided information on the fall migration of this species; identified major spawning grounds; and identified overwintering habitats along the lower Mackenzie River and Delta.

- In 1985, DFO completed an assessment of fish passage culverts that were constructed to simulate stream conditions on the Liard River tributaries. Four small streams crossed by the Liard Highway were studies to assess the effects of culverts on fish. During this study, it was found that culvert riprap when not buried by sediment was effective in reducing current velocities and that culvert icing became suspended by the riprap, allowing flow and subsequently fish passage under the ice.

Table 7.1.14
Linear Corridors

Hypothesis	**Research and Monitoring Recommendations**	**Status of Recommendations**
MEMP 2 Increased traffic on the Dempster Highway and on roads on the North Slope will decrease the number of caribou and alter their distribution. BREAM R17 Hydrocarbon development in the Beaufort Region and roadway development to the Yukon North Slope will alter the number of Barren Ground Caribou and their distribution.	1985/86 MEMP • Refer to Table 7.1.10	• Refer to Table 7.1.10
MEMP 5 Oil and gas development, construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose. BREAM R20 Oil and gas development, construction, and clearing activities and the presence of an above-ground pipeline and gathering system will change the abundance and distribution of moose.	1985/86 MEMP • Refer to Table 7.1.10	• Refer to Table 7.1.10
MEMP 16/BREAM R27 The construction and presence of linear corridors will affect the number, distribution and quality of fish, and fishing success.	1985/86 MEMP • The group discussed the need for: 1) studies to improve the design of culverts to allow fish passage during icy conditions; 2) studies to document the distribution, movements and critical habitats for whitefish and grayling; 3) systematic monitoring of fish and selected indicator species; and 4) expansion of the existing hydrometric network. 1991/92 BREAM • No specific research or monitoring was recommended.	• Various research and monitoring projects were identified that relate to baseline information on aquatics and whitefish. Also identified was a DFO assessment of fish culverts.

- In 1985, Interprovincial Pipeline Ltd. undertook a three-year aquatic monitoring program of the Norman Wells to Zama Oil Pipeline.
- As part of NOGAP Project 8.12, the Freshwater Institute (DFO) conducted research on stock differentiation of broad whitefish in terms of movements, locations of rearing/overwintering/spawning areas and other critical life history events. This included specific studies on:
  - spawning, migration, overwintering and dispersal of broad whitefish
  - Mackenzie Shelf coregonid young-of-the-year distribution study
  - salinity tolerance of whitefish
  - broad whitefish stock description
  - identification of coregonids
  - hybridization of coregonids
  - external scarring of whitefish from the western Northwest Territories
  - broad whitefish population dynamics
  - investigation of food Chains and fish migration using the stable isotopes of sulfur, carbon and nitrogen
- As part of NOGAP Project A20, hydrologic analysis of the Mackenzie River basins was completed in areas expected to be crossed by a potential Mackenzie Valley pipeline. This work involved: (1) the installation of additional gauges to provide estimates of peak streamflows along the pipeline corridor from the Delta to Norman Wells; (2) collection of meteorological data to provide information on precipitation distribution and magnitude necessary for calibration of rainfall-runoff models; and (3) collection of supplementary data on streambed sediments.

During the 1991/92 BREAM workshop, MEMP Hypothesis 16 (renamed BREAM 27) was not evaluated and no further research or monitoring recommendations were made.

7.1.15 Increased Levels of Wage Employment

MEMP 18: Wage employment will change the harvest of white whales.

During the 1985/86 MEMP workshop, participants concluded that wage employment could affect the composition of the harvest as well as the number and/or composition of the harvesting group. It was, therefore, recommended that white whale monitoring program being conducted by DFO should continue as it provides valuable information on the age structure of the white whale harvest, current status and trends in the

Mackenzie population and aids in the identification of potential conflicts with industry operations. It was also suggested that the program be expanded to include the collection of information concerning the employment status of the hunter to help evaluate the level of impact that wage employment may have on the harvest. It was, however, recognized that obtaining this type of personal information on a consistent basis would be difficult.

The Department of Fisheries and Oceans continued to monitor the harvest for white whales each summer between 1983 and 1986, after which this responsibility was assumed by the Fisheries Joint Management Committee (FJMC). Records of the number of animals struck and landed, and the sex and size of the landed whale are maintained each year and selected samples are collected annually. These data are collected by the FJMC as part of the Inuvialuit Harvest Study, which was initiated in 1987 to provide a continuous, long-term record of the harvest of 69 species of birds, terrestrial mammals and marine mammals from the Mackenzie Delta and Beaufort Sea region.

Since the 1985/86 MEMP workshop, a number of other studies of relevance to MEMP Hypothesis 18 have been completed (INAC 1988; INAC 1991). These addressed:

- the effects of rotational wage employment on families and workers in the Beaufort Sea" Mackenzie Delta region;
- renewable resource impacts and mitigation measures related to northern hydrocarbon development;
- identification of impact indicators for renewable resource harvesting; and
- a critique of the use native harvest surveys and statistics,

MEMP 22: Increased levels of wage employment will change the total annual harvests of resources by communities in the region.

Table 7.1.15
Increased Levels of Wage Employment

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 18 Wage employment will change the harvest of white whales	1985/86 MEMP • Group supported continuation of white whale monitoring program and expansion to include collection of data on employment status of hunter.	• DFO continued to monitor harvest for white whales each summer between 1983 and 1986, after which this responsibility was assumed by FJMC. These data now collected as part of the Inuvialuit Harvest Study, initiated in 1987 and ongoing • A number of other relevant studies initiated over past 5 years to address: effects of wage employment on regional residents; renewable resource impacts related to northern development; identification of impact indicators; and a critique of the use of native harvest surveys.
MEMP 22 Increased levels of wage employment will change the total annual harvests of resources by communities in the region.	1985/86 MEMP • Additional information on wage employment, harvest effort, harvest composition and mutual aid, cooperation and sharing required to adequately test this hypothesis.	• Post-construction studies initiated by both IPL and the Dene Nation/Canadian Wildlife Service to determine the socio-economic impacts of the Norman Wells to Zama pipeline project. • A number of harvest studies ongoing or initiated.

Based on a number of assumptions regarding employment, mutual aid and sharing, and harvesting levels (see Section 4.15), participants of the 1985/86 MEMP workshop concluded that this hypothesis was invalid. However, it was agreed that additional information was needed to adequately test this hypothesis. The key indicators for further research and monitoring were identified as being:

(1) wage employment - specifically, the subgroup identified the need for data on labour force participation rates by age, sex, occupation, industry, hours, duration of employment, location of employment and wage rates. It was suggested that a compilation and interpretation of existing data sources would be required to establish a baseline.

