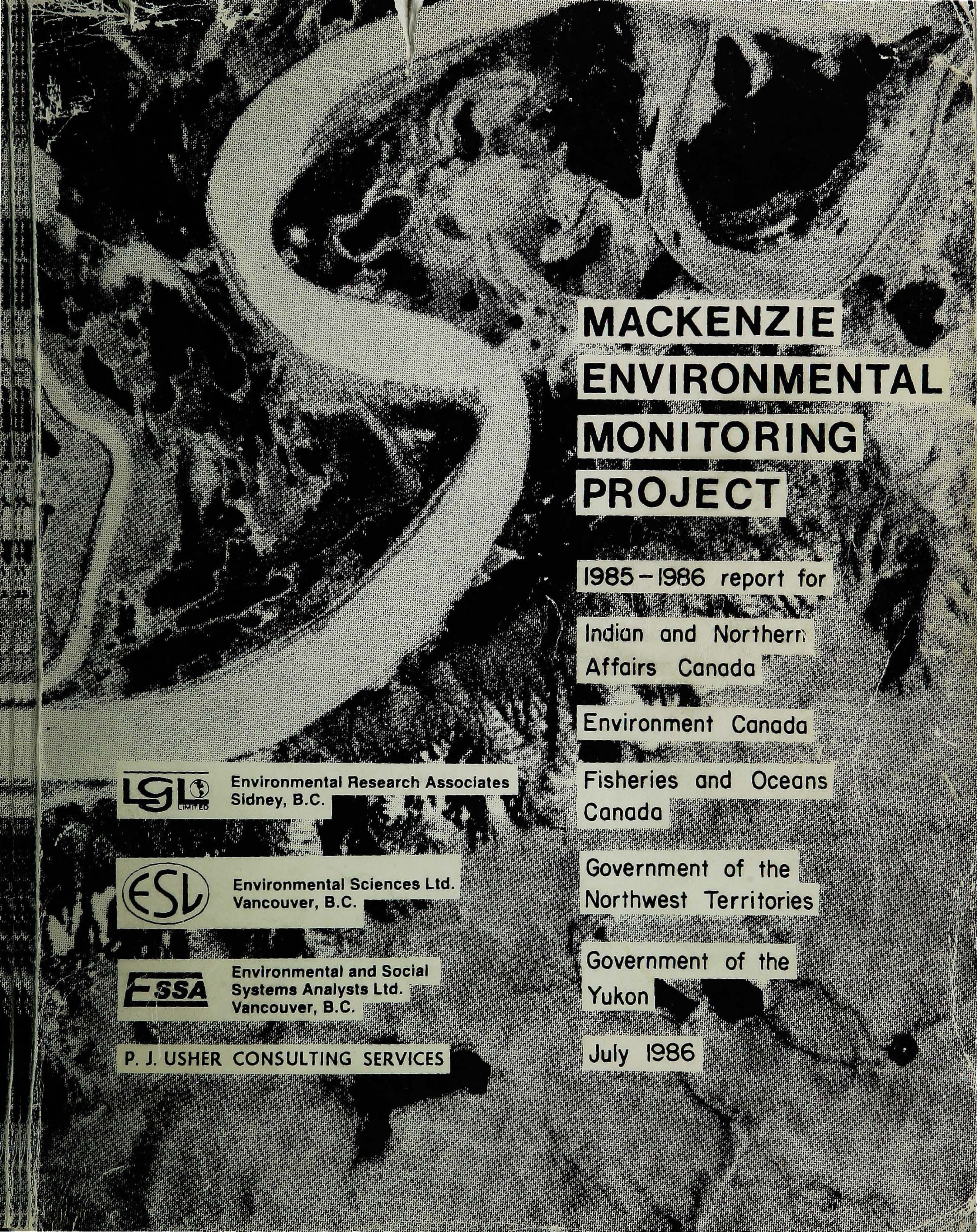


MACKENZIE ENVIRONMENTAL MONITORING PROJECT

1985 – 1986 report for

Indian and Northern Affairs Canada

Environment Canada

Fisheries and Oceans Canada

Government of the Northwest Territories

Government of the Yukon

July 1986

LGL Limited
Environmental Research Associates
Sidney, B.C.

ESL
Environmental Sciences Ltd.
Vancouver, B.C.

ESSA
Environmental and Social Systems Analysts Ltd.
Vancouver, B.C.

P. J. USHER CONSULTING SERVICES

MACKENZIE ENVIRONMENTAL MONITORING PROJECT
1985-1986 FINAL REPORT

Prepared by

LGL Limited
ESL Environmental Sciences Limited
ESSA Environmental and Social Systems Analysts Limited
P.J. Usher Consulting Services Limited

for

Indian and Northern Affairs Canada
Environment Canada
Fisheries and Oceans Canada
Government of the Northwest Territories
Government of the Yukon

July 1986

MACKENZIE ENVIRONMENTAL MONITORING PROJECT
1985-1986 FINAL REPORT

This report has not undergone detailed technical review by the government agencies sponsoring this project and the content does not necessarily reflect the views and policies of these agencies.

This unedited version is undergoing a limited distribution to transfer the information to persons and agencies concerned with oil and gas industrial development activities in the Mackenzie River valley and delta region. This distribution is not intended to signify publication and, if the report is referenced, the author(s) should cite it as an unpublished report prepared for the government agencies indicated below.

Any comments concerning the content of this report should be directed to:

Fred McFarland
Northern Environment Directorate
Indian and Northern Affairs Canada
Les Terrasses de la Chaudiere
Ottawa, Ontario
K1A 0H4

This report should be cited as follows:

Indian and Northern Affairs Canada, Environment Canada, Fisheries and Oceans Canada, Government of the Northwest Territories and the Yukon Territorial Government. 1986. Mackenzie Environmental Monitoring Project 1985-86 Final Report. Unpubl. Rep. by LGL Limited, ESL Environmental Sciences Limited ESSA Environmental and Social Systems Analysts Ltd. and P.J. Usher Consulting Services Limited. 308 p. + Appendices.

PREFACE

The restricted objectives of the Mackenzie Environmental Monitoring Project should be emphasized. The intent of the project is not to provide recommendations for a definitive research program which would address all the fundamental knowledge gaps that exist in the region. The cost of acquiring these data would be very high and may still fail to address the issues which finally emerge as those of regulatory and public concern. The objective of MEMP is to identify and recommend those research and monitoring activities which are considered necessary for the responsible management of a phased development of Mackenzie region hydrocarbons, through the administration of the relevant legislation administered by the funding agencies. The specific focus and objectives of MEMP should not detract from an overall recognition of our fundamental knowledge gaps. Encouragement and support should be given to those agencies with responsibilities to conduct research programs which reflect their particular mandate in this region.

Fred McFarland
Northern Environment Directorate
Indian and Northern Affairs Canada

ACKNOWLEDGMENTS

The Mackenzie Environmental Monitoring Project relies on the cooperation and contributions of a large number of scientists and managers from government agencies, the oil industry, universities and consulting firms as well as individuals from the communities. We would like to acknowledge the contributions of all workshop participants in the conclusions and recommendations presented in this report. In particular the following individuals and organizations are thanked for their contributions during workshops and community meetings.

Albert Elias	Inuvialuit Game Council
Alex Aviugana	Inuvialuit Game Council
Frank Pope	Great Bear DIZ Society
Jim Pierrot	Great Bear DIZ Society
Jim Allard	Great Bear DIZ Society
Maurice Mendo	Great Bear DIZ Society
Albert Adams	Mackenzie Delta Regional Council
David Krutko	Mackenzie Delta Regional Council
Bob Simpson	Mackenzie Delta Regional Council
Chris O'Brien	Dene Nation
Jim Allard	Metis Association
George Edwards	Aklavik Hunters and Trappers Association
Ed Pessah	Dome Petroleum
John Ward	Dome Petroleum
Terry Antoniuk	Gulf Canada Resources Limited
Cal Sikstrom	ESSO Resources Canada Limited
Archie Pick	Interprovincial Pipelines (N.W.) Limited
Paul Wolfe	Alaska Department of Fish and Game

Lee Doran	Polar Gas
Doug Bruchett	Petro Canada
John Hunt	Petro Canada

For each hypothesis a recorder was designated to be responsible for organization and in some cases writing results of subgroup meetings. Their efforts during and after the workshop are gratefully acknowledged. These individuals were as follows:

Margaret McLaren	LGL Limited
Peter McLaren	LGL Limited
Aaron Sekerak	LGL Limited
Walt Younkin	Hardy & Associates Limited
Lorraine Allison	Salix Enterprises Limited
Susan Fleck	Government of Northwest Territories
Bob Ferguson	Government of Northwest Territories
Harvey Jessup	Yukon Territorial Government
Alan Gell	Mike Miles and Associates Limited
Mike Miles	Mike Miles and Associates Limtied
Pamela Norton	PN Research Projects
Peter Usher	P.J. Usher Consulting Services Limited
Dave Thomas	Arctic Laboratories Limited

Workshop facilitators are especially thanked for their diligent efforts: Nick Sonntag, Bob Everitt, Glenn Sutherland, Mike Jones and Peter McNamee, all of ESSA Environmental and Social Systems Analysts Limited.

Management of the project was by Alan Birdsall, Aaron Sekerak (LGL Limited) and Bob Everitt (ESSA Limited). Peter Usher (P.J. Usher Consulting Limited) and Bob Everitt are thanked for their introductory remarks to the harvesting section of the report. Wayne Duval of ESL Limited edited Hypotheses 1 to 20. Aaron Sekerak, Nell Stallard and Jill Peterson (LGL Limited) were responsible for structure of the final report and final editorial details. Word processing was by Lisa Clark and Gillian Calvert of LGL Limited.

The steering committee for the project was composed of Terry Antoniuk, Bill Brakel, Lee Doran, Rick Josephson, Fred McFarland, Jim McTiernan and Heather Myers.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

SUMMARY

There is considerable concern that hydrocarbon development activities in the Beaufort Sea, Mackenzie Delta, and Mackenzie Valley may result in adverse environmental impacts. Because of these concerns and the recognized uncertainties associated with environmental impact assessment, there is a clear need for environmental research and monitoring programs that are fully integrated with ongoing and future exploration and development plans. In response to this need, Indian and Northern Affairs Canada (INAC) and Environment Canada initiated the Beaufort Environmental Monitoring Project (BEMP) in 1983. While BEMP has guided monitoring in the offshore marine environment since that time, no comparable program existed in the terrestrial and freshwater environment of the Mackenzie Delta and the Mackenzie Valley. In early 1985, in recognition of the need for such a program, INAC and Environment Canada, together with the Department of Fisheries and Oceans, the Government of the Northwest Territories, and the Yukon Territorial Government, initiated the Mackenzie Environmental Monitoring Program (MEMP). This report summarizes the results of the first year of MEMP (March 1985 to March 1986).

The overall objective of the Mackenzie Environmental Monitoring Program is to recommend a monitoring and research program that will:

1. address significant potential impacts;

2. be based on the best current understanding of industrial development scenarios and ecological processes;

3. have the capability to respond to changing industrial development scenarios and new information regarding ecological processes in the region;

4. be applicable and practical; and

5. be supported with a full scientific and technical justification.

This report is the first product of a series of steps aimed at meeting the immediate objective of producing a plan for initiating research and

monitoring activities. Most of the report describes possible effects of development uncertainties in regard to our predictive capability, recommended research plans and rationale for the recommended studies. Also included is a description of the methods used throughout the program, since the nature of the recommendations have been heavily influenced by the methods.

MEMP is being conducted using techniques and procedures proven during the Beaufort Environmental Monitoring Program (INAC and Environment Canada 1984, 1985). To date, MEMP has proceeded through an initial workshop in Yellowknife (26-30 March 1985), technical meetings on resource harvesting held in Yellowknife (June 1985), and Inuvik and Norman Wells (September 1985), and a second workshop in Edmonton (4-8 November 1985). The Yellowknife workshop was designed to obtain the raw material that would allow for construction of conceptual models of effects of oil and gas development on the people and the environmental resources in the study area. These conceptual models form the basis of the impact hypotheses and the research and monitoring recommendations that have been used throughout the program. Many of the hypotheses developed are concerned with the biophysical effects of development. However, MEMP is also concerned with the effects of oil and gas development on the harvesting of fish and wildlife.

A number of terms were defined for MEMP:

Impact hypothesis is a set of statements that links development activities with their potential environmental effects.

Monitoring is a test of an impact hypothesis designed to: 1) measure environmental impacts; and 2) analyse cause-effect relationships. Monitoring is not surveillance, nor is it part of the regulatory process used to ensure that an industry meets the environmental terms and conditions of its operating permits. Rather monitoring is defined here as a scientific process designed to test specific hypotheses on the causes of environmental impacts and how they are expressed in the environment.

Valued ecosystem components (VECs) are activities, resources, or environmental features that: 1) are important to local human populations; or 2) have national or international profiles; and 3) if altered from their existing status, will be important in evaluating the impacts of development and in focusing regulatory policy. For MEMP the list of VECs included the populations, harvests and quality of a number of species of birds, fish and mammals and the physical resources of air, drinking water and landscape quality.

In order to develop and relate VECs, impact hypotheses and hydrocarbon development plans into meaningful studies that will track environmental uncertainties, the approach of MEMP is based on general principles of Adaptive Environmental Assessment and Management (Holling 1978). These were modified and successfully used in BEMP from 1983 to 1985 (INAC and Environment Canada 1984, 1985).

The basic approach proceeds through eight tasks:

1. identification of valued ecosystem components (VECs);

2. identification of development activities;

3. identification of the temporal horizon and within-year resolution;

4. identification of the spatial extent and resolution;

5. identification of impact hypotheses that causally relate development activities to VEC's

6. screening of impact hypotheses for validity, relevance and credibility;

7. evaluation of impact hypotheses; and

8. design of research and monitoring programs.

Execution of each of these tasks involves modeling, workshops or reporting and was accomplished through the previously identified workshops and technical meetings involving northern residents, government scientists, industry representatives and consultants. For the 25 impact hypotheses that were developed, the conclusions and recommendations are as follows.