(2) harvesting effort - the subgroup recommended that harvesting effort should be monitored on a case study basis.

(3) harvest composition - it was noted that annual community harvest data would be adequate to test this impact hypothesis. It was suggested that harvest data should be reconstructed from existing databases to establish an historical account and to establish a baseline for natural variability.

(4) mutual aid, cooperation and sharing - the subgroup recommended that monitoring should focus on the viability and strength of family, household, kinship and alliance systems within communities through which mutual aid, sharing and cooperation are affected.

In 1985, a monitoring report was prepared by Interprovincial Pipeline Ltd (IPL) to provide a review of the socio-economic impacts of the Norman Wells to Zama Pipeline project. The report discusses the success of information and consultation with communities; benefits to northern business for the purchase of goods and services; and the extent of northern employment and training resulting from the construction phase of this project. In summary, this monitoring report supports the linkages that wage employment reduces the time available for harvesting and that employment income allowed for the purchase of new equipment, which could possibly be used for future hunting and fishing activities.

The Dene Nation and the Canadian Wildlife Service also conducted a post-construction study to determine what impacts the Norman Wells project had on occupational status and traditional activities of Dene living within seven Mackenzie Valley communities. Results of the surveys suggested that only minor changes in harvest effort and harvest success occurred during the construction phase. Of those residents interviewed, most reported that they had put less effort into hunting but that their hunting success only decreased marginally and that consumption of country foods did not appear to change. However, the report cautiously states that there were indications that a move away from a social and economic system based on harvesting to one based more on wage economy had begun to occur during the relatively short construction period.

Since the MEMP workshop, a number of harvest studies were either initiated or continued to be supported. As an ongoing, long-term project, the Department of Renewable Resources, GNWT has been compiling fine-fur harvest data for each of the GNWT regions as well as the entire NWT. These reports provide a standardized database for each community, which allows annual comparisons to be made to determine trends in the number of trappers, volumes of species and aggregate prices paid by species.

To compliment the Inuvialuit Harvest Study, the FJMC and DFO conducted a study of fish harvest levels in areas outside but adjacent to the Inuvialuit Settlement Region. The domestic harvest was monitored in the Arctic Red River and Fort McPherson area of the Mackenzie watershed. This study served to expand the existing fish harvest database, which can be used to further study the relationships of harvest and wage employment and potential conflicts between harvest and industry activity.

7.1.16 Conflicts between Industry and Harvesters

MEMP 24: Industrial activities in harvesting areas will reduce the harvests of mammals, birds and fish because of conflicts between industry and harvesters over land use.

Participants of the 1985/86 MEMP workshop concluded that based on the development scenario, it was possible that harvests could be reduced as a result of industrial development and land use conflicts. It was recommended that further study would be required to determine if impacts on the harvest were occurring and how significant these changes were (Table 6.1.16). The group suggested that the following information would be required as part of existing or future processes dealing With negotiation, mitigation and compensation. These include:

(1) the location of proposed or probable industrial developments and a knowledge of existing land use by native harvesters;

(2) collection of data by community residents for determining actual effects of land use conflicts on harvests; and

(3) assessment of the effectiveness of existing negotiation, mitigation and compensation mechanisms.

Specifically, the group noted that it would be important to determine effective means of measuring the level of harvest effort on an individual or community basis to assess whether industry activity is directly or indirectly affecting level of effort.

For the purposes of the Dene/Metis land claim settlement, the Dene/Metis Negotiating Secretariat initiated a mapping project to obtain traditional knowledge related to land use of the Mackenzie Valley. An historical database was developed, and computerized maps summarizing information such as locations of trails, hunting areas, traplines, fishing areas and extent of traditional land between 1885 and 1979 were prepared.

In 1987, the Department of Renewable Resources undertook an evaluation of the Norman Wells project to assess the effectiveness of the department's participation in the public and regulatory review processes and project and impact management; to provide recommendations for the Department's participation in future large-scale developments; and to provide recommendations on improving public and regulatory review processes, The report indicates that during the oilfield expansion project, hunting pressure in the area experienced a marked increase. The number of resident sport hunting licenses doubled during the construction years (1983 and 1984) from the three previous years, and the resident hunter moose harvest experienced a two-fold increase. Three compensation claims were filed and, in two other situations, individuals met with IPL to discuss hunting and trapping concerns. Ail claims were settled in a timely manner to the satisfaction of parties involved.

Table 7.1.16
Conflicts between Industry and Harvesters

Hypothesis	Research and Monitoring Recommendations	Status of Recommendations
MEMP 24 Industrial activities in harvesting areas will reduce the harvests of mammals, birds and fish because of conflicts between industry and harvesters over land use.	1985/86 MEMP • Group identified the need to establish negotiation, mitigation and compensation processes. The need for further information as part of these processes included: (1) location of proposed or probable developments and knowledge of native land use; (2) traditional knowledge related to land use; and (3) effectiveness of existing negotiation, mitigation and compensation mechanisms.	• Dene mapping project undertaken to obtain traditional knowledge related to land use of the Mackenzie Valley. • Department of Renewable Resources undertook evaluation of department's participation in the Norman Wells expansion project. As part of this review, information related to harvest impacts and success of compensation process examined.

7.1.17 Increased Hunting by Non-locals

MEMP 14: Improved access and increased fishing pressure will decrease the abundance of fish and affect their distribution.

During evaluation of this hypothesis in the 1985/86 MEMP and the 1991/92 BREAM workshops (BREAM R25), it was concluded that increased fishing pressure on fish populations could be significant as a result of improved access. While it was noted that overfishing could be controlled to a certain extent by imposing quotas, catch limits and seasonal openings on various fisheries, it was recognized that enforcing these type of regulations, particularly in the Arctic, is difficult. A number of monitoring and research programs were recommended by the 1985/86 MEMP working group (Table 7.1.17). Despite much work in these areas over the following six years, the need for further study on the basic biology and population size of the species captured was identified by the BREAM working group.

During the MEMP workshop, the following monitoring was recommended:

(1) *Collection of total annual catch data for major fish species in the sport, domestic and commercial fisheries for each waterbody to allow more accurate predictions of the effects of future increases in catch.*

(2) *Index monitoring of catch and fish populations through length/age frequencies from catches or population samples and evaluation of catch per unit effort in domestic and commercial fisheries or experimental studies involving sampling gillnets. This would aid in identifying trends in population sizes caused by harvesting activities.*

The working group also identified a number of research needs related to management of important target species.

(1) ***Arctic char*** *- data on the response of populations of western arctic char to exploitation in various fishing is lacking. However, it was noted that given the limited number and size of these populations in Canada, further disturbances through* scientific study may not be justified.

Table 7.1.17
Increased Hunting by Non-locals

Hypothesis	**Research and Monitoring Recommendations**	**Status of Recommendations**
MEMP 14 (BREAM R25) Improved access and increased fishing pressure will decrease the abundance of fish and affect their distribution.	1985/86 MEMP • Group identified need for monitoring of catch data for major fish species in the sport, domestic and commercial fisheries; and index monitoring of catch and fish populations. • Several research initiatives recommended for target fish species (arctic char, whitefish, arctic grayling, lake trout). • 1991/92 BREAM • New information available but there still exists the need for further study on basic biology and population size of harvested fish species.	• Over the past 6 years, DFO has initiated several studies to improve our knowledge related to population sizes and characteristics, and existing pressures of the domestic, sport and commercial harvests on key target fish species (particularly arctic char and broad whitefish).
MEMP 20 Competition by non-locals will change the number of white whales landed and increase mortality in the population.	1985/86 MEMP • No research or monitoring programs recommended by the working group	• N/A
MEMP 25 Increases in hunting by non-locals will restrict harvest by local natives.	1985/86 MEMP • Group identified the need to document baseline information on non-local harvests (i.e., harvest level, location and composition).	• Department of Renewable Resources undertook a program to collect and report on annual non-native resident harvests.

In 1983, DFO undertook a sampling program to collect biological data (age, length, weight, sex, maturity, fecundity, condition) on arctic char that were captured by a fish weir and trap on the Rat River. This report provides baseline data on the characteristics and abundance of a population that is Subjected to a domestic fishery by residents of Aklavik and Fort MacPherson.

In 1984, DFO conducted population studies of arctic char in the Big Fish River as well as surveys of 19 rivers from the Yukon to Victoria Island. The objectives of this work were two-fold: (1) to provide an assessment of total harvest taken by the domestic fishery in the Big Fish River and examine \the distribution and movement of this population; and (2) to assess arctic char habitat, potential spawning and overwintering areas and potential sites for fish weirs in the region. This baseline data was considered essential to assessing any changes in harvest levels in the domestic fishery and providing information necessary for management of these populations.

Monitoring of the domestic commercial fisheries for arctic char in both the Big Fish River and Rat River areas continued in 1986 and provided further baseline information on the annual harvests. Monitoring of the fishery in the Big Fish River/Cache Creek area was considered to be particularly important to assessing the potential effects of improved access on fish populations since in recent years access to this river in early winter (i.e., a time when arctic char are concentrated in small areas and are vulnerable to over-fishing) was improved by use of snowmobiles.

In 1986, DFO and NOGAP funded a study to examine the discreteness and number of char stocks in the western Arctic using morphometric, meristic and electrophoretic techniques, and to establish the relatedness of these stocks. In 1990, a supplementary project was initiated to investigate the population dynamics of early life history stages. Char were sampled from sites on Joe and Cache creeks and on the Firth, Babbage, Canoe and Rat rivers. Results of these studies indicated that char in this region are structured into genetic stocks and that these stocks retain their fidelty to at least some rivers during allHfe history stages.

(2) ***Lake trout*** *- compilation of available records and knowledge on the distn'bution of lake trout is required. Limited field sampling should be undertaken to address data* gaps.

(3) ***Whitefishes*** *- while research is required on all species of Whitefish, particular emphasis was placed on broad whitefish due to its importanoe in the domestic fisheries and its abundanoe in the region. Speoifioally, continuation of research on differentiation of broad whitefish stooks in terms of movements, rearing looations, overwintering and spawning areas and other oritioal life history events was reoommended.*

In addition to the ongoing DFO/NOGAP~funded study on broad whitefish stock differentiation, DFO initiated a number of sampling programs specifically related to whitefish populations in the western Arctic. These included:

- ♦ A long-term study to examine the external scarring of whitefish from the western Northwest Territories and its possible implications to development of fisheries. Results of this study indicated that the frequency of scarred individuals varied geographically from the Mackenzie mainstem and tributaries and, further, that fish from mainstem locations had approximately twice the frequency of scarring than fish from tributary locations. Smaller scars were restricted to fish from locations with connections to the Arctic Ocean and therefore were attributed to marine parasitic copepods or arctic lampreys. Larger scarring was attributed to attacks by lamprey or previous gillnetting capture. These results indicated that increased fishing pressure could decrease the quality of fish and, thus, their saleability.
- ♦ A study to collect data on key diagnostic characters of coregonids that define and identify fish of different ages and sizes to species. The ability identify all stages of fish development to a species level was considered essential to obtaining knowledge on the size of regional populations of coregonids and to assessing the risk of populations to exploitation and development activities.
- ♦ A study to examine the extent of hybridization in coregonids of the western Arctic. Field collections in the Wood Bay area indicated that most coregonids in the region hybridize freely and the rates of hybridization are very high.

(4) **Arctic grayling** - experimental harvest study would provide some data to assess the effects of increased fishing pressure on grayling. To determine the vulnerability of this species to overfishing, it was also recommended that research be initiated to determine whether grayling form discrete populations (or stocks) and spawn in their natal streams.

MEMP 20: Competition by non-locals will change the number of white whales landed and increase mortality in the population.

During the 1985/86 MEMP workshop, the working group concluded that it was unlikely that competition by non-local hunters would cause an increase in the level of the harvest or mortality of white whales. Therefore, no research or monitoring to address this hypothesis was considered necessary. This hypothesis was reviewed during the 1990/91 BREAM program and It was concluded that this hypothesis was no longer a concern due to the existence of the IFA strucutures (internally regulated by the Fisheries Joint Management Committee) and the fact that hunters now have to be a "beneficiary" to harvest white whales in this region.

MEMP 25: Increases in hunting by non·locals will restrict harvest by iocal natives.

Evaluation of this hypothesis in 1985/86 led to the conclusion that increased immigration of non-native and native people into the region would result in increased competition for fish, birds and large game if there was no compensating legislation or regulations in place. The working group identified the need to document baseline information on non-local harvests such as level and location of effort, and composition of the harvest. Further monitoring of the species and harvesting areas of concerns was recommended in the event that significant increases in the nonlocal harvest occur. The group also suggested that research on the status of selected species populations should be undertaken where there is a concern that harvests are approaching or exceeding sustainable levelS.