HYPOTHESIS NO. 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.
VEC:	Arctic fox and red fox
Conclusion:	a) Gravel extraction - invalid for arctic fox - unlikely for red fox b) Garbage - possible but of low significance
Recommendations:	Garbage treatment and education.
HYPOTHESIS NO. 2:	Increased traffic on the Dempster Highway and roads on the North Slope will decrease the number of caribou and alter their distribution.
VEC:	Caribou
Conclusion:	Likely valid
Recommendations:	Studies on traffic levels and control; distribution of caribou; harvesting information.
HYPOTHESIS NO. 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.
VEC:	Grizzly bear
Conclusion:	Valid
Recommendations:	Control by mitigative techniques, record grizzly bear kills.
HYPOTHESIS NO. 4:	Oil and gas development activities will alter the water regime and decrease muskrat populations.
VEC:	Muskrat
Conclusion:	Invalid and not worth testing
Recommendations:	No specific studies required.

HYPOTHESIS NO. 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.

VEC: Moose
Conclusion: Unlikely
Recommendations: Monitor browse regeneration, record moose kills.

HYPOTHESIS NO. 6: Oil and gas exploration and development activities that alter habitat permanently or temporarily will influence the distribution and abundance of marten.

VEC: Marten
Conclusion: Unlikely and of low significance
Recommendations: No specific studies required.

HYPOTHESIS NO. 7: Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.

VEC: Waterfowl
Conclusion: Possible but detection difficult due to natural variations
Recommendations: Mitigate possible effects through land use and education.

HYPOTHESIS NO. 8: Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species.

VEC: Raptors
Conclusion: Likely but of low significance
Recommendations: No specific studies.

HYPOTHESIS NO. 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.

VEC: Waterfowl
Conclusion: Valid but of low significance
Recommendations: Proper disposal practices.

HYPOTHESIS NO. 10: Chronic (episodic) spills of crude oil and diesel fuel near staging and moulting areas of nesting colonies will reduce the abundance of waterfowl

VEC: Waterfowl

Conclusion: Valid under some circumstances but of low significance

Recommendations: Documentation of mortality of birds resulting from oil spills.

HYPOTHESIS NO. 11: Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat.

VEC: Waterfowl, fish and muskrat

Conclusion: Unlikely to have significant effects if predictions on subsidence are correct

Recommendations: Methods to predict subsidence are uncertain; studies required on reservoir geology, terrain and permafrost distribution at Niglintgak; monitor ground surface elevations.

HYPOTHESIS NO. 12: Air emissions resulting from oil and gas development and operation will adversely affect air quality.

VEC: Air quality

Conclusion: Invalid

Recommendations: Compliance with operational permits.

HYPOTHESIS NO. 13: Increased local disturbance due to activities related to hydrocarbon development will result in decreases in fish quality.

VEC: Fish

Conclusion: Invalid

Recommendations: None

HYPOTHESIS NO. 14:	Improved access and fishing pressure will decrease the abundance of fish and affect their distribution.
VEC:	Fish
Conclusion:	Valid, likely to have significant effects
Recommendations:	Distribution and population studies; investigate population response to exploitation; monitor harvests.
HYPOTHESIS NO. 15:	Waste discharges and accidental oil/chemical spills will lead to unpotable water and decreased acceptability of fish as a food source.
VEC:	Potable water and fish quality
Conclusion:	a) potable water-unlikely but could have significant local effects b) fish quality-unlikely but could have significant local effects
Recommendations:	a) potable water-monitor results of regional studies b) fish quality-continue present studies on metals and hydrocarbons in fish
HYPOTHESIS NO. 16:	The construction and presence of linear corridors will affect the number, distribution and quality of fish, and fishing success
VEC:	Fish
Conclusion:	Valid and significant for fish numbers and distribution; valid but insignificant for fish quality and fishing success
Recommendations:	Mitigate significant effects through known techniques; site specific information on fish required in most cases.
HYPOTHESIS NO. 17:	Wolverines that are attracted to camps and garbage will be killed as nuisance animals, thus reducing the population
VEC:	Wolverine
Conclusion:	Unlikely
Recommendations:	Mitigate possible effects through line trapping and relocation of nuisance animals.

HYPOTHESIS NO. 18: Wage employment will change the harvest of white whales

VEC: White whale

Conclusion: Possibly valid in terms of harvest composition; probably invalid in terms of level of harvest

Recommendations: Continue monitoring white whale harvests

HYPOTHESIS NO. 19: Vessel traffic will decrease the harvest of white whales

VEC: White whale

Conclusion: Possible but unlikely

Recommendations: Continue current monitoring study.

HYPOTHESIS NO. 20: Competition by non-locals will change the number of white whales landed and increase mortality in the population

VEC: White whale

Conclusion: Unlikely

Recommendations: None

HYPOTHESIS NO. 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

VEC: Waterfowl

Conclusion: Valid but unlikely

Recommendations: None

HYPOTHESIS NO. 22: Increased levels of wage employment will change the total annual harvest of resources by communities in the region

VEC: Mammals, birds and fish

Conclusion: Invalid under present conditions

Recommendations: Information on present wage employment and harvesting practices required to provide baseline information.

HYPOTHESIS NO. 23:	Changes in access will alter the harvest of birds, fish and mammals
VEC:	Mammals, birds and fish
Conclusion:	Valid for mammals and fish, but unlikely for migratory birds
Recommendations:	Document current harvests of mammals and fish
HYPOTHESIS NO. 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
VEC:	Mammals, birds and fish
Conclusions:	Possible at local level especially for trapping
Recommendations:	Obtain harvest and land use information.
HYPOTHESIS NO. 25:	Increases in hunting by non-locals will restrict harvest by local natives
VEC:	Birds and fish
Conclusions:	Valid under present conditions
Recommendations:	Document non-local harvests; document native harvests for selected species; animal population studies.

RÉSUMÉ

Les répercussions de l'exploitation des hydrocarbures sur l'environnement de la mer de Beaufort, du delta du Mackenzie et de la vallée du Mackenzie suscitent de vives inquiétudes. Ces inquiétudes et les incertitudes liées à l'évaluation des effets environnementaux ont rendu nécessaire l'établissement de programmes de recherche et du surveillance environnementales s'intégrant parfaitement aux travaux engagés ou prévus d'exploration et de mise en valeur. Pour combler ce besoin, le ministère des Affaires indiennes et du Nord Canadien (MAINC) et le ministère de l'Environnement ont lancé en 1983 le "Projet de surveillance environnementales de la mer de Beaufort" (PSEB). Même si le PSEB a guidé la surveillance dans l'environnement marin au large des côtes depuis cette époque, il n'existe encore aucun programme comparable pour le milieu terrestre et les eaux douces du delta du Mackenzie et de la vallée du Mackenzie. Au début de 1985, reconnaissant le besoin d'un tel programme, le MAINC et Environnement Canada, de concert avec le ministère des Pêches et Océans, le gouvernement des Territoires du Nord-Ouest et le gouvernement territorial du Yukon, ont lancé le Programme de surveillance environnementale du Mackenzie (PSEM). Le présent rapport résume les résultats de la première année du PSEM (de mars 1985 à mars 1986).

L'objectif général du Programme du surveillance environnementale du Mackenzie est de recommander l'adoption d'un programme de surveillance et de recherche qui portera sur ce qui suit:

1. viser les répercussions possibles le plus importantes;

2. se baser sur les meilleures connaissances actuelles en matière de développement industriel et de processus écologiques;

3. pouvoir s'adapter à l'évolution des scénarios de développement industriel et tenir compte des nouvelles données sur les processus écologiques dans la région;

4. être applicable et pratique;

5. s'appuyer sur une solide justification scientifique et technique.

Le présent rapport est le premier résultat d'une série d'étapes axées sur l'objectif immédiat du programme, c'est-à-dire produire un plan pour amorcer des activités de recherche et de surveillance. L'essentiel du rapport décrit les conséquences possibles des hésitations de développement en ce qui concerne notre capacité de prédiction, les plans de recherche recommandées et la justification des études recommandees. On y trouve aussi une description des méthodes employées pendant toute la durée du programme, puisque la nature des recommandations procède largement de ces méthodes.

Le PSEM est exécuté à l'aide de techniques et de méthodes éprouvées au cours du Programme de surveillance environnementale de la mer de Beaufort (MAINC et Environnement Canada 1984, 1985). À ce jour, le PSEM à tenu un premier atelier à Yellowknife (du 26 au 30 mars 1985), des réunions techniques sur la récolte des ressources tenues à Inuvik, à Norman Wells et à Yellowknife (juin 1985), ainsi qu'un deuzième atelier à Edmonton (du 4 au 8 novembre 1985). L'atelier de Yellowknife visait à obtenir les données brutes permettant de construire des modèles conceptuels pour examiner les effets de l'exploitation des hydrocarbures (pétrole et gaz) sur la population et les ressources environnementales dans la zone observée. Ces modèles conceptuels constituent la base des hypothèses d'impact et des recommandations de recherche et de surveillance qui ont été employées pendant tout le programme. Un bon nombre des hypothèses élaborées portent sur les effets biophysiques de la mise en valeur. Toutefois, le PSEM s'intéresse aussi aux effets de la mise en valueur pétrolière et gazière sur la récolte faunique en milieu aquatique et terrestre.

Un certain nombre de termes ont été définis pour le PSEM:

Ainsi, une **hypothèse d'impact** est un ensemble d'énoncés qui rapprochent les activités de développement de leurs effets possibles sur l'environnement.

La surveillance est l'essai d'une hypothèse d'impact visant à: 1) mesurer les répercussions environnementales et 2) à analyser les relations causales. La surveillance est plutôt définie ici comme une méthode scientifique conçue pour vérifier des hypothèses spécifiques sur les causes des répercussions environnementales et comment ces hypothèses trouvent leur expression dans l'environnement.

Les éléments prisés de l'écosystème (EPE) sont des activités, des ressources ou des entités environnementales qui: 1) sont importantes pour les populations humaines locales ou 2) sont reconnues à l'échelon national ou international et 3) lorsqu'elles sont modifiées, jouent un rôle important dans l'évaluation des effets du développement et dans l'orientation des politiques de réglementation. Pour le PSEM, la liste des EPE englobait les populations, les récoltes et la qualité d'un certain nombre d'espèces d'oiseaux, de poissons et de mammifères ainsi que les ressources physiques liées à la qualité de l'air, de l'eau potable et du paysage.

Afin de développer et de rapprocher les EPE des hypothèses d'impact et des plans de mise en valeur des hydrocarbures dans des études sur les incertitudes environnementales, l'approche du PSEM s'est appuyé sur des principes généraux d'évaluation et d'aménagement adaptatifs de l'environnement (Holling 1978). Ces principes ont été modifiés puis ils ont été employés avec succès dan le PSEB de 1983 à 1985 (MAINC et Environnement Canada 1984, 1985).

L'approche fondamentale repose sur les huit tâches suivantes:

1. identification des éléments prisés de l'écosystème (EPE);

2. identification des activités de mise en valeur;

3. identification des limites temporelles et de la résolution dans l'année;

4. identification de l'étendue et de la résolution spatiale;

5. identification des hypothèses d'impact qui relient de façon causale les activités de développement aux EPE;

6. sélection des hypothèses d'impact en fonction de leur validité, de leur pertinence et de leur vraisemblance;

7. évaluation des hypothèses d'impact; et

8. élaboration des programmes de recherche et de surveillance.

L'exécution de chacune des tâches qui précèdent nécessité des travaux de modélisation, la tenue d'ateliers ou la préparation de rapports, et elle a été accomplie grâce aux ateliers et aux réunions techniques précédemment identifiées et auxquels ont participé des résidents de Nord, des scientifiques et représentants du gouvernement ainsi que des experts-conseils. Les 25 hypothèses d'impact qui ont été élaborées, les conclusions et les recommandations se trouvent ci-après.

Première hypothèse: La présence de plates-formes de forage en mer, la construction de camps (et les déchets qui en résultent) et l'extraction du gravier entraîneront une diminution de nombre de renards arctiques et de renards roux.

EPE: Renard arctique et renard roux

Conclusions:
a) Extraction de gravier - non valable pour le renard arctique
peu probable pour le renard roux
b) Ordures - possibles, mais de portée limitée

Recommandations: Traitement des ordures et éducation.

2e hypothèse: La circulation accrue sur la route de Dempster et les chemins du Versant Nord (North Slope) fera diminuer le nombre de caribous et modifiera leur répartition.

EPE: Caribou

Conclusion: Probablement valable

Recommandations: Études sur les niveaux de circulation et leur régulation; répartition du caribou; informations sur la récolte.

3e hypothèse: L'extraction du gravier, la construction, la prospection sismique et les autres activités de mise en valeur ainsi que la présence de camps et d'ordures feront diminuer le nombre d'ours bruns et modifieront leur répartition.

EPE: Ours brun

Conclusion: Valable

Recommandations: Régulation par des techniques de réduction, enregistrement de cas de mortalité de l'ours brun.

4e hypothèse:	Les activités de mise en valeur pétrolière et gazière modifieront le régime hydrique et feront diminuer les populations de rats musqués.
EPE:	Rat musqué
Conclusion:	Non valable et essais injustifiés
Recommandations:	Aucune étude particulière n'est requise.
5e hypothèse:	Les activités de mise en valeur pétrolière et gazière, les travaux de construction et de défrichement ainsi que la présence d'un pipeline à la surface du sol modifieront l'abondance et la répartition des orignaux.
EPE:	Orignal
Conclusion:	Improbable
Recommandations:	Surveiller la régénération des jeunes pousses, enregistrer les cas de mortalité de l'orignal.
6e hypothèse:	Les activités de prospection et de mise en valeur de pétrole et du gaz qui altèrent l'habitat de façon permanente ou temporaire influenceront la répartition et l'abondance de la martre d'Amérique.
EPE:	Martre d'Amérique
Conclusion:	Peu probable et sans trop de conséquence
Recommandations:	Aucune étude particulière n'est requise.
7e hypothèse:	La perturbation associée à la mise en valeur des hydrocarbures sur les lieux mêmes ou à proximité des aires de rassemblement, de mue et de nidification de la sauvagine affectera l'abondance et la répartition de la sauvagine.
EPE:	Sauvagine
Conclusion:	Possible mais la détection est difficile en raison des variations naturelles
Recommandations:	Réduire les effets possibles par une bonne utilisation du sol et des efforts d'éducation.

8e hypothèse:	La perturbation et les altérations de l'habitat par suite de la mise en valeur des hydrocarbures affecteront la répartition ou l'abondance des espèces de rapaces.
EPE:	Rapaces
Conclusion:	Probable, mais sans trop de conséquence
Recommandations:	Aucune étude particulière.
9e hypothèse:	La présence de camps et de sites d'élimination des ordures attirera les prédateurs et donnera lieu à des changements dans l'abondance et la répartition locale de la sauvagine.
EPE:	Sauvagine
Conclusion:	Valable mais sans trop de conséquence
Recommandations:	De bonnes pratiques d'élimination.
10e hypothèse:	Les déversements chroniques (épisodiques) de pétrole brut et de carburant Diesel près des aires de rassemblement et de mue des colonies en nidification réduiront l'abondance de la sauvagine.
EPE:	Sauvagine
Conclusion:	Valable dans certaines circonstances, mais sans trop de conséquence
Recommandations:	Documentation concernant la mortalité des oiseaux par suite de déversements d'hydrocarbures.
11e hypothèse:	L'affaissement du terrain par suite de l'extraction des hydrocarbures modifiera l'abondance et la répartition de la sauvagine, du poisson et du rat musqué.
EPE:	Sauvagine, poisson et rat musqué
Conclusion:	N'aura probablement aucun effet important si les prédictions sur l'affaissement sont justes
Recommandations:	Les méthodes de prédiction de l'affaissement sont incertaines; des études sont requises concernant la gîtologie, la répartition des terrains et du pergélisol à Niglintgak; surveiller les élévations à la surface du sol.

12e hypothèse: Les émissions d'air résultant de la mise en valeur et de l'exploitation du pétrole et du gaz affecteront la qualité de l'air.

EPE: Qualité de l'air
Conclusion: Non valable
Recommandations: Respect des permis d'exploitation.

13e hypothèse: La perturbation locale accrue en raison des activités liées à la mise en valeur des hydrocarbures provoquera une diminution de la qualité des poissons.

EPE: Poisson
Conclusion: Non valable
Recommandations: Aucune

14e hypothèse: L'accès plus facile et la pression de pêche rendront les poissons moins abondant et affecteront sa répartition.

EPE: Poisson
Conclusion: Valable, aura probablement des effets importants
Recommandations: Études sur la répartition et les populations; étudier la réaction des populations à l'exploitation; surveiller les récoltes.

15e hypothèse: Les déversements d'ordures et les déversements accidentels de pétrole ou de produits chimiques contamineront l'eau et feront diminuer l'acceptabilité du poisson comme source d'alimentation.

EPE: Qualité de l'eau potable et du poisson
Conclusions:
a) pour l'eau potable, peu probable, mais possibilité d'effets graves sur le milieu immédiat
b) pour la qualité du poisson, peu probable, mais possibilité d'effets graves sur le milieu immédiat

Recommandations:
a) eau potable - surveiller les résultats des études régionales
b) qualité du poisson - poursuivre les études en cours sur les métaux et les hydrocarbures dans les populations de poisson.

16^e hypothèse: La construction et la présence de corridors linéaires affecteront le nombre, la répartition et la qualité du poisson ainsi que le succès des efforts de pêche.

EPE: Poisson

Conclusions: Valable et importante pour le nombre et la répartition du poisson; valable mais non significative pour la qualité du poisson et le succès des efforts de pêche.

Recommandations: Réduire les effets significatifs en recourant aux techniques connues; réunir et diffuser des données propres à l'endroit en ce qui concerne le poisson dans la plupart des cas.

17^e hypothèse: Les carcajous qui sont attirés dans les camps et près des ordures ménagères seront tués en tant qu'animaux nuisibles, ce qui réduira leur population.

EPE: Carcajou

Conclusion: Peu probable

Recommandations: Réduire les effets possibles en recourant au piégeage par lignes et au déplacement des animaux nuisibles.

18^e hypothèse: La main-d'oeuvre salariée modifiera la récolte de bélugas.

EPE: Béluga

Conclusion: Probablement valable en ce qui concerne la composition des récoltes; probablement non valable pour ce qui est du niveau de récolte

Recommandations: Poursuivre la surveillance des récoltes de bélugas.

19^e hypothèse: Le trafic des navires fera diminuer la récolte de bélugas.

EPE: Béluga

Conclusion: Possible mais peu probable

Recommandations: Poursuivre les études actuelles concernant la surveillance.

20e hypothèse:	La concurrence par des étrangers fera varier le nombre de bélugas récoltés et fera augmenter la mortalité dans leur population.
EPE:	Béluga
Conclusion:	Peu probable
Recommandations:	Aucune
21e hypothèse:	L'accès accru ou amélioré, combiné à la mise en valeur des hydrocarbures fera augmenter la récolte de sauvagine, laquelle entraînera une réduction numérique et affectera la répartition de la sauvagine.
EPE:	Sauvagine
Conclusion:	Valable, mais peu probable
Recommandations:	Aucune
22e hypothèse:	Les niveaux accrus de main-d'oeuvre salariée feront varier la récolte annuelle totale de ressources par localité dans la région.
EPE:	Mammifères, oiseaux et poissons
Conclusion:	Non valable dans les conditions actuelles
Recommandations:	Des recommandations sont nécessaires concernant la main-d'oeuvre salariée et les pratiques de récolte actuelles pour fournir des données de base.
23e hypothèse:	Les modifications dans les possibilités d'accès affecteront la récolte des oiseaux, des poissons et des mammifères.
EPE:	Mammifères, oiseaux et poissons
Conclusion:	Valable pour les mammifères et les poissons, mais peu probable dans les cas des oiseaux migrateurs
Recommandations:	Réunir de la documentation concernant les récoltes actuelles de mammifères et de poissons.

24e hypothèse:	Les activités industrielles dans les zones de récolte reduiront la récolte des mammifères, des oiseaux et des poissons en raison de conflits qui surviendront entre l'industrie et les récolteurs au sujet de l'utilisation du sol.
EPE:	Mammifères, oiseaux et poissons
Conclusion:	Possible au niveau local, particulièrement pour ce qui est du piégeage
Recommandations:	Se renseigner au sujet des récoltes et de l'utilisation du sol.
25e hypothèse:	Les augmentations de prises par les chasseurs étrangers limiteront la récolte des autochtones qui vivent sur place.
EPE:	Oiseaux et poissons
Conclusion:	Valable dans les conditions actuelles
Recommandations:	Réunir de la documentation concernant les récoltes des étrangers; réunir de la documentation concernant les récoltes des autochtones en ce qui concerne certaines espèces choisies; préparer des études sur les populations d'animaux.

INTRODUCTION

There is considerable concern that hydrocarbon development activities in the Beaufort Sea, Mackenzie Delta, and Mackenzie Valley may result in adverse environmental impacts. Because of these concerns and the recognized uncertainties associated with environmental impact assessment, there is a clear need for environmental research and monitoring programs that are fully integrated with ongoing and future exploration and development plans. In response to this need, Indian and Northern Affairs Canada (INAC) and Environment Canada initiated the Beaufort Environmental Monitoring Project (BEMP) in 1983. While BEMP has guided monitoring in the offshore marine environment since that time, no comparable program existed in the terrestrial and freshwater environment of the Mackenzie Delta and the Mackenzie Valley. In early 1985, in recognition of the need for such a program, INAC and Environment Canada, together with the Department of Fisheries and Oceans, the Government of the Northwest Territories, and the Yukon Territorial Government, initiated the Mackenzie Environmental Monitoring Program (MEMP). This report summarizes the results of the first year of MEMP (March 1985 to March 1986).

The overall objective of the Mackenzie Environmental Monitoring Program is to recommend a monitoring and research program that will:

1. address significant potential impacts;

2. be based on the best current understanding of industrial development scenarios and ecological processes;

3. have the capability to respond to changing industrial development scenarios and new information regarding ecological processes in the region; and

4. be applicable and practical; and

5. be supported with a full scientific and technical justification.

This report is the first product of a series of steps aimed at meeting the immediate objective of producing a plan for initiating research and moniment uncertainties in regard to our predictive capability, recommended research plans and rationale for the recommended studies. Also included is a description of the methods used throughout the program, since the nature of the recommendations have been heavily influenced by the methods.

MEMP is being conducted using techniques and procedures proven during the Beaufort Environmental Monitoring Program (INAC and Environment Canada 1984, 1985). To date, MEMP has proceeded through an initial workshop in Yellowknife (26-30 March 1985), technical meetings on resource harvesting held in Yellowknife (June 1985), and Inuvik and Norman Wells (September 1985), and a second workshop in Edmonton (4-8 November 1985). The Yellowknife workshop was designed to obtain the raw material that would allow for construction of conceptual models of effects of oil and gas development on the people and the environmental resources in the study area. These conceptual models form the basis of the impact hypotheses and the research and monitoring recommendations that have been used throughout the program.

Many of the hypotheses developed are concerned with the biophysical effects of development. However, MEMP is also concerned with the effects of oil and gas development on the harvesting of fish and wildlife. This meant that northern residents have had considerable influence over the direction taken by MEMP with respect to resource harvesting and the development of impact hypotheses. Special technical meetings on resource harvesting were held in northern communities in order to obtain and maximize the contribution of native people.

Based on the conceptual models a refined set of impact hypotheses was developed. These hypotheses were evaluated at the Edmonton workshop ad recommendations for monitoring and research were prepared. This report presents those recommendations within the framework of the impact hypotheses.

METHODS

Definitions

Impact Hypothesis

Central to the methods of this study is the concept of an impact hypothesis. Simply stated, an impact hypothesis is a set of statements that links development activities with their potential environmental effects. Every impact hypothesis has three primary parts that must be defined:

1. the action - that which is the potential cause of an effect;

2. the valued ecosystem component (VEC) or indicator - that which is the measure of effect; and,

3. the linkages - that set of statements that link the action to the VEC.

Monitoring

Monitoring is a test of an impact hypothesis designed to: a) measure environmental impacts; and b) analyse cause-effect relationships.

Monitoring in this context becomes the repetitive measurement of variables that are likely to change due to direct or indirect effects of development activity. The primary purpose of monitoring is to determine the causes of effects not associated with natural variability. The results of monitoring can be used to trigger a mitigative regulatory response. Monitoring is not surveillance, nor is it part of the regulatory process used to ensure that an industry meets the environmental terms and conditions of its operating permits. Rather monitoring is defined here as a scientific process designed to test specific hypotheses on the causes of environmental impacts and how they are expressed in the environment.

The above types of monitoring programs in environmental management are needed because of our limited predictive capability in relation to environmental change as consequences of development. Assessments techniques are limited because of scientific uncertainty about the cause and effect relationships between project activities and the environmental resources being changed.

Models and Workshops

The development, refinement, and evaluation of impact hypotheses combined with the design of specific studies was organized through the use of workshops. In MEMP the identification of impacts and development of a monitoring plan was organized through the use of a conceptual modeling approach. This approach is based on Adaptive Environmental ASsessment and Management (Holling 1978) and was first used in BEMP (INAC and Environment Canada 1984, 1985) and (Everitt et al. 1985). The basic approach proceeds through eight tasks:

1. identification of valued ecosystem components (VECs);
2. identification of development activities;
3. identification of the temporal horizon and within-year resolution;
4. identification of the spatial extent and resolution;
5. identification of impact hypotheses that causally relate development activities to VEC's
6. screening of impact hypotheses for validity, relevance and creditability;
7. evaluation of impact hypotheses; and
8. design of research and monitoring programs.

Execution of each of these tasks involves modeling, workshops or reporting. The first five tasks, necessary for the development of the conceptual model are accomplished efficiently in a modeling workshop.

The remaining tasks are best accomplished in small working groups that may or may not be part of a larger workshop. A detailed description of the tasks is provided in Everitt et al. (1985) and INAC and Environment Canada (1985).

PROBLEM DEFINITION

During the Yellowknife workshop, conceptual models were developed to define the scope of the MEMP. These models were developed through a set of structured exercises based on the first five tasks previously identified. These exercises began with a description of the proposed oil and gas development activities in the Mackenzie Delta followed by an unrestricted discussion of concerns and issues by workshop participants. After presentation of a synthesis of the issues, a discussion on the spatial aspects of the study area took place. This was followed by an effort designed to identify the linkages between major components of the conceptual model that will guide MEMP.

Proposed Development Activities

Hydrocarbon development within the study area has been under way for a substantial period of time and is presently occurring in three general areas:

1. the Norman Wells area, where the completion of an oil pipeline to Alberta has increased production drilling in the Norman Wells field and has spurred interest in exploration activities throughout the general region;

2. the Colville Lake area, where seismic and exploratory drilling is proceeding; and

3. the Mackenzie Delta area, where exploration over the last 25 years has resulted in the discovery of both oil and gas reserves and where exploration is continuing.

Development within the study area is ultimately dependent on the presence of a hydrocarbon transportation system. Several pipelines are presently proposed or being considered. Decisions to proceed with pipeline systems or marine shipping will be critical events in shaping the nature and pace of development within the study area over the next 20 years.

Appendix A provides a detailed summary of the proposed development for the study area. Material included in this summary is for the most part presented in other sources in more detail. Development activities and facilities are described and assessed in Volumes 2 and 4 of the Environmental Impact Statement for Hydrocarbon Development in the Beaufort Sea - Mackenzie Valley region (Dome et al. 1982). Similarly, documents included in the application to the National Energy Board prepared by Polar Gas describe and assess the impact of gas pipeline construction and operation. Other documents dealing with previously proposed pipelines contain descriptions of development activities and facilities as do those prepared by producers in the Delta region concerning gas production and processing.

The development of a conceptual model and ultimately impact hypotheses require that specific activities that are expected to have impact be detailed. A preliminary list of these activities is:

- construction and operation of gas processing facilities
- construction and operation of oil processing facilities
- construction and operation of support facilities
- construction and operation of oil pipelines
- construction and operation of gas pipelines
- operation of staging sites on the river and delta
- construction and operation of airstrips
- construction and presence of all-weather roads
- seismic activities
- exploration activities
- operation of a topping plant
- operation of gravel pits, quarries
- material removal in general
- water withdrawals
- atmospheric emissions
- causeways
- waste disposal

- reservoir pumping
- power consumption by industry
- oil spills
- spills of toxicants, sewage effluent.