The Department of Renewable Resources undertook an ongoing program to collect and report on annual non-native resident harvests. These annual reports summarize harvest data for selected species by community and region, and include additional information such as location of the harvest, and demographics of the harvester. While this survey program is not directly appiicable to MEMP Hypothesis 25 because it does not focus on increased non·local demand for fur, fish and game resources, it does provide useful information with which to assess the effect of increased non-local harvesting on local native hunting,

The concern embodied in MEMP Hypothesis 25 was addressed through the Community-based Concerns Working Group'during the 1991i92 BREAM program. However, it was noted that as a resuit of the Gwich'in and Sahtu land claim agreements, mechanisms for regulating hunting and fishing activities in the region are now in place and, therefore, is not a significant issue.

7.2 CATASTROPHIC OIL SPILLS

The 1992/93 BREAM program represented the first year in which the issue of catastrophic oil spills was addressed through the BEMP/MEMP/BREAM process. Despite this, few research and monitoring needs related to assessing the potential risks and effects of large oil spills on fish and wildlife resources were identified during the evaluation of the nine spill-related impact hypotheses. The majority of the recommendations involved post-spill studies to assist in the assessment of impact and recovery/restoration of resources and resource uses after potential oil spills. The following sections identify, on a scenario-by-scenario basis, those recommendations made for pre-spill research and monitoring, and discusses whether new studies have been initiated over the past year in response to these recommendations. Due to the fact that the 1993/94 fiscal year represented the final year of NOGAP, many of the research priorities under this program for 1992/93 and 1993/94 focussed on completin9 projects already underway. Consequently, many of these recommendations have not been directly acted upon. However, some relevant research has been initiated through other funding sources and, where possible, these studies are also discussed below. The following does not represent an exhaustive review of all research relevant to the recommendations made through BREAM.

7.2.1 Offshore Island Platform Blowout of Crude Oil

The following recommendations for research and monitoring were made in relation to assessing the potential direct and indirect impacts of an offshore platform blowout of crude oil on marine and marine-associated mammals (Hypothesis C1), semi-aquatic mammals (Hypothesis C5), birds (Hypothesis C11), and fish (Hypothesis C17) and the harvest of these resources.

(1) Review the DFO sampling program for white whales to determine if adequate baseline data is available with which to assess the potential effects of oil on the skin and internal organs of beluga whales. If necessary, additional specimens should be archived for future analyses.

Although this recommendation has yet to be acted upon, DFO in cooperation with the FJMC will be preparing a summary document that will review the sampling protocols and the results of data collected over the course of the sampling program. This docLIment will be published by the end of the 1994/95 fiscal year (B. Fergusson pers. comm.).

(2) In addition to the CWS loon monitoring program already underway, develop effective monitoring programs for some of the valued bird species occurring in the southeastern Beaufort Sea.

CWS has been conducting a number of NOGAP-funded projects on the distribution and abundance of birds in the southeast Beaufort Sea and Mackenzie Delta to aid in assessing the effects of fLIture hydrocarbon development in the region. The McKinley Bay sea duck monitoring program was initiated in 1981. The objective of this study was to collect baseline data on the numbers of moulting ducks in McKinley Bay to determine the effects that future development of a harbour complex and year·round support base has on bird use of the area. Aerial surveys were conducted each year from 1981 to 1985, and again from 1990 to 1993 under NOGAP funding (Project C.7.2). The results of this program indicated that due to substantial natural variability in the numbers of moulting diving ducks using the bay each year, it would be extremely difficult to detect any impacts of future development activities. It was concluded that aerial surveys of moulting sea ducks are not effective in monitoring the impacts associated with industrial disturbances (Cornish and Dickson 1994).

In 1992 and 1993, NOGAP provided funding to study the spring migration of waterbirds along offshore leads in the Beaufort Sea in relation to future oil and gas development (Project C.23). The objectives of this program were to examine the temporal and spatial distribution of migrating birds in the Beaufort Sea as well as Amundsen Gulf and Lambert Channel, and to assess the potential impacts that future development (including offshore oil spills) may have on spring migrants. Aerial surveys were conducted In May and June of 1992 and 1993 under varying open·water conditions (Alexander et al. 1994). A full assessment of the impacts of an offshore oil spill in the Beaufort Sea on spring migrating birds will be published in a Canadian Wildlife Occasional Paper in about a year (L. Dickson, CWS, pers. comm.).

In 1991, CWS initiated a study to examine the distribution and abundance of shorebirds in the Mackenzie Delta (NOGAP Project C.24). This involved aerial and ground surveys to identify the most important breeding and staging areas on the Delta and to determine the density of shorebirds using the area.

Table 7.2.1
Offshore Platform Blowout of Crude Oil

Hypothesis	Pre-spill Research and Monitoring Recommendations	Status of Recommendations
BREAM C 1 The effects of an island platform blowout of crude oil during summer on marine and marine-associated mammals and their harvest. (The VECs included white whales, bowhead whales, ringed seals, bearded seals and polar bears)	• Review the DFO sampling program for white whales to determine if adequate baseline data is available with which to assess the potential effects of oil on the skin and internal organs of beluga whales. If necessary, additional specimens should be archived for future analyses.	• Not acted upon. A summary document of the smapling program and its results will be prepared by DFO by the end of the 1994/95 fiscal year (B. Fergusson, pers. comm.)
BREAM C 5 The effects of an island platform blowout of crude oil during summer on semi-aquatic mammals and their harvest. (The VECs included muskrat and mink.)	• Review existing information on the physiological effects of oil on muskrat, and the fate and effects of hydrocarbgon portions in muskrat, and determine need for additional research.	• Not acted upon
BREAM C 11 The effects of an island platform blowout of crude oil during summer on birds and their harvest. (The VECs included tundra swans, terrestrial geese, loons, brant, eider ducks, other ducks, alcids and shorebirds.)	• Review existing literature on aspects of oil uptake by birds • Conduct field tests of the effectiveness of selected bird scaring devices under Beaufort Sea conditions. • Determine stopover and turnover patterns of brant migrating along the Beaufort Sea coast and eider ducks migrating offshore • Develop effective monitoring programs for some of the valued bird species occurring ni the Canadian Beaufort Sea. • Examine aerial- and boat-survey data on spatial and temporal patterns of the swimming migration of murre from large colonies in the Canadian High Arctic to help in assessing the susceptibility of the Cape Parry murre colony to an oil spill.	• Not acted upon • Not acted upon • Informatin on turnover rates of brant during their fall migration and eider ducks in leads offshore have been identified as areas where further research is required (L. Dickson, CWS, pers. comm.; Alexander *et al.* 1994) • Several CWS NOGAP programs are either ongoing or have been completed in the past two years (Projects C.7.2 – McKinley Bay Sea Duck Monitroign; Project C.23 – Predicting impacts of oil spills on migrating eiders and other seabirds in the southern Beaufort Sea; Project C.24 – Use of Lansat imagery to determine important areas for shorebirds in the Mackenzie Delta) • Not acted upon. Research on the migration patterns of various murre colonies in the eastern Arctic have shown substantial variations both among and within colonies (G. Donaldson, National Wildlife Research Centre, pers. comm.)