Valued Ecosystem Components

Beanlands and Duinker (1983) define valued ecosystem components (VECs) as:

"attributes or components of the environment for which there is public or professional concern or both, and to which the assessment should be primarily directed.... These may be determined on the basis of perceived public concerns related to social, cultural, economic, and aesthetic values. They may also reflect the scientific concerns of the professional community....".

This definition is extremely general and each new application must make a more specific definition. For this project the following definition was proposed. Valued ecosystem components (VECs) are activities, resources, or environmental features that:

1. are important to local human populations; or

2. have national or international profiles; and

3. if altered from their existing status, will be important in evaluating the impacts of development and in focusing regulatory policy.

The VECs identified by MEMP participants are air quality, water quality, landscape quality and population harvests and quality of the following animals:

<u>**Mammals**</u>	<u>**Birds**</u>	<u>**Fish**</u>
caribou	snow geese	broad and lake whitefish
polar bear	raptors	inconnu
grizzly bear	ducks	Arctic cisco
moose	loons	burbot
arctic and red fox		Arctic char
beaver		pike
muskrat		lake trout
marten		
white whale		
wolverine		

It is important to note that social and economic considerations of development, except those of resource harvesting, are excluded from the list of valued ecosystem components. While it may be necessary to consider many of the social and economic impacts, they will only be considered to the extent that they affect valued ecosystem components.

Study Area

Areas that were considered part of the study area (Figure 1) included the Tuktoyaktuk Peninsula, the entire Mackenzie Delta down to normal low water level and the mainstem Mackenzie River south to Fort Norman. The eastern and western limits of the study area are somewhat flexible. This was particularly true for the Colville Lakes area to the east, and the Peel drainage and the Dempster highway route to the west.

The southern limit of the study area is the Mackenzie River at Fort Norman, at the mouth of the Great Bear River. The northern limit of the study area was subject to some debate, but eventually agreement was reached that the normal low water mark would be an appropriate boundary. This choice raised some questions regarding coastal zone processes, as they might affect the shoreline area. It was resolved that if such processes affected habitat above the low water mark, they should be considered, but the bounds of the study area, insofar as areas of impact are concerned, would remain the low water mark.

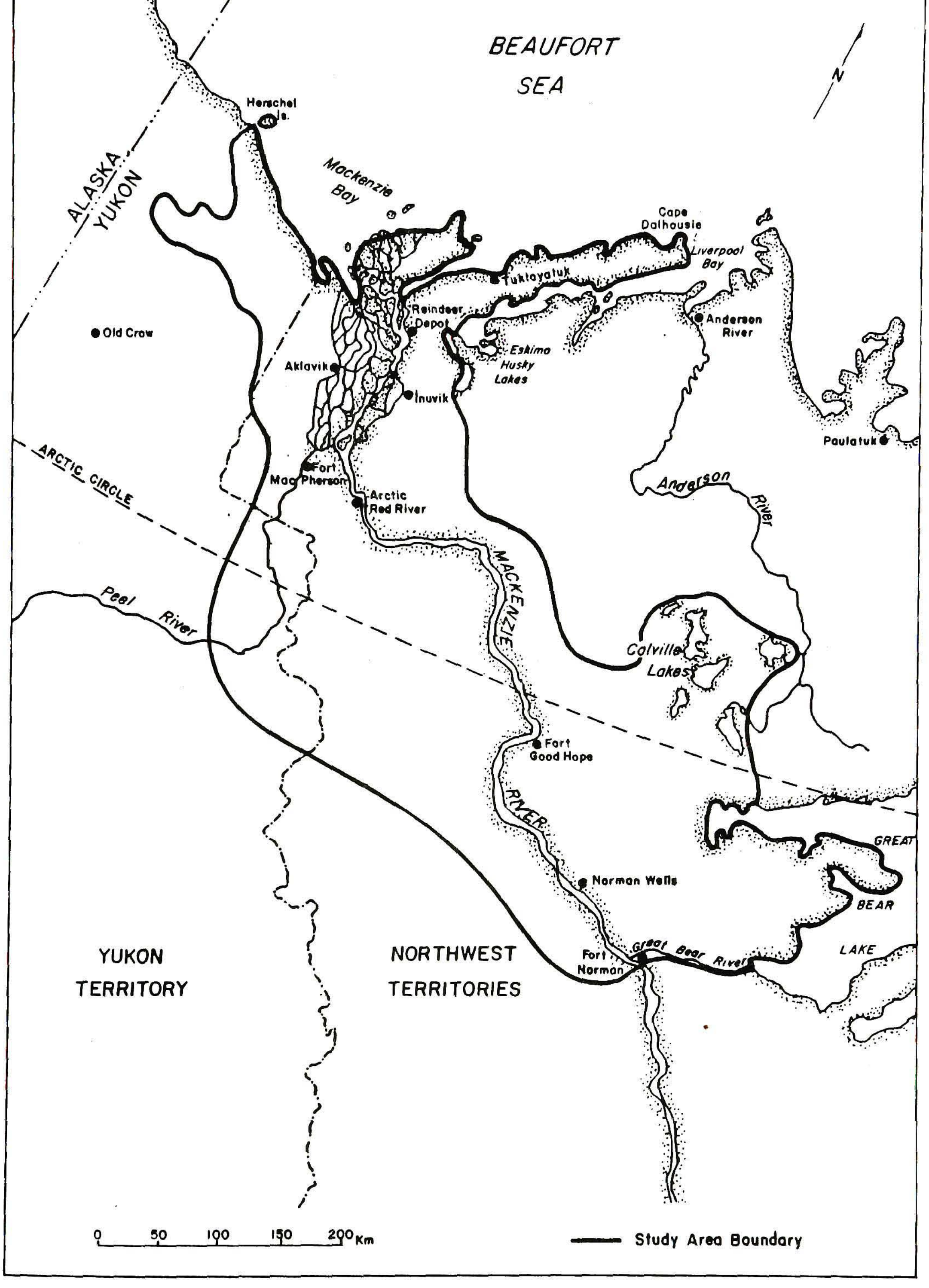


Figure 1.1 Proposed boundaries of the MEMP study area.

The western and eastern boundaries of the study area raise more difficult questions. To the west, Herschel Island is included in the northwest corner. The western boundary follows the proposed National Park boundary at the Babbage River. It is intended to include the North Slope as far west as the continental divide. To the east, the Colville Lakes area is included but the whole of the Anderson River drainage is not. The primary interest in the Colville Lakes area was from the perspective of the exploration effects on caribou, although, in addition, several lakes in this area support substantial lake trout populations. Interest in the Anderson River drainage related to the potential for oil spills in the area affecting the water quality and fish. However, such impacts were not considered to be likely within the time frame of this study (20-year development scenario).

Planning Horizon

To be more meaningful, conceptual models must be placed in an appropriate temporal context and a choice of a time horizon must be made. For this study the development scenario was produced assuming a twenty-year planning horizon. Because of considerable uncertainty about the scale and pace of development, it is difficult to forecast many of the more detailed aspects of the development scenario. However, an even longer time horizon may be required to detect impacts on longer lived VECs. Thus monitoring activities of development may require more than 20 years.

Linkages Between Key Components in the Conceptual Model

To gain a better understanding of the social and environmental system within the study area the following components were recognized:

1. development activities

2. socio-economic system

3. physical processes, terrain and vegetation

4. fish and water quality

5. mammals

6. birds

7. resource harvesting

The last five components are the major parts of the conceptual model. Because the MEMP program is primarily an environmental monitoring program many of the social and economic impacts of development were not considered. However, because the impacts on resource harvesting are within the mandate of the program, it was necessary to consider some social and economic information. The development scenario, of course, is the major driving force. The Yellowknife workshop identified the linkages between the seven components of the conceptual model as shown in Table 1.

REFERENCES

Beanlands, G.E. and P.N. Duinker. 1983. An ecological framework for impact assessment in Canada. Halifax: Institute for Resource and Environmental Studies. 132 p.

Dome Petroleum Limited, Esso Resources Canada Limited and Gulf Canada Resources Inc. 1982. Environmental impact statement for hydrocarbon development in the Beaufort Sea - Mackenzie Delta region. Vol. 2. Development Systems. Vol. 4. Biological and physical effects.

Everitt, R., D.A. Birdsall and D.P. Stone. 1985. Beaufort Environmental Monitoring Project. Proc. Conf. Northern Hydrocarbon Development, Environmental Problem Solving - International Society of Petroleum Industry Biologists. September 24-26 1985, Banff Alberta.

Holling, C.S. (ed.). 1978. Adaptive environmental assessment and management. Chichester: Wiley & Sons.

Indian and Northern Affairs Canada and Environment Canada. 1985. Beaufort Environmental Monitoring Project 1984-85 Final Report. Unpubl. rep. by ESL Environmental Sciences Limited, LGL Limited, ESSA Limited, Arctic Laboratories Limited and Arctic Sciences Limited. 162 p.

Table 3.3 Major linkages between components of the MEMP conceptual model.

TO FROM	PHYSICAL PROCESSES, TERRAIN, AND VEGETATION	FISH AND WATER QUALITY	LARGE MAMMALS	OTHER MAMMALS	BIRDS	RESOURCE UTILIZATION
DEVELOPMENT SCENARIO	-concentrations of CO_2, SO_2, NO_x -fuel usage -location and areal extent of pipelines (above, below ground) & roads (temporary and permanent) -location and areal extent of camps, airstrips, drilling platforms -water withdrawals -abandonment procedures -revegetation/ reclamation -location of seismic lines -oil spills (frequency, volume, duration) -seasonality of construction -design standards for erosion subsidence -construction techniques -locations where channel/coast needs stabilization	-barge traffic -dredging -location of water extraction -location of linear corridor (roads; pipelines) -staging areas -seasonality of construction -location of gravel extraction areas -amounts of waste generated by type (domestic, industrial) -method of waste handling -characteristics of substances spilled accidentally -sites where blasting may be necessary -extent & location of channelization	-frequency of road traffic -location of roads -access -location of work sites (people, dwelling type, waste management) -gravel extraction -aircraft frequency -seismic lines	-frequency of road traffic -location of roads -access -location of work sites (people, dwelling type, waste management) -gravel extraction -aircraft frequency -seismic lines	-presence of towers, wires with bright lights -location of production facilities -frequency of traffic -location of roads -location of work sites (people, dwelling type, waste management) -aircraft frequency	-rotation schedules -opportunities for wage employment -access to harvesting areas -construction & operation personnel management -disturbance (noise) -training policies -timing & location of development activities
SOCIO-ECONOMIC INFORMATION			-people engaged in recreational activities -number of people working			-number of tourists -community profile (demography) -employment patterns -location of harvesting areas -seasonality of harvest -interest in development -community development plans
PHYSICAL PROCESSES, TERRAIN AND VEGETATION		-lake drawdown from water withdrawals -areas with slope instability -location of groundwater flows -areas with net accumulation of sediments (mainstem) -flow in areas where water withdrawals are occurring		-areal extent of habitat types .climax evergreen .deciduous (grasses, willow, alder, poplar) .non-climax evergreen .tundra (sedge, alpine) .emergent vegetation .submergent vegetation .eskers, gravel deposits -snow depth in caribou range -depth in ponds, sloughs -water level changes	-areal extent of bird habitat (losses) -water level effects on bird habitat	-terrain changes affecting access -snowmelt -runoff -freeze-up of water bodies
FISH AND WATER QUALITY				-concentrations of heavy metals and toxics that might affect mink, otter	-number of fish by area -changes in siltation pattern	-distribution (temporal, spatial) of fish by species -quality by species -sustained yield by species
LARGE MAMMALS/ OTHER MAMMALS					-number of foxes near all facilities	-distribution (temporal, spatial) of animals by species -age, sex distribution of animals by species -quality and condition of animals by species -sustainable yield
BIRDS			-predation by golden eagles			-temporal availability of geese, ducks -raptors (gyrfalcons)
RESOURCE UTILIZATION		-fish caught by domestic, commercial and sport fisheries by species and location (present and future) -quality of fish flesh	-animals harvested by species, sex, age, and locations	-animals harvested by species, sex, age, and locations	-utilization of birds by species and season -nonconsumptive use	

PART 1: BIOLOGICAL HYPOTHESES

INTRODUCTION

The following material describes, in detail, workshop results of 17 hypotheses relating possible effects of hydrocarbon development activities on various types of natural resources. These include various species of fish, birds and wildlife as well as potable water and air quality. Although a common format was adopted for each hypothesis, some decisions regarding style and treatment were left to each subgroup.

HYPOTHESIS NO. 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

PARTICIPANTS

Terry Antoniuk	John McDonald
Albert Elias	Margaret McLaren
Harvey Jessup	Wendy Nixon
David Krutko	Peter Usher

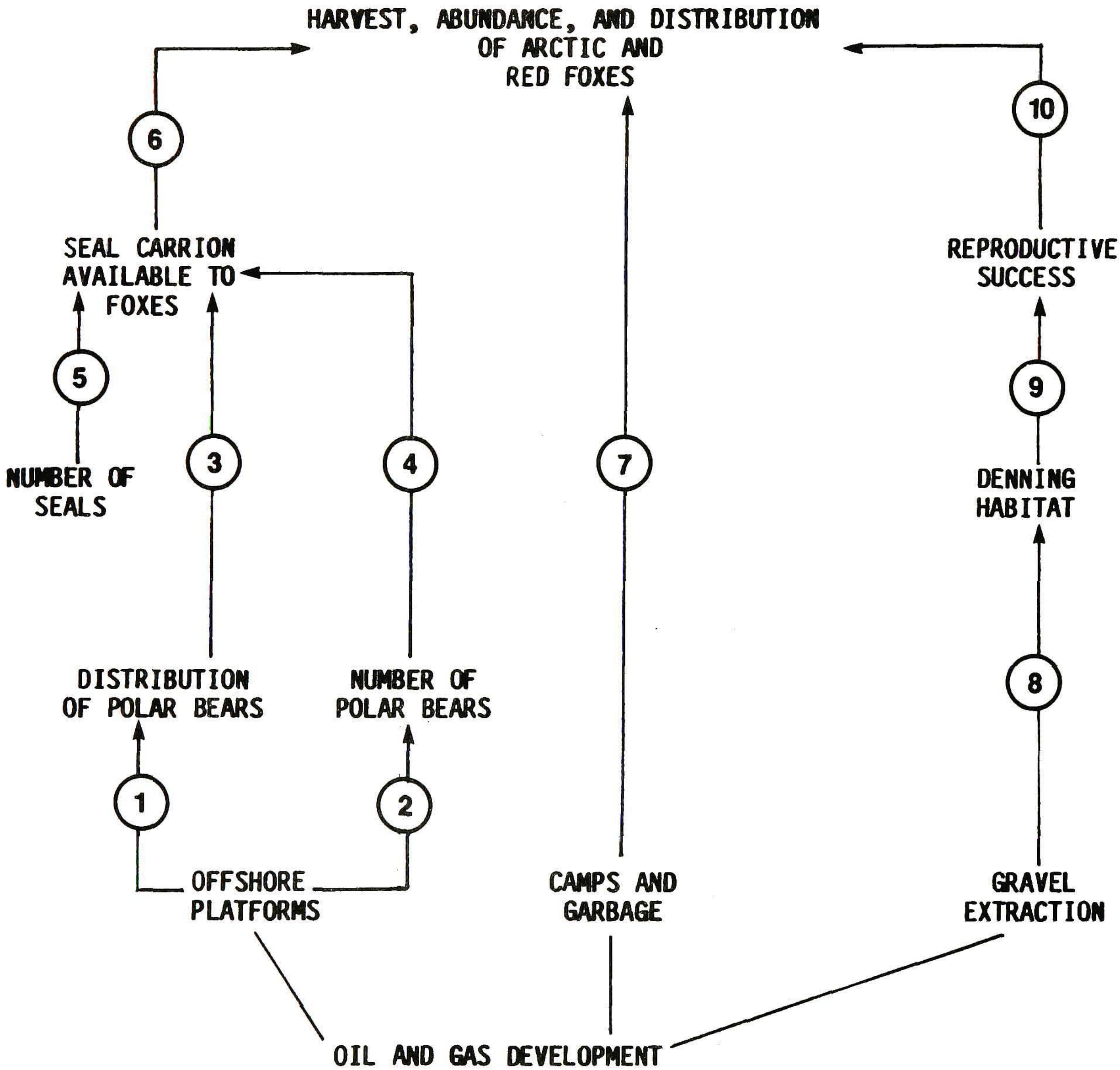
INTRODUCTION

In summer arctic foxes occur primarily in tundra and taiga portions of the study area, and are most commonly found on the Yukon North Slope and on the Tuktoyaktuk Peninsula. On the North Slope, arctic foxes den in areas of mixed sand and gravel soil; all known dens are west of the Babbage River (Smits and Jessup 1985). During the denning period, arctic foxes eat primarily small mammals, and, to a lesser extent, birds (Macpherson 1969). During winter, however, foxes move onto the sea ice where they scavenge carcasses of seals killed by polar bears (Macpherson 1969; A. Elias, pers. comm.). Foxes that move onto the sea ice tend to be young animals and often travel long distances. Foxes tagged at Prudhoe Bay have been recovered on Banks Island and on the Tuktoyaktuk Peninsula (Eberhardt and Hanson 1978). Foxes that travel tend to be healthier and have better quality pelts than animals that do not travel (A. Elias, pers. comm.).

Red foxes are more abundant than arctic foxes on the delta and in treed portions of the study area. This species also feeds on small rodents and birds throughout the year and does not travel on the ice during winter. Although red foxes occur on the Yukon North Slope in summer, Inuit observers report that they move south by December, apparently because the hard snow of the tundra prevents foxes from reaching small mammals (H. Jessup, pers. comm.). Because red foxes do not travel on the sea ice, Links 1 to 6 of the hypothesis do not apply to this species (Figure 1-1).

FIGURE 1-1

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



LINKAGES

Link 1: Polar bears that encounter offshore platforms will subsequently be attracted to these facilities.

Link 2: Polar bears that approach offshore structures have to be controlled, and this will result in the need to destroy some bears.

Link 3: Changes in the distribution of polar bears will alter the distribution of seal carrion on the ice.

Link 4: A decrease in the number of polar bears will reduce the amount of seal carrion on the ice.

Link 5: A decrease in the number of seals due to offshore activities will reduce the amount of seal carrion.

Link 6: A decrease in the amount and change in the distribution of seal carrion will decrease the number of arctic foxes.

Link 7: The presence of camps and refuse will affect the abundance and distribution of arctic and red foxes.

Link 8: Gravel extraction activities will decrease the amount of denning habitat.

Link 9: A decrease in the amount of denning habitat will reduce the reproductive success of arctic and red foxes.

Link 10: Reproductive success influences the abundance and distribution of foxes.

LINKAGES

Link 1: Polar bears that encounter offshore platforms will subsequently be attracted to these facilities.

Participants of past BEMP workshops concluded that some polar bears will be attracted to offshore and coastal industry facilities (Indian and Northern Affairs Canada and Environment Canada 1984, 1985, Stirling et al. 1977, 1978). However, it was agreed that polar bears would usually only be attracted over relatively short distances, and that only a small proportion of the regional population would actually be involved in direct interactions with offshore structures.

Link 2: Polar bears that approach offshore structures have to be controlled, and this will result in the need to destroy some bears.

The 1984 and 1985 BEMP reports documented several instances where it has been necessary to destroy polar bears for reasons of human safety at both offshore and onshore industry facilities. Two specific instances in the Beaufort Sea were cited, where bears were shot after killing humans. Additional bears may also have been shot by Inuvialuit hunters at sites of industrial activity, but were not reported as nuisance bears because they were considered part of the legal quota.

Link 3: Changes in the distribution of polar bears will alter the distribution of seal carrion on the ice.

This link was considered valid. However, the subgroup concluded that it is unlikely that changes in the distribution of polar bears will affect the availability of seal carrion to arctic foxes, since foxes are known to follow polar bears on the sea ice (A. Elias, pers. comm.).

Link 4: A decrease in the number of polar bears will reduce the amount of seal carrion on the ice.

Although the loss of even a single polar bear has the potential to reduce the amount of carrion on the ice, the amount of carrion is also determined by the amount of the kill that is consumed by the bear. Polar bears frequently consume only the blubber from seals that they kill (Stirling 1974; Stirling and McEwan 1975), thereby leaving the remainder of the carcass for foxes. However, more of the carcass is eaten when seals are not abundant (Stirling and Archibald 1977) and in these circumstances less food may be available for consumption by foxes. In general, there does not seem to be an excess of food available for foxes. Seal carrion that is available tends to be completely consumed by foxes (A. Elias, pers. comm.). It was concluded that a loss of polar bears through Link 2 is unlikely to have significant effects on the populations of arctic foxes since (1) they are able to cover long distances in search of food and (2) mortality of polar bears following active industry attraction to facilities is expected to be low.

Link 5: A decrease in the number of seals due to offshore activities will reduce the amount of seal carrion.

Seal carrion is available to arctic foxes only when seals are partially consumed before being abandoned by bears. Since polar bear populations are controlled to some degree by the availability of ringed seals (Stirling et al., unpubl. data cited in INAC and Environment Canada 1985), a significant reduction in the number of seals would result in a decrease in the size of bear populations and therefore, less seal carrion for foxes.

During the BEMP workshops in 1984 and 1985 the potential effects of offshore hydrocarbon development on Beaufort Sea populations of ringed seals and bearded seals were examined. The development activities of primary concern were marine vessel traffic, seismic activities, dredging operations, aircraft overflights, and activities at offshore platforms and islands. BEMP participants concluded that effects of offshore hydrocarbon development on ringed seals were possible, but would be difficult or impossible to detect given the natural variability in Beaufort Sea ringed seal populations and the difficulty of establishing cause-effect relationships between population changes and industry activities. It was expected that effects at the population level of either species were unlikely.

During the BEMP workshops, the effects of increased frequency of icebreaker traffic on ringed and bearded seal pup production was also examined. Direct pup mortality as a result of icebreaker traffic was anticipated for both species but the effect was not expected to be significant at the population level. Interference with vocalizations of male bearded seals due to icebreaker traffic and a subsequent reduction in mating success was considered likely but at a local level such that industry-related effects on pup production would not be detectable.

The potential for large-scale destabilization of the Amundsen Gulf ice cover and, hence, a significant change in the total annual amount of open water in the region was identified as a significant concern in relation to regional ringed seal pup production, as well as regional populations of ringed seals and polar bears in Amundsen Gulf. On the basis of limited available information on the physical processes controlling the ice edge stability, the hypothesis that icebreaker traffic through Amundsen Gulf will move the stable ice edge to the east was considered possible, but unlikely. Even if this should occur, the effect on the total amount of open water was expected to be influenced by other factors such as the location of the polar pack ice edge and general wind conditions which could advect ice into or away from Amundsen Gulf. It was recommended that a research program be initiated to analyse existing data on ice and seals in the Beaufort region and to determine if there were measurable effects on ringed seals in Amundsen Gulf during years of natural destabilization.

Participants of past BEMP workshops concluded that it is unlikely that offshore activity will significantly affect ringed seal populations. Therefore, the working group concluded that it is also unlikely that development would reduce the availability of seal carrion to arctic foxes.

Link 6: A decrease in the amount and change in the distribution of seal carrion will decrease the number of arctic foxes.

Inuit observers reported that seal carcasses are always well utilized by foxes (A. Elias, pers. comm.). This indicates that there is probably not an excess of food available to foxes on the ice and that the availability of seal carrion could potentially affect the number of foxes. Although this link was considered valid it was concluded that development will not reduce the amount of seal carrion on the ice.

Link 7: The presence of camps and refuse will affect the abundance and distribution of arctic and red foxes.

There are several mechanisms through which camps and the presence of garbage may affect the numbers and distribution of arctic and red foxes. Camps could act as 'artificial bait stations', particularly in offshore areas, and lead to locally dense congregations of foxes. Increased availability of food may in turn favour greater survival of foxes, although local concentrations may be easily trapped or killed as nuisance animals.

Both arctic and red foxes are attracted to camps by garbage and workers who frequently feed these animals (H. Jessup, D. Krutko, pers. comms.). For example, food handouts from workers at Issungnak attracted up to 20 arctic foxes for a period of several weeks (D. Krutko, pers. comm.), while a camp at Johnson Point on Banks Island attracted 50-60 foxes (Urquhart 1971). In the Prudhoe Bay area, the density of arctic fox dens is higher than that in surrounding areas (Eberhardt et al. 1983). Reproductive success in a year when lemmings were not particularly abundant was also higher near Prudhoe Bay, and these authors attributed this success to availability of food from garbage and handouts.

Although garbage handling is controlled by various regulations, refuse is usually incinerated only once per day and may be available to foxes at other times (D. Krutko, pers. comm.). The subgroup recommended that an education program be implemented to inform workers of the potential consequences and hazards of feeding foxes (e.g., rabies).

The potential for trapping of foxes concentrated near camps, particularly those on the sea ice off the Yukon North Slope was identified as an area of concern by the subgroup. According to H. Jessup (pers. comm.) the local breeding population on the North Slope may only be able to sustain a harvest of 60-80 foxes per year but Inuvialuit who have trapped in the area believe that several hundred foxes could readily be taken each winter. Trapping could affect both local and distant populations, since the origin of the foxes on the ice in this region remains unknown. If offshore platforms attract local breeding individuals as well as travelling foxes and, if trapping extends into April when foxes are returning to terrestrial denning areas, local breeders may be trapped during the den re-occupancy period. At least some arctic foxes display year-to-year fidelity to den sites (Eberhardt et al. 1983). Loss of local breeders could reduce the numbers of foxes that den on the North Slope for at least the season in which resident foxes are trapped.

Although the group acknowledged that congregations of foxes at camps could facilitate the spread of rabies, this was not considered a serious issue. Rabies epidemics occur naturally and may be naturally spread by contact among foxes feeding on seal carrion. The group concluded that attraction of foxes to camps would not significantly increase the risk of spreading the disease.

Link 8: Gravel extraction activities will decrease the amount of denning habitat.

The potential for loss of arctic fox den sites in the Yukon North Slope was not considered an issue because all known dens are west of the Babbage River in areas where gravel extraction is unlikely. Den sites in coastal areas of the North Slope were identified during recent surveys conducted by the Government of Yukon, Department of Renewable Resources (H. Jessup, pers. comm.).

The effect of gravel extraction on den sites for red foxes in the Mackenzie Delta was considered an area of concern because of the scarcity of gravel in this area. Although industry has attempted to avoid destruction of existing dens during gravel extraction operations, the group noted that dens do not remain indefinitely and there is little or no information regarding the characteristics of sites selected for new dens. Nevertheless, it was considered likely that, even after extraction activities were complete, sufficient gravel would remain to permit foxes to establish dens within the Delta. The group expected that revegetation of mined sites would accelerate stabilization and improve sites for future denning. It was also noted that foxes have established dens in berms and in gravel pits at facilities such as DEW Line sites.

Link 9: A decrease in the amount of denning habitat will reduce the reproductive success of arctic and red foxes.

Since arctic foxes do not den within the Delta this link is valid only for red foxes. [The presence of arctic foxes on the Delta is believed to be due to their winter dispersal patterns (N.W.T. harvest records; YTG trapper interviews in Aklavik)]. A decrease in the amount of denning habitat would only have a direct effect on reproductive success if availability of den sites were presently limiting the size of the red fox population. There is no evidence to confirm or deny such a relationship for foxes in the Mackenzie Delta or the MEMP study area in general. However, in the context of this hypothesis, the lack of evidence for or against this link is not important since the previous link was concluded to be invalid.

Link 10: Reproductive success influences the abundance and distribution of foxes.