Table 7.2.1 (cont'd)

Hypothesis	Pre-spill Research and Monitoring Recommendations	Status of Recommendations
BREAM C 17 The effects of an island platform blowout of crude oil during summer on fish and their harvest. (The VECs included broad whitefish, lake whitefish, arctic cisco, least cisco, dolly varden, pacific herring.)	• Coduct research on the effects of oil on the homing abilities of Dolly Varden • Monitor the condition of livers of harvested fish species, continue archiving tissue samples, and examine the effects oflong-term storage on petroleum hydrocarbons that are present in fish tissue samples. • Conduct research to determine hydrocarbon depuration rates of more local fish species, and develop a better understanding of the effect of suspended particulates on the acquisition of taint.	• Not acted upon • Not acted upon • Research has been initiated by the Freshwater Institute (DFO) on threshold levels of taint and depuration rates in rainbow trout and arctic charr (R. Danell, DFO, pers. comm.)

(3) Conduct research to determine the stopover and turnover patterns of brant geese migrating along the Beaufort Sea coast, and eider ducks migrating offshore.

Information on stopover and tlirnover patterns of fall migrating brant along the Beaufort Sea coast and eider ducks in offshore leads of the Beaufort Sea has been recognized by CWS as an area of where further research is needed (L. Dickson, pers. comm.; Alexander et al. 1994).

(4) Due to the lack of information on the temporal and spatial pattern of swimming migrations of the Cape Parry murre colony, it is not pOSSible to determine the susceptibility of this colony to oil spills. Examination of aerial· and boat·survey data on the migration patterns of larger colonies in the Canadian High Arctic could be instructive.

This recommendation has not been acted upon. However, results of research on the migration patterns of various murre colonies in the eastern Arctic indicate that there is substantial variation both among and within colonies, which would hamper making any extrapolation to the Cape Parry colony (G. Donaldson, National Wildlife Research Centre, pers. comm.).

(5) Conduct a literature review on aspects of oil uptake by birds (including effects of oil ingestion, potential for taint, avoidance of oil-contaminated habitats and prey), and formulate research recommendations based on the results of this review.

A literature review has not been initiated over the past year in response to this recommendation.

(6) Conduct field tests of the effectiveness of selected bird scaring devices under Beaufort Sea conditions. A recent literature review and analysis (Koski el a/. 1993) identifies the most promising scare techniques for various oil spill situations in the Beaufort Sea, and identifies techniques that hold promise but require field testing.

(7) Conduct research on the effects of oil on the homing abilities of Dolly Varden.

(8) Monitor the condition of livers of harvested fish species, continue archiving tissue samples, and examine the effects of long-term storage on petroleum hydrocarbons that are present in fish tissue samples.

These recommendations have not been acted upon.

(9) Conduct research to determine hydrocarbon depuration rates of more local fish species, and develop a better understanding of the effect of suspended particulates on the acquisition of taint.

To further earlier work (1986/87), the Freshwater Institute initiated a study in 1991 to determine threshold levels of taint and depuration rates in arctic charr and rainbow trout using low concentrations of water-soluble fraction (WSF) of Norman Wells crude oil. This work was flmded by the Bandersmith Oil Spill Program. A final report of the study results is currently in publication (R. Danell, DFO, pers. comm.).

7.2.2 Barge Spill of Diesel Fuel

During evaluation at BREAM Hypotheses C9 (effects on birds and their harvest) and C18 (effects on fish and their harvest), the following research and monitoring programs were recommended in order to better assess the potential effects of a river barge spill of diesel fuel and associated cleanup and countermeasures activities on these resources. Because many of the same generic research needs were identified for evaluating the effects of an offshore blowout (see Section 7.2.1), only those recommendations specific to Hypotheses C9 and C18 are discussed below.

(1) Collect better information on bird use of the East Channel (the main barge channel through the Deita) to heip in predicting impacts of spills on waterbirds.

This recommendation was not given a high priority given the limited number of waterbirds believed to occur in this part of the river and the fact that a barge spill would be small relative to some potential offshore spills. No new research has been initiated in response to this recommendation. However, some data on use of the East Channel by waterbirdS has been collected incidentally as part of a NOGAP·funded project on migratory bird populations and habitats in and near Kendall Island Bird Sanctuary (J. Hines, CWS, pers. comm.).

(2) Initiate research to develop a better understanding of the role of sllspended sediments on the fate of oil in the Mackenzie River environment.

In 1994, Environment Canada initiated a long-term investigation of the role of inorganic particles on the fate of oil and, in particular, the removal of oil from shorelines (G. Sergy, EC, pers. comm.). While this study is generic in its application (Le., it is not related to any specific geographic location), it is expected to provide information of relevance to the Mackenzie River environment. This study has been funded by Imperial Oil, Exxon, the Marine Spill Response Cooperative, and Environment Canada.

(3) Conduct research to determine hydrocarbon depuration rates of local fish species.

(4) Develop a better understanding of the effects of suspended partiCUlates on the acquisition of taint and on bioaccumulation aspects of taint.

As noted earlier in Section 7.2.1, the Freshwater Institute initiated a study in 1991 to determine threshold levels of taint and depuration rates in arctic charr and rainbow trout using low COncentrations of water-soluble fraction (WSF) of Norman Wells crude oil.

Table 7.2.2
Barge Spill of Diesel Fuel

Hypothesis	**Pre-spill Research and Monitoring Recommendations**	**Status of Recommendations**
The effects of diesel spill on the Mackenzie River from a barge on the number and harvest of birds. (Four VEC groups were selected: Terrestrial geese, tundra swans, brant, and red-throated loons.)	• Determine stopover and turnover patterns of brant geese migrating along the Beaufort Sea coast in late summer • Conduct a literature review on aspects of oil uptake by birds • Collect information on use of the East Channel by waterbirds	• See BREAM C 11; Section 7.2.1 • See BREAM C 11; Section 7.2.1 • Although no new research has been initiated, information on bird use of the East Channel has been collected incidentally as part of ongoing CWS studies.
BREAM C 18 The effects of a diesel spill no the Mackenzie River from a barge on fish and their harvest. (The VECs included: broad whitefish, northern pike, burbot, and inconnu.)	• Develop a better understanding of the role of suspended sediments on the fate of oil in the Mackenzie River environment. • Conduct research to determine hydrocarbon depuration rates of local fish species • Develop a better understanding of the effects of suspended particulates on the acquisition of taint and on bioaccumulation aspects of taint	• Environment Canada has initiated a long-term investigation into the role of inorganic particles on the fate of oil and, in particular, the removal of oil from shorelines (G. Sergy, pers. comm.) • Research has been conducted by the Freshwater Institute (DFO) on threshold levels of taint and depuration rates in rainbow trout and arctic charr (R. Danell, DFO, pers. comm.)