Reproductive success ultimately determines the abundance of foxes. However, both the abundance and distribution of foxes, particularly the arctic fox, are affected by several other factors. The abundance of arctic foxes is cyclic and is controlled at least in part by the availability of lemmings (Macpherson 1969). The distribution of arctic foxes in winter is largely determined by the distribution of food, and food availability directly affects both their survival and abundance. It was suggested that foxes that travel in search for food in winter tend to be healthier than more sedentary individuals (A. Elias, pers. comm.).

CONCLUSIONS

The linkages concerning the effects of gravel extraction on fox populations (Links 8 to 10) were considered invalid for arctic foxes (because their denning distribution does not overlap with projected areas of gravel extraction) and unlikely for red foxes. On the basis of existing information, the other linkages were considered possible but probably of low significance. The subgroup concluded that the effects of hydrocarbon development on arctic foxes would be difficult to detect because effects (if they occur) are expected to be small in relation to the high degree of natural variability in fox distribution and numbers.

RESEARCH

During the workshop, it was noted that the existing knowledge of arctic foxes in the study area is inadequate in several respects. It is known that individual foxes travel long distances on the sea ice but very little is known regarding the travel rates, pattern of movements, or relationships of foxes on the sea ice to breeding populations. The working group agreed that this information is essential for the management of fox populations and would be of value in verifying the conclusion reached by the subgroup that hydrocarbon development will not significantly affect arctic fox populations.

The presence of offshore drilling sites provides an opportunity for research on foxes that travel on the ice. A tagging program at drilling sites could establish whether (1) individual foxes remain at camps for extended periods, or (2) if foxes observed at camps are individuals from a continuously moving population. Subsequent observations of marked animals would provide further information of movement patterns and aid in the identification of discrete populations. Some subgroup participants believed that the first step toward the establishment of a research program for arctic foxes should be a compilation of all existing literature including that from Soviet sources and Alaskan and Canadian 'grey literature'. Although much of the available literature has been compiled by the Yukon Department of Renewable Resources, syntheses of the data exist for only relatively restricted subjects and geographic areas (Usher 1971; Smits and Jessup 1985).

A further indicator of the status of exploited fox populations is catch per unit effort. Any significant variation in catch per unit effort beyond normal limits of variability over the population cycle is the first concrete indication of significant change in a regional fox population. In order for catch per unit effort to function as an adequate index, a time series of data covering two or more population cycles is considered necessary. Some baseline data could be assembled from a review of existing literature, but most data requirements can only be satisfied through coordination of research efforts with harvest survey programs recommended in relation to the resource harvesting hypotheses (Numbers 18-25).

LITERATURE CITED

Eberhardt, L.E,. R.A. Garrott and W.C. Hanson. 1983. Den use by arctic foxes in northern Alaska. J. Mamm. 64:97-102.

Eberhardt, L.E. and W.C. Hanson. 1978. Long-distance movements of arctic foxes tagged in northern Alaska. Can. Field-Nat. 92:386-389.

Indian and Northern Affairs Canada and Environmental Canada. 1984. Beaufort Environmental Monitoring Project 1983-1984 Final Report. Unpubl. rep. by LGL Limited, ESL Environmental Sciences Limited and ESSA Limited. 292 p.

Indian and Northern Affairs Canada and Environmental Canada. 1985. Beaufort Environmental Monitoring Project 1984-85 Final Report. Unpubl. rep. by ESL Environmental Sciences Limited, LGL Limited, ESSA Limited, Arctic Laboratories Limited and Arctic Sciences Limited. 162 p.

Macpherson, A.H. 1969. The dynamics of Canadian arctic fox populations. Can. Wildl. Serv. Rep. Ser. 8. 52 p.

Smits, C.M.M. and H. Jessup. 1985. Den distribution, harvest utilization and management of arctic fox in northern Yukon Territory. Preliminary Rep. by Yukon Dep. Renewable Resources, Fish and Game Branch.

Stirling, I. 1974. Midsummer observations on the behaviour of wild polar bears (Ursus maritimus). Can. J. Zool. 52:1191-1198.

Stirling, I. and W.R. Archibald. 1977. Aspects of predation of seals by polar bears. J. Fish. Res. Board Can. 34:1126-1129.

Stirling, I., C. Jonkel, P. Smith, R. Robertson and D. Cross. 1977. The ecology of the polar bear (Ursus maritimus) along the western coast of Hudson Bay. Can. Wildl. Serv. Occas. Paper 33. 64 p.

Stirling, I. and E.H. McEwan. 1975. The caloric value of whole ringed seals (Phoca hispida) in relation to polar bear (Ursus maritimus) ecology and hunting behaviour. Can. J. Zool. 53:1021-1027.

Stirling, I., R.E. Schweinsburg, W. Calvert and H.P.L. Kiliaan. 1978. Population ecology of the polar bear along the proposed Arctic Islands gas pipeline route. AIPP preliminary report 1977, ESCOM Rep. No. AI-15, Environmental-Social Program, Northern Pipelines, Ottawa. 71 p.

Urquhart, D.R. 1971. An interim report on the findings and progress of the Banks Island Project. Unpubl. Rep. to Superintendent of Game Manage., Government of the N.W.T.

Usher, P.J. 1971. The Bankslanders: Economy and ecology of a frontier trapping community, Vol. 2 - Economy and Ecology. NSRG-71-2, North. Sci. Res. Group, Dep. Indian Affairs and Northern Development, Ottawa.

HYPOTHESIS NO. 2

INCREASED TRAFFIC ON DEMPSTER HIGHWAY AND ROADS ON THE NORTH SLOPE WILL DECREASE THE NUMBER OF CARIBOU AND ALTER THEIR DISTRIBUTION

PARTICIPANTS

Lee Doran	Fred McFarland
Susan Fleck	Margaret McLaren
Ron Graf	Wendy Nixon
Harvey Jessup	Nicholas Sonntag
David Krutko	

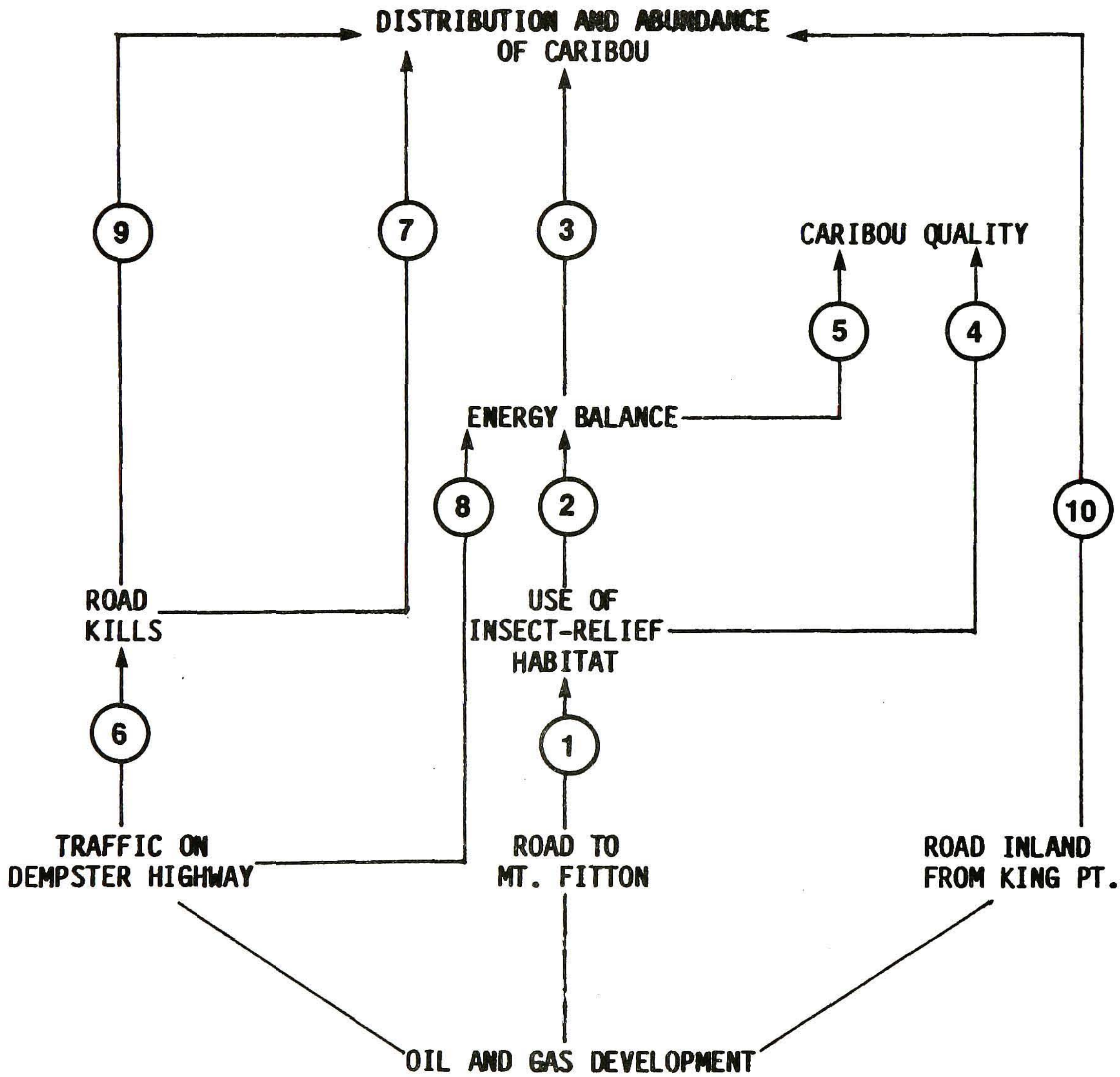
INTRODUCTION

The estimated size of the Porcupine caribou herd is about 135,000 animals (D. Russell, Canadian Wildlife Service, pers. comm.), and the range of this herd extends over the northern Yukon, northwestern Northwest Territories and northeastern Alaska. The herd winters as two populations: one in the vicinity of Arctic Village, Alaska, and the other (about 80,000 animals) in the Yukon and adjacent N.W.T.

There is considerable variability in the wintering areas of the Yukon population. In most years, the herd is located south of the Richardson Mountains, but occasionally large numbers of caribou remain on the North Slope and the western Mackenzie Delta. In years when the herd moves south of the Richardson Mountains, its wintering area can be predicted to some extent from information on snow depth. In years of low snowfall, caribou winter primarily in the Eagle Plains area, which supports a high biomass of lichens. However, in years of high snowfall, most caribou remain south or west of the Dempster Highway in the Ogilvie Mountains and the upper Peel River drainage. These areas tend to receive less snow than the Eagle Plains (D. Russell, pers. comm.). Although caribou presence can be predicted to some degree from snow depth, other unknown factors also control caribou movement. For example, during the winter of 1984-85, Eagle Plains received a substantial amount

FIGURE 2-1

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



LINKAGES

Link 1: Traffic on the proposed road inland to Mt. Fitton (or through Blow Pass) could act as a barrier to a large segment of the Porcupine caribou herd and prevent animals from reaching insect-relief areas in the northern Richardson Mountains in late July and early August.

Link 2: Restricted access to insect-relief areas will increase the daily energy requirements associated with insect avoidance, reduce fat storage in the fall and may also result in an increased incidence of parasites in caribou.

Link 3: Lower energy levels will result in decreased calving success, lower calf survival and, therefore, lower numbers of caribou.

Link 4: Reduced access to insect-relief habitat will increase the incidence of parasites and reduce the quality of caribou hides.

Link 5: Decreased animal fat levels will reduce the quality of caribou meat and hides.

Link 6: Increased traffic on the Dempster Highway will increase the number of caribou killed as a result of collisions with vehicles.

Link 7: Road kills on the Dempster Highway will decrease the abundance of caribou.

Link 8. Increased traffic levels on the Dempster Highway will harass caribou and increase energy expenditure.

Link 9: Increased traffic on the Dempster Highway will act as a barrier and prevent access of caribou to habitat south of the highway.

Link 10: Traffic on the proposed road inland from King Point could act as a barrier to the bull/barren cow segment of the herd and force animals to travel a greater distance to reach the large post-calving aggregations of caribou.

of snow, and the caribou wintered on the North Slope and in the Richardson Mountains. However, the herd had remained on the North Slope through the fall; they did not move south, encounter deep snow and then return north.

The spring migration of caribou occurs in two phases. Pregnant females commence their northward migration in March; bulls and immature and barren cows do not follow until about mid-April. Pregnant cows arrive on the calving grounds by late May or early June before the snow melt is complete. Calving occurs primarily in snow-free areas of the foothills north of Brooks Range in northeast Alaska. Scattered calving bands may occur as far east as the Mackenzie Delta, but large numbers of parturient cows are rarely found east of Stokes Point (Curatolo and Roseneau 1977; D. Russell, pers. comm.). Bulls and barren cows that winter in Alaska and the Yukon or N.W.T. reach the Yukon North Slope by mid-June, and over 100,000 animals may be present on the North Slope at this time. The bull groups gradually move westward and join the cows and calves in large post-calving aggregations near the Yukon-Alaska border.

During July, these large groups move eastward to the northern Richardson Mountains to seek relief from insects. In August, they disperse into smaller groups throughout the northern Yukon and into Alaska. Fall migration begins in September and the animals usually reach the wintering areas by late October. The rut occurs during the second week of October when the herd is usually located south of the Peel River.

The number of animals in the Porcupine caribou herd has remained stable over the last 20 years (Bergerud et al. 1984). The harvest by natives has been estimated at 2.9-4.8% of the population each year (Thomas, pers. comm., cited by Dickinson and Herman 1979).

LINKAGES

Link 1: Traffic on the proposed road inland to Mt. Fitton (or through Blow Pass) could act as a barrier to a large segment of the Porcupine caribou herd and prevent them from reaching insect-relief areas in the northern Richardson Mountains in late July and early August.