7.2.3 Pipeline Spill of Crude Oil

During the evaluation of BREAM Hypotheses C3 and ce, which dealt with the effects of a pipeline spill in the Mackenzie River on terrestrial and semi-aquatic mammals, it was recommended that a review of existing information related to the chronic and acute effects of oil on grizzly bear, moose, wolves, faxes, mink, muskrat and beaver be undertaken. It was suggested that any information gaps identified through the literature review should be highlighted and opportunistic research conducted to address the data gap, with a priority placed on research related to grizzly bear due to their low densities in the region and the economic value of this species. A literature review of the effects of oil on terrestrial and semi·aquatic mammals has not yet been undertaken.

Table 7.2.3
Pipeline Spill of Crude Oil

Hypothesis	Pre-spill Research and Monitoring Recommendations	Status of Recommendations
BREAM C 3 The effects of a pipeline spill of crude oil during summer on terrestrial mammals. (There VEC groups were selected: moose, balck and grizzly bear, and wolves and foxes.)	• Review existing literature on the chronic and acute effects of oil on terrestrial mammals (i.e., the VEC species). Any information gaps should be noted and opportunistic research conducted, with a priority on grizzly bear.	• Not acted upon
BREAM C 6 The effects of a pipeline spill of crude oil during summer on semi-aquatic mammals. (The VECs included mink, muskrat and beaver.)	• Review existing literature related to the chronic and acute effects of oil on semi-aquatic mammals (i.e., the VEC species). As above, any information gaps should be highlighted and opportunistic research conducted.	• Not acted upon

7.2.4 Under-ice Spill of Crude Oil

During the evaluation of BREAM ca, it was concluded that pre-spill research specifically related to the effects of a river spill of crude oil on birds was a low priority due to the insignificant nature of most predicted impacts. Nevertheless, a number of information needs were identified by the working group.

(1) To assist in predicting the likelihood, degree and circLImstances of exposure of birds and their food and habitats to oil, a review of existing information and results of ongoing studies on the fate of oil under river ice (e.g., oil particle interactions, potential for surfacing of oil from under ice) should be conducted.

As part of the Behaviour of Spilied Oil at Sea (BOSS) project, a comprehensive review of all available information (published and unpublished) relating to the fate and behaviour of oil in ice was completed (OF Dickins and Fieet Technology 1992). This document summarizes the findings from spills of opportunity, field and iaboratory tests, and analytical modelling as it relates to the behaviour of oil under continuous ice, in leads and broken ice, and on snow and ice. Physical processes such as spreading, encapsulation, migration through ice, and transport are discussed for each of these topic areas.

(2) There is a need for additional information on harvest of waterbirds in the Fort Norman area.

It was assumed that a harvest study would be initiated as part of the land claims settlement process, and that such studies were not within the scope of BREAM program.

(3) Develop a better understanding of the potential effects of 011 on raptors based, at least initially, on existing information and ongoing studies.

No detailed information regarding the loss of Bald eagles as a result of the Exxon Valdez oil spill were available at the time of the 1992/93 BREAM workshop. However, a number of studies have since been published which will aid in further evaluation of this Impact hypothesis (e.g., Bowman and Schempf 1993; Piatt el al. 1990). Proceedings from the February 1993 Exxon Valdez Oil Spill Symposium in Anchorage, Alaska are currently under review and expected to be published within the next year (B. Spies, Applied Marine Science, pers. comm.).

Table 7.2.4
Under-ice Spill of Crude Oil

Hypothesis	**Pre-spill Research and Monitoring Recommendations**	**Status of Recommendations**
BREAM C 8 The effects of an oil pipeline rupture and associated countermeasures at a river crossing in spring on birds and their harvest. (Three VEC groups were selected: dabbling ducks, geese & swans, and raptors.)	• Develop a better understanding of the fate of oil under river ice based, at least initially, on existing information and ongoing studies. Of particular concern is oil/particle interactions in the river and the possibility of oil surfacing through the ice in the days before breakup. • Develop a better understanding of the effects of oil on raptors based, at least initially, on existing information and ongoing studies. • Review existing literature on aspects of oil uptake by birds	• As part of the BOSS project, Environment Canada, the U.S. Minerals Management Service and the American Petroleum Institute funded a comprehensieve review of the fate and behaviour of oil-in-ice (DF Dickins Associates and Fleet Technology 1992). • A number of studies were initiated following the Exxon Valdes oil spill to determine the effects of the spill on bald eagles. • See BREAM C 11; Section 7.1.2

(4) Review existing literature related to aspects of oil uptake by birds

This recommendation was also made in relation to BREAM C11 (i.e., the effects of an offshore platform blowout of crude oil on birds) and is discussed earlier in Section 7.1.2.

APPENDIX A

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Able, Alice	Dene Nation					•			
Adams, Stewart	Ma. Delta Reg. Council			•		•			
Alexander, Stewart	Canadian Wildlife Service					•			
Allard, Jim	Great Bear DIZ			•		•			
Allison, Lorraine	Salix Enterprises			•					
Andre, Dan	Gwitch'in Tribal Council							•	
Andrew, Tom	University of Alberta					•			
Andriashek, Dennis	Canadian Wildlife Service	•							
Antoniuk, Terry	**Gulf Canada Resources**			•	•	•	•		
Aviugana, Alex	**Inuvialuit Game Council**			•	•	•		•	
Babaluk, John	DFO							•	
Bailey, John	Inuvialuit Game Council							•	•
Balanoff, Wayne	INAC					•			
Bannon, Peter	INAC				•				
Barchard, Wayne	Environment Canada	•							
Barry, Tom	Canadian Wildlife Service	•							
Bastedo, Jamie	GNWT					•			
Beckstead, Gary	HBT Agra Ltd.							•	
Bell, Bob	FJMC						•		
Benoit, Joe	Gwitch'in Tribal Council								•
Bergmann, Martin	DFO						•	•	•
Bernard, Dave	**ESSA Ltd.**				•		•	•	•
Birchard, Evan	Esso Resources Ltd.	•					•	•	
Birdsall, Alan	LGL Ltd.	•	•	•					
Blasco, Steve	EMR	•							
Bond, Bill	DFO	•	•			•			
Boothroyd, Peter	Canadian Wildlife Service					•			