Caribou have been observed in the Richardson Mountains since the late 1800's (Surrendi and deBock 1976). Since 1971, detailed data have been collected on the numbers and movements of caribou. These records indicate that at least a portion (in some years, more than half) of the herd passes through the area of the proposed road en route to their summer range. In mid-July of 1971 and 1972, approximately 5000 caribou crossed the Blow River into the northern Richardson Mountains. In 1973, approximately 70,000 caribou crossed the Blow River to reach their summer range (Surrendi and deBock 1976). In 1978 and 1979, 10,000 to 15,000 caribou moved through the Barn Mountains across the Blow Valley to the Richardson Mountains. In late July of 1982, most of the herd was located on the coastal plain in the Blow and Babbage River drainages (Yukon Department Renewable Resources, unpubl. reports). The majority of the caribou summering in the northern Yukon in 1984 (4000 caribou) and 1985 (40,000 caribou) passed through the Blow River drainage in mid- to late July en route to the northern Richardson Mountains (W. Nixon, pers. comm.).

Interactions between vehicular traffic and caribou have been studied on the Dempster Highway, in the Alaskan oil fields, in Mount McKinley Park (now Denali National Park) and elsewhere. The result of these studies suggest that traffic has variable effects depending on individual caribou. Some individuals or groups of caribou alter or delay their movements, but others apparently display no overt behavioural response to traffic; they will cross a road once traffic has passed, and may feed near a road with low levels of traffic (Surrendi and deBock 1976; Tracy 1977; Russell and Martell 1985). Dau and Cameron (1985) and Smith et al. (1985) studied the effects of vehicular traffic on caribou in northern Alaska during the insect harassment season. They found that the caribou moving north did cross the road toward insect relief areas and that their return movements tended to be deflected along the road and around a processing facility. In 1984, movement south was not deflected along the road, but road crossing occurred in the evening when there was less traffic. Dau and Cameron (1985) recommended that traffic be minimized during the period of 1 July to 1 Augustto reduce interference with summer movements of caribou to insect-relief areas.

The above information suggests that frequent traffic on a road inland to Mt. Fitton could interfere with the movement of at least some caribou migrating eastward to the Richardson Mountains in July and August. However, the working group concluded that, because the passage of caribou is fairly rapid (1-2 weeks) and predictable, effective mitigation (cessation or convoying of traffic) would be possible.

Link 2: Restricted access to insect-relief areas will increase the daily energy requirements associated with insect avoidance, reduce fat storage in the fall, and may also result in an increased incidence of parasites in caribou.

During periods of insect harassment, caribou use various strategies to reduce the degree of contact with mosquitoes and parasitic flies (nasal bot flies, Cephenemyia trompe, and warble flies, Oedemagena tarandi). When insect harassment is severe, caribou in the Barn and Richardson Mountains move to high slopes and ridges where wind exposure is greatest. If movement to insect-relief habitat is impeded, it is conceivable that caribou will employ other strategies to avoid insects (e.g., an increase in the rate of movement in a circular pattern (milling within a group) or in an upwind direction to increase apparent wind speed). Caribou that move to avoid insects spend less time feeding (have reduced energy intake) and have a greater energy expenditure (S. Fancy, in prog.; W. Nixon, pers. comm.). During the insect season, caribou are often already in poor physical condition (Kelsall 1968).

It is considered possible that the parasite load of caribou will increase if parasitic flies have more opportunities to contact individuals, although this has not been confirmed through research conducted to date. Studies of insect harassment of the Porcupine caribou herd indicate that there were few days of severe insect harassment in 1984 and 1985, but low to moderate levels of harassment occurred on several days (CWS, in prog.). Restricted access to insect-relief habitat does have the potential to increase daily energy requirements, and possibly the incidence of parasites, especially during periods of moderate to severe insect harassment. Increased parasite load has been shown to reduce fat reserves and general body condition (Dieterich et al. 1981; Hout and Beaulieu, in press).

Link 3: Lower energy levels will result in decreased calving success, lower calf survival and therefore lower numbers of caribou.

This link was considered valid. Increased parasite load has been shown to reduce body condition (Dieterich et al. 1981; Hout and Beaulieu, in press). Poor body condition (i.e., low fat reserves) has been related to reduced fertility in Peary caribou (Thomas 1982). Reindeer herders in Yakutsk Province, U.S.S.R. increased productivity from 67-72 to 78-89 calves/100 cows by using systemic drugs to reduce the parasite load, primarily bots and warbles (D. Russell, pers. comm.). Helle and Tarvainen (1984) reported that reindeer calves were significantly lighter in weight in the fall and early winter when insect harassment was severe during the summer of birth. They also found that, in one of the two areas they studied, insect harassment directly influenced calf survival. Poor feeding conditions in late winter, followed by a summer with severe insect harassment resulted in significant levels of calf mortality.

Link 4: Reduced access to insect-relief habitat will increase the incidence of parasites and reduce the quality of caribou hides.

As previously discussed, it is possible that a delay in the movement of caribou to traditional insect-relief areas could increase the rate of warble fly infestation of individuals or the entire herd. However, this was not considered an area of concern since a very high proportion of caribou are normally infested with parasites (Kelsall 1968) and the hides of infected animals are only of poor quality in the spring when breathing holes of warble larvae are open. Caribou are generally not hunted for their hides in spring because the hair is loose at this time of year and the skins are of little value for clothing or bedding (D. Krutko, pers. comm.).

Link 5: Decreased animal fat levels will reduce the quality of caribou meat and hides.

In the northern Yukon, native hunters traditionally harvest caribou 1) in the fall during the southward migration of the herd to wintering grounds, and 2) in the spring during northward migration to the calving grounds. Caribou are in peak condition in the fall prior to the rut. Caribou meat is of poor quality during the rut and, therefore, hunters normally avoid shooting bulls during this period. Adult males begin to regain fat in late winter (Dauphiné 1976) and the best caribou meat is from animals that have substantial amounts of fat (D. Krutko, pers. comm.).

It was considered unlikely that any development-related disturbance would affect the condition of the caribou more adversely than the stress associated with migration or rut. However, the combined energy costs required for migration, insect avoidance, increased parasite load, and increased movement due to traffic may reduce the body condition (i.e., fat reserves) of the caribou and result in lower quality meat.

There is no evidence to suggest that hide quality is affected by fat levels in the caribou. The preferred hides are those taken during the fall hunt when the hair is shorter and does not shed (D. Krutko, pers. comm.).

Link 6: Increased traffic on the Dempster Highway will increase the number of caribou killed as a result of collisions with vehicles.

This link was considered valid by the workshop subgroup. Most collisions were expected to occur in December and January because of the long periods of darkness during these months.

Link 7: Road kills on the Dempster Highway will decrease the abundance of caribou.

This link was considered self-evident and valid. However, the number of caribou killed by collisions with vehicles was expected to be insignificant at the population level.

Link 8: Increased traffic levels on the Dempster Highway will harass caribou and increase energy expenditure.

Several studies have shown that some caribou near the Dempster Highway do react to traffic by running (Surrendi and deBock 1976; Horejsi 1981;

Russell and Martell 1985). Although Russell and Martell (1985) indicated that levels of traffic were low during their investigations, they found no consistent differences between activity patterns of caribou adjacent to the highway and those more distant from the highway. Given the levels of traffic predicted in the development scenario the sub-group concluded that harassment of caribou by traffic was likely to have small effects on the energy balance of individuals.

Link 9: Increased traffic on the Dempster Highway will act as a barrier and prevent access of caribou to habitat south of the highway.

There are numerous examples of crossings of both highways and railways by herds of caribou and wild reindeer (e.g., Jakimchuk 1980; Skogland and Mølmen 1980; Bergerud et al. 1984) and the sub-group concluded that access to areas south of the highway would not be permanently blocked. However, the subgroup also concluded that traffic could cause short- or medium-term changes in the distribution of caribou near roads. Short-term displacements where caribou approach the road are deflected by traffic, but eventually cross at the original location, probably occur frequently (e.g., Surrendi and deBock 1976; Russell and Martell 1985). Longer-term displacement in which caribou do not cross the highway or move a considerable distance before crossing have also been observed. In one case, a group of about 1000 caribou attempted to cross the highway near the Yukon-NWT border but were deflected by traffic. These animals then moved along a ridge parallel to the highway and eventually crossed near Eagle Plains about 110 km from their original attempted crossing point (D. Krutko, pers. comm.). This type of change in the distribution of caribou may be significant both to harvest levels (if a temporary increase in the number of caribou near the highway increases the harvest) and to distribution of the harvest (if traditional migration routes that cross the highway are changed).

Link 10: Traffic on the proposed road inland from King Point could act as a barrier to the bull/barren cow segment of the herd and force animals to travel greater distance to reach the large post-calving congregations of caribou.

As discussed in previous links, increased traffic on roads on the North Slope may impede movement of caribou along the Richardson Mountains migration route. It was suggested that monitoring of caribou movement and convoying of traffic when caribou were present could minimize interference with migration. However, some members of the working group were uncertain that regulations requiring convoys could be justified because they believed that (1) deflection of this segment of the herd inland around the quarry was unlikely to cause a significant increase in energy expenditure and (2) blockage of movement of some individuals would not likely cause significant effects on the population. Other participants agreed that the potential effects of traffic on the caribou population in the spring were not as significant as those during the insect season. However, they indicated that some provision for monitoring the approach of caribou should be made and that convoying or other measures should be employed in years when a large number of animals are migrating.

CONCLUSION

The subgroup considered the overall hypothesis to be valid. In particular, there is evidence to suggest that insect harassment in conjunction with severe winters can affect calf survival. Therefore, reduced access to insect-relief habitat could affect the abundance of caribou. (However, mitigative techniques, such as road closures during the week when large groups of caribou are moving east, could prevent traffic from restricting access of caribou to insect-relief areas).

Presently, road kills are less than 100 animals/year. Projected traffic levels are about three times greater than present levels. If a linear relationship between the number of road kills and the volume of traffic is assumed to exist then about 300 caribou would be lost each year.

Traffic on the Dempster Highway has caused some caribou to alter and delay their movements. Although the animals eventually cross the highway, it is not always at the original crossing site or within the same day. With increased traffic, longer-term changes in the distribution of caribou and the location of crossing sites along the highway may occur. A primary concern of some members of the subgroup was that changes in the distribution of caribou would influence the success of native hunters.

RESEARCH

The group concluded that research on the use of insect-relief habitat by caribou should be continued. This research is presently being conducted by the Canadian Wildlife Service. Initiation of further studies should be contingent on the results of the present research.

MONITORING

Aerial monitoring of caribou movements in July should be initiated in the North Slope area (if the proposed roads are constructed) so that the appropriate measures can be taken to minimize interference with caribou migrations. In addition, the working group recommended that sightings of road kills along the Depster Highway be documented so that mitigative measures (e.g., warning signs, speed limits, convoys) could be employed if the number of caribou lost on the highway significantly increases.

During the workshop, much of the discussion focused on the potential effects of traffic on the distribution of caribou during fall migration and the development of an inexpensive method for determining whether the distribution would change in response to increased traffic levels. To monitor the effects of traffic on caribou distributions, information would have to be obtained regarding (1) traffic levels in September and most of October, and (2) the number of animals harvested and the locations where they are harvested. Information about traffic levels in September and most of October can be obtained from ferry records. Hunter checks to determine number of animals taken already exist. It was considered feasible to obtain information about locations where harvested animals were taken through the existing system. Information from these two sources would have to be combined with data regarding seasonal movements of the Porcupine herd before any conclusions about change in distribution of harvest could be drawn. Therefore, the subgroup recommended the continuation of the program that is being conducted by the Yukon territorial government and the Canadian Wildlife Service to monitor the distribution and movements of the Porcupine caribou herd.

LITERATURE CITED

Bergerud, A.T., R.O. Jakimchuk and D.R. Carruthers. 1984. The buffalo of the north: Caribou (Rangifer tarandus) and human developments. Arctic 37:7-22.

Curatolo, J.A. and D.G. Roseneau. 1977. The distribution and movements of the Porcupine caribou herd in northeastern Alaska and the Yukon Territory, 1976. Rep. by Renewable Resources Consulting Services Ltd. 59 p.

Dau, J.R. and R.D. Cameron. 1985. Responses of barren-ground caribou to petroleum development near Milne Pt., Alaska. Appendix A. In: Smith, W.T., R.D. Cameron and K.R. Whitten. 1985. Distribution and movements of caribou in relation to the Kuparuk development area. Alaska Dep. Fish and Game Prog. Rep. Fed. Aid in Wildl. Restor. Proj. W-22-2, W-22-3 and W-22-4. Job 3:30.

Dauphiné, T.C., Jr. 1976. Biology of the Kaminuriak population of barren-ground caribou. Part 4: Growth, reproduction and energy resources. Can. Wild. Serv. Rep. Ser. No. 38.

Dieterich, R.A., J.K. Morton and S.L. Rauch. 1981. Reindeer health aide manual. University of Alaska.

Dickinson, D.M. and T.B. Herman. 1979. Management of some terrestrial mammals in the Northwest Territories for sustained yields. Report for Science Advisory Board of N.W.T. 71 p.

Helle, T. and L. Tarvainen. 1984. Effects of insect harassment on weight gain and survival in reindeer calves. Rangifer 4:24-27.

Horejsi, B.L. 1981. Behavioural responses of barren ground caribou to a moving vehicle. Arctic 34:180-185.

Hout, J. and M. Beaulieu. In press. Relationship between parasite infestation levels and body fat reserves in George River caribou in spring and fall. 2nd North American Caribou Workshop, Montreal.

Jakimchuk, R.D. 1980. Disturbance to barren-ground caribou: A review of the effects and implications of human developments and activities. Rep. by R.D. Jakimchuk Management Assoc. Ltd. In: Analyses of the characteristics and behaviour of barren-ground caribou in Canada. Polar Gas Project, Toronto.

Kelsall, J.P. 1968. The migratory barren-ground caribou of Canada. Queen's Printer, Ottawa. 340 p.

Russell, D.E. and A.M. Martell. 1985. Influence of the Dempster Highway on the activity of the Porcupine caribou herd. Pages 22-26. In: A.M. Martell and D.R. Russell (eds.). Caribou and Human Activity. Proc. 1st North Am. Caribou Workshop. Whitehorse, Yukon, 28-29 Sept. 1983. Can. Wildl. Serv. Spec. Publ., Ottawa. 68 p.