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Borstad, Gary	G.A. Borstad Assoc. Ltd.		•	•					
Bradstreet, Michael	LGL Ltd.			•	•				
Braham, Howard	NOAA (USA)		•						
Brakel, Bill	**Environment Canada**	•	•	•	•	•	•		
Bromley, Bob	GNWT					•			
Bruchett, Doug	Petro-Canada			•					
Buchanan, Bob	LGL Ltd.						•		
Budgell, Paul	DFO		•		•				
Buist, Ian	SL Ross Env. Res. Ltd.							•	•
Bunch, Jim	DFO	•							
Carpenter, Andy	Inuvialuit Game Council		•						
Chang-Kuo, Ken	DFO					•		•	
Charlie, Johnny	Porcupine Car. Mgt. Bd.							•	•
Charlie, Stephen	Environment Canada								•
Clarkson, Peter	GNWT					•			
Connacher, Barry	Barcon Ltd.					•			
Cook, Greg	INAC					•			
Cosens, Sue	DFO				•			•	•
Cowles, Cleve	Min. Man. Serv. (USA)			•					
Cretney, Walter	DFO				•				
Cubbage, James	Cascadia Research (USA)				•				
Cullen, Andrew	INAC		•	•					
Danielewicz, Ben	Dome Petroleum Ltd.	•	•						
Davies, Stuart	North/South Consult. Inc.				•			•	
Davis, Rolph	**LGL Ltd.**	•	•	•	•		•	•	•
de Lange Boom, Bodo	Seakem Oceanog. Ltd.				•				
de March, Larry	DFO						•	•	

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Decker, Bob	GNWT					•			
DeLancey, Debbie	GNWT			•		•			
Devenis, Peter	Gulf Canada Res. Inc.				•		•		
Dickson, Lynne	**Canadian Wildlife Serv.**			•		•	•	•	•
Doran, Lee	Polar Gas			•					
Dowler, Don	FJMC								•
Dunbar, Max	McGill University	•	•						
Duval, Wayne	**Axys Envir. Consult. Ltd.**	•	•	•	•	•	•	•	•
Edwards, George	Beaufort DIZ		•						
Elias, Albert	**Inuvialuit Game Council**		•	•		•			•
Englehart, Rainer	COGLA				•				
English, Karl	LGL Ltd.	•							
Erickson, Paul	Seakem Oceanog. Ltd.						•		
Everitt, Robert	ESSA Ltd	•		•		•			
Fabijan, Michael	FJMC					•			
Federko, Len	Gulf Canada Res. Inc.				•				
Fergusson, Brian	DFO							•	•
Finley, Kerry	LGL Ltd.		•						
Fissell, David	**Arctic Sciences Ltd.**	•	•	•	•		•	•	
Fleck, Susan	GNWT			•		•			
Ford, John	ESL Envir. Sciences Ltd.				•				
Frost, Jennet	GNWT					•			
Fuller, Stephan	Cordillera Resources Ltd.	•							
Gallaway, Benny	LGL Ltd. (USA)	•							
Gayle, Jan	Shell Canada Ltd.								•
Geiselman, Joy	Min. Manag. Serv. (USA)	•							

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Gell, Alan	Independent			•		•			
George, John	North Slope Bor. (USA)		•	•					
Gillam, Andy	CBR International Inc.				•				
Gilman, Vic	DFO					•			
Glaholt, Randal	GNWT				•	•			
Graf, Ron	GNWT			•		•			
Grant-Francis, Dyan	GNWT					•			
Green, Roger	Univ. Western Ontario				•				
Green, Nelson	Inuvialuit Game Council			•					
Green, Jeff	Delta Group Ltd.						•	•	•
Griffith, William	LGL Ltd.	•	•	•					
Gulmont, Francois	INAC	•							
Hagen, Larry	GNWT					•			
Hall, Russ	GNWT					•			
Haller, Albert	INAC	•							
Hanbidge, Bruce	WMAC							•	•
Harper, John	Coast. & Ocean Res. Ltd.	•	•				•	•	•
Harwood, Lois	DFO	•	•		•	•		•	•
Hawkes, Michael	YTG	•							
Hawkings, Jim	Canadian Wildlife Service					•			
Hayes, John	Interprov. Pipelines Ltd.								•
Heard, Doug	GNWT					•			
Herbert, Brian	INAC							•	
Hill, Philip	DFO	•							
Hoagak, Charlie	Inuvialuit Game Council							•	•
Hoeffs, Manfred	YTG						•		
Hoos, Richard	Trans Can. Pipelines Ltd.							•	•

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Hubert, Ben	Boreal Ecol. Serv. Ltd.					•			
Hunt, John	Petro-Canada			•					
Hurst, Ricki	**INAC**	•	•	•	•	•	•	•	
Jackson, Wilfred	Sahtu Regional Council							•	
Jakimchuk, Ron	Renewable Res. Ltd.					•			
Jandali, Tarek	ESL Envir. Sciences Ltd.	•							
Jessup, Harvey	YTG			•		•			
Johnson, Stephen	**LGL Ltd.**	•				•	•	•	•
Johnston, Laura	Environment Canada								•
Jones, Michael	ESSA Ltd.			•					
Josephson, Rick	DFO		•	•					
Kennedy, Gay	GNWT					•			
Kerr, Gordon	Environment Canada							•	
Kimmerly, Peter	Gulf Canada Res. Ltd.				•				
Kingsley, Michael	DFO	•	•			•			
Klein, Dave	University of Alaska (USA)							•	
Koshinsky, Gordon	DFO						•		
Kotchea, Steve	Fort Liard Band								•
Kristofferson, Allen	DFO					•			
Krutko, David	Mack. Delta Regn. Coun.			•		•		•	
Langford, Bob	Government of B.C.	•							
Langtry, Ted	INAC	•							
Laraque, Helena	GNWT							•	
Latour, Paul	GNWT							•	
Lawrence, Michael	**North/South Cons. Inc.**		•			•	•	•	•
Levagood, Dick	Shell Canada Ltd.								•

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Little, Lois	Lutra Associates Ltd.					•		•	
Lloyd, Kevin	GNWT					•			
Lockhart, Lyle	DFO							•	
MacDonald, Jim	Shell Canada Ltd.								•
Mackas, Dave	**DFO**	•	•	•	•				
Mackenzie-Grieve, George	Environment Canada					•			
Mageau, Camille	INAC		•		•				
Mansfield, Arthur	DFO	•							
Marko, John	Arctic Sciences Ltd.	•	•						
Marmorek, David	ESSA Ltd.	•	•						
Marr, Ian	Canadian Coast Guard								•
Martens, Harvey	HBT Agra Ltd.						•	•	
Matthews, Steve	GNWT			•		•		•	
Matthews, Doug	GNWT						•		•
Matthews, Lorne	GNWT							•	
McCallum, John	Dene Nation					•			
McCart, Peter	Aquatic Environments Ltd.			•					
McComiskey, Jim	National Energy Board	•	•						•
McCormick, Kevin	Canadian Wildlife Service					•			
McCormick, George	INAC						•		•
McCue, Cara	GNWT							•	
McDonald, Rob	DFO		•						
McDonald, John	ESL Env. Sciences Ltd.	•		•		•			
McFarland, Fred	INAC		•	•					
McInnes, Kay	INAC					•		•	
McKee, Jillian	Deh Cho Regional Coun.								•

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

NAME	AFFILIATION	83	84	85	86	87	90	91	92
McKinnon, George	DFO					•			
McLaren, Peter	LGL Ltd.			•					
McLaren, Margaret	LGL Ltd.			•					
McNamee, Peter	**ESSA Ltd.**	•	•				•		
Mead, Doug	Shell Canada Ltd							•	•
Meisner, Doug	ESSA Ltd.							•	
Melling, Humphrey	DFO	•	•	•					
Mendo, Maurice	Great Bear DIZ			•		•			
Metikosh, Serge	INAC	•							
Miles, Mike	M. Miles Assoc. Ltd.			•		•			
Mills, Hal	INAC					•			
Moen, John	INAC			•					
Moll, David	INAC					•			
Montague, Jerome	Min. Manag. Serv. (USA)				•				
Moore, Steve	GNWT					•			
Moore, Anita	Boreal Institute					•			
Morrison, Robert	Gulf Canada Res. Inc.	•							
Mossop, Dave	YTG		•	•		•			
Muir, Langley	COGLA	•	•						
Murray, Carol	ESSA Ltd.							•	
Myers, Heather	GNWT		•	•				•	
Nagy, John	GNWT							•	•
Nasogaluak, Sheila	Beaufort/Mackenzie DIZ							•	
Nerini, Mary	Nat. Mar. Mam. Lb. (USA)				•	•			
Nixon, Wendy	Canadian Wildlife Service			•					
Norton, Pamela	PN Research Projects		•	•					
Norwegian, Leo	Deh Cho Regional Coun.								•

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Nyder, Sheldon	GNWT					•			
O'Brien, Chris	Dene Nation			•					
Owens, Rob	Foothills Pipelines Ltd.						•	•	
Packman, Glen	Environment Canada				•				
Payne, Jerry	DFO		•						
Pessah, Ed	**Dome Petroleum Ltd.**	•	•	•	•	•			
Pick, Archie	Interprov. Pipelines Ltd.			•					
Pierrot, Jim	Great Bear DIZ			•		•			
Poole, Kim	GNWT					•			
Pope, Frank	Sahtu Regional Council			•				•	•
Potter, Steve	SL Ross Env. Res. Ltd.							•	
Reist, Jim	DFO					•			
Robinson, Don	ESSA Ltd.							•	
Richardson, John	LGL Ltd.			•	•				•
Russell, Don	Canadian Wildlife Service							•	
Rose, Mike	ESSA Ltd.							•	
Schell, Don	**Univ. of Alaska (USA)**	•	•	•				•	
Schweinsburg, Ray	GNWT	•	•						
Scullion, John	INAC		•						
Searing, Gary	LGL Ltd.					•			
Sekerak, Aaron	**LGL Ltd.**	•	•	•		•			
Sergy, Gary	Environment Canada						•		
Shank, Chris	GNWT					•			
Sikstrom, Cal	Esso Resources Ltd.			•					
Simpson, Bob	Mack. Delta Reg. Coun.			•					
Smiley, Brian	**DFO**	•	•				•	•	
Smith, Tom	DFO		•						

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Snider, Anne	INAC							•	•
Snow, Norm	Joint Secretariat							•	•
Sonntag, Nicholas	ESSA Ltd.	•	•	•					
Sopuck, L.	Renewable Res. Ltd.					•			
Spearing, Ted	Chevron Can. Res. Ltd.						•		
Stein, Jeff	DFO			•					
Stenhouse, Gordon	GNWT					•			
Stephen, Bob	Lutra Associates Ltd.					•	•	•	
Stewart, Donna	INAC					•			
Stone, David	**INAC**	•	•	•	•				
Strong, Tom	DFO		•	•		•			
Sutherland, Glen	ESSA Ltd.			•					
Sutherland, Dave	Environment Canada			•					
Swyripa, Murray	INAC								•
Taylor, Mitch	GNWT					•			
Taylor, Ken	Polar Gas Ltd.					•			
Thomas, David	**Axys Env. Consult. Ltd.**	•	•	•	•	•	•	•	•
Thomson, Denis	LGL Ltd.	•	•						
Tricoteux, Lorne	INAC					•			
Usher, Peter	P.J. Usher Consult. Ltd.			•		•			
Van de Pypekamp, Willem	Shell Canada Ltd.								•
Vonk, Patricia	**Axys Env. Consult. Ltd.**		•		•		•	•	•
Ward, John	**Amoco Can. Pet. Ltd.**		•	•	•		•	•	
Wagner, Gary	EIRB							•	
Webb, Tim	ESSA Ltd.	•	•						
Webb, Bob	Webb Environ. Serv. Ltd.								•
Wiebe, John	Environment Canada	•							

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Wilson, Robert	DFO		•						
Wilson, Brian	Environment Canada	•	•						
Wolfe, Robert	Alask Fish & Game (USA)			•					
Wolfe, Douglas	NOAA (USA)	•							
Wolki, Fred	Inuvialuit Game Council				•				
Wong,Brian	DFO					•			
Younkin, Walt	HBT Agra			•			•		

Compiled by Wayne Duval, Axys Environmental Consulting Ltd., Vers. Date: 93-06-10

NOTES

1. This directory includes meeting and workshop participants, study team members and persons supplying information to the study team.
2. While an attempt has been made to include everyone that has contributed to these projects in the directory, there is no guarantee that the list is complete. I apologize to anyone I may have missed.
3. Several individuals have had more than one affiliation during the course of these projects - only their affiliation during the last year that they were involved in one of the projects is indicated.
4. Persons having participated in these projects for 4 years or more are designated as "veterans" and indicated in bold face type.

APPENDIX B
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LITERATURE CITED

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