Skogland, T. and Ø. Mølmen. 1980. Prehistoric and present habitat distribution of wild mountain reindeer at Dovrefjell. Pages 130-141. In: Reimers, E., E. Gaåre and S. Skjenneberg (eds.). Proc. 2nd Int. Reindeer/Caribou Symp. Røros, Norway. Direktoratet for vilt og ferskvannfisk, Trondheim.

Smith, W.T., R.D. Cameron and K.R. Whitten. 1985. Distribution and movements of caribou in relation to the Kuparuk development area. Alaska Dept. Fish and Game Prog. Rep. Fed. Aid in Wildl. Restor. Proj. W-22-2, W-22-3 and W-22-4. Job 3:30.

Surrendi, D.C. and E.A. deBock. 1976. Seasonal distribution, population status and behavior of the Porcupine caribou herd. Rep. by Can. Wildl. Serv., Edmonton. Mackenzie Valley Pipeline Investigations. 144 p.

Thomas, D.C. 1982. The relationship between fertility and fat reserves of Peary caribou. Can. J. Zool. Vol. 60:597-602.

Tracy, D.M. 1977. Reactions of wildlife to human activity along Mount McKinley National Park Road. M.Sc. Thesis. Univ. of Alaska, Fairbanks. 260 p.

HYPOTHESIS NO. 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

PARTICIPANTS

Susan Fleck	Nicholas Sonntag
Harvey Jessup	Dave Thomas
Cal Sikstrom	Walt Younkin

INTRODUCTION

In the Northwest Territories, the distribution of grizzly bears is generally limited to the treeline, tundra and mountains, while black bears are dispersed throughout the boreal forest. The average density of grizzly bears on Richards Island and the Tuktoyaktuk Peninsula has been estimated at one bear per 250 km^2, which is much lower than that observed for other grizzly bear populations in the Yukon and N.W.T. (Miller et al. 1982; Nagy et al. 1983).

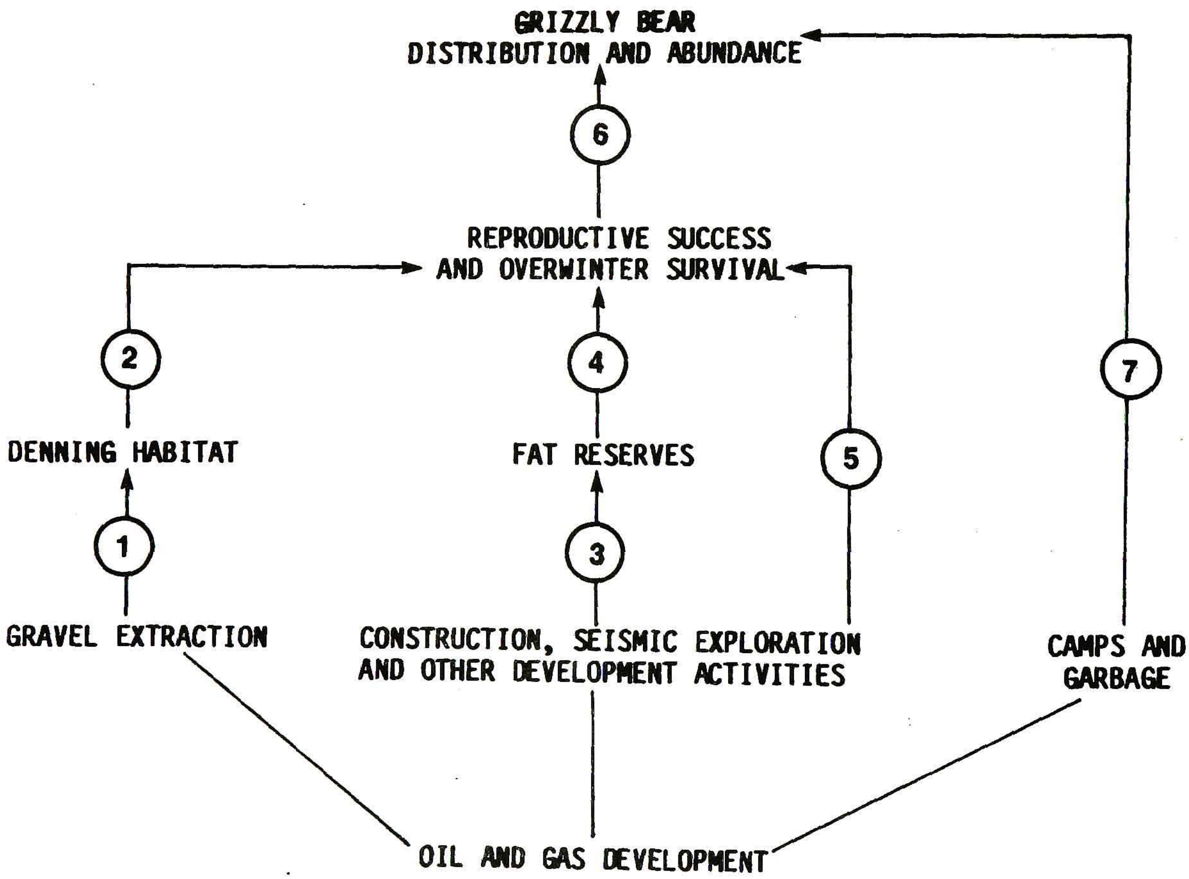
Like polar bears, grizzlies have very low adult mortality rates and a low reproductive potential. In the Mackenzie Delta area, females do not breed until they are 5 years old and produce an average of 2.2 cubs every three or four years (Nagy et al. 1983). Grizzlies maintain territories. Male and female territories overlap, but adult males will not tolerate the presence of any other male. Females will occasionally share their territory with a daughter (Pearson 1975).

All grizzly bears hibernate during the winter. They enter dens in early October and do not emerge until seven or eight months later (Nagy et al. 1983). During denning, the bears lose an average of 25-30% of their fall body weight.

After emergence from their dens, bears continue to lose weight until mid-July, although they continue to feed on tender green sedges and forbs and

FIGURE 3-1

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



LINKAGES

Link 1: Gravel extraction will remove denning habitat.

Link 2: A decrease in denning habitat will result in a decrease in reproductive success and overwinter survival.

Link 3: Construction and other development activities during late summer may disrupt feeding activity and increase movement of bears, which will result in decreased fat reserves in the fall.

Link 4: Fat reserves determine reproductive success, overwinter survival and quality of the fur.

Link 5: Construction, seismic exploration and other development activities during winter may cause bears to abandon their dens, which will reduce overwinter survival and reproductive success.

Link 6: Reproductive success and overwinter survival determine, in part, the size of the grizzly bear population.

Link 7: Grizzly bears that are attracted to camps and garbage may be destroyed as nuisance animals, which will result in a decrease in the grizzly bear population.

the occasional reindeer carcass (Nagy et al. 1983). Between mid-July and mid-September, the bears must feed extensively to build up fat reserves for winter. In late summer, bears become extremely hungry and search for fat- and carbohydrate-rich food sources that are easily converted into fat reserves.

Bears have been hunted in the Richards Island/Tuktoyaktuk Peninsula region for many years. The Tuktoyaktuk Hunters and Trappers Association (HTA) has a quota for five grizzlies which allows successful hunters to sell the hides or to offer sport hunts. With an average price of $3000-$5000/sport hunt, grizzly bears provide a substantial source of revenue.

Concerns related to the effects of hydrocarbon development in the northern Mackenzie Valley region on grizzly bears are (1) disturbance during the August-September feeding period; (2) disturbance of dens; (3) loss of denning habitat; and (4) increase in numbers of nuisance bears. These effects could influence the reproductive success and/or overwinter survival of grizzly bears, and cause a decrease in the abundance of these animals (Fig. 3-1).

Proposed oil industry facilities could affect grizzly bears primarily on the Tuktoyaktuk Peninsula or in the Mackenzie Delta, as well as near Holmes Creek and Parsons Lake. Grizzly bears in the Colville Lakes region or within the Mackenzie River Valley near Norman Wells could also be affected by development in these areas.

LINKAGES

Link 1: Gravel extraction will remove denning habitat.

Within the Mackenzie Delta and on the Tuktoyaktuk Peninsula, bears are known to prefer den sites along lake shores and stream banks with sandy or silty soils (Harding 1976). Dens are rarely used more than once, and fidelity to den sites has not been observed (Mychasiw and Moore 1984).

Development activities will require substantial amounts of sand and gravel. Because of land use regulations, sites selected for extraction operations are generally located on well-drained terrain not adjacent to water bodies. Most borrow areas will only be used during short construction periods, and the deposits remaining after extraction operations should still provide some suitable denning habitat for grizzly bears. Although den sites can be a limiting factor to the overwinter survival of grizzly bears (Pearson 1975), given the proposed development scenarios, this is not expected to be a significant concern. Suitable denning habitat is widespread in the study area (Pearson and Nagy 1976).

Link 2: A decrease in denning habitat will result in a decrease in reproductive success and overwinter survival.

This link is considered invalid because gravel extraction operations are not expected to result in a reduction in the availability of den sites for grizzly bears.

Link 3: Construction and other development activities during late summer may disrupt feeding activity and increase movement of bears, which will result in decreased fat reserves in the fall.

No studies have been conducted to determine if disturbance of bears by human activities will result in reduced fat reserves. Studies of bear behaviour in parks have indicated that bears actively avoid humans (Herrero 1985). Harding and Nagy (1980) reported that bears tended to avoid active drilling and staging camps by distances of at least 1 km. In Alaska, the heart rate of bears in dens was higher when there was construction activity during the period of denning (Reynolds et al. 1983). Black bears in the vicinity of the Tar Sands project at Cold Lake, Alberta, were more active than bears that resided elsewhere (Tietje and Ruff 1983).

The above evidence suggests that human activity in the vicinity of bears can result in increased activity of some individuals and cause avoidance of parts of their territory. If the disturbance occurs during the July-September feeding period, it might disrupt normal feeding activities and prevent bears from gaining the necessary weight (i.e., fat reserves) needed for the winter months. In the summer of 1986, radio-collared bears on Richards Island will be observed to determine whether or not bears avoid areas of hydrocarbon exploration activity.

Link 4: Fat reserves determine reproductive success, overwinter survival, and quality of the fur.

In the context of this link, reproductive success is defined as the potential for a female to give birth to cubs. Grizzlies mate in June, but the fetuses do not become implanted in the womb until October. The cubs are born in late December and suckle the female while she hibernates. By spring, the cubs weigh 5-7 kg.

Little definitive information on grizzly bears is available in relation to the validity of this link. In Minnesota, female black bears that did not reach a threshold fall weight did not produce cubs during the following spring (Rogers 1976). Nagy et al. (1983) reported finding a cub that apparently died of starvation during the winter. Other instances of emaciated subadults and old bears found dead in their dens have been documented (Reynolds et al. 1976). In the Arctic, where grizzly bears hibernate for 7-8 months of the year and pregnant females have an additional energy cost associated with the support of 2 or 3 growing cubs, adequate fat reserves are extremely important for both the overwinter survival of bears and, in particular, reproductive success.

It was noted that the quality of grizzly fur is very important to sport hunters (A. Adams, pers. comm.). However, the relationship between the quality of fur and the fat reserves of bears is presently unknown.

Link 5: Construction, seismic exploration and other development activities during winter may cause bears to abandon their dens, which will reduce overwinter survival and reproductive success.

Harding and Nagy (1980) reported that two grizzly bears abandoned their dens as a result of winter seismic operations and gravel mining. During winter, energy demands increase dramatically for a non-hibernating bear and survival of the animal is unlikely (R. Archibald, pers. comm.). If development activity causes a female with cubs to abandon her den, the potential for both reproductive success and overwinter survival will be reduced.

Link 6: Reproductive success and overwinter survival determine, in part, the size of the grizzly bear population.

This link is self-evident and valid. Recruitment into the population is determined primarily by the number of cubs born and their subsequent survival. Since grizzly bear cubs and subadults already have the highest rate of natural mortality (Nagy et al. 1983), a further reduction in the number of cubs born and in the overwinter survival of subadult bears will reduce recruitment into the breeding population and cause a gradual decline in the size of the population.

Link 7: Grizzly bears that are attracted to camps and garbage may be destroyed as nuisance animals, which will result in a decrease in the grizzly bear population.

It has been well documented that grizzly bears are attracted to camps and garbage (Herrero 1985) because they provide an accessible and concentrated source of food. Once a bear becomes habituated to garbage, it may be extremely difficult to deter the animal from the site. In these cases it is sometimes necessary to destroy the bear if it becomes a nuisance or safety hazard.

Proper handing of camp wastes and garbage, the implementation of awareness programs, and the use of bear detection and deterrent techniques could be effective in reducing the number of bear encounters that occur. Research on methods for detecting and deterring bears is being conducted at Churchill, Manitoba and Norman Wells (Stenhouse 1982, 1983; Clarkson, in press). A deterrent technique involving the use of guns that fire rubber bullets is particularly promising and could be effective in reducing the number of bear kills.

A sustainable yield of less than 2% has been calculated for adult female polar bears using a population model developed by Taylor et al. (in press). Since the population characteristics of grizzly bears in the Mackenzie Delta are similar to those employed in the polar bear model, the subgroup expected that the sustainable yield for the grizzly bear population would be only slightly higher than that predicted for polar bears. Nagy et al. (1983) suggested that the bear population in the Delta area (estimated at 80 animals) could not sustain an average annual mortality of over 7 or 8 individuals. In the event that the number of nuisance bear kills exceeds the present quota of 5 bears, a gradual decline in the size of grizzly bear populations in the Mackenzie Delta and Tuktoyaktuk Peninsula area would likely occur.

CONCLUSION

Given the current development scenario, the subgroup concluded that this hypothesis is valid. In view of present harvest levels and low reproductive rates, an increase in bear mortality due to development activities (e.g., nuisance bear kills), that exceeds population losses associated with the harvest, is expected to result in a gradual decline in the grizzly bear population. However, the potential effects of development activities that directly influence bear populations (i.e., disturbance of denning bears and bear/human conflicts that result from improper garbage handling practices) could be controlled by appropriate planning and mitigative techniques.

Given the probable scale and timing of hydrocarbon development in the region, it is not expected that bears would avoid large portions of their range or be disturbed so frequently in late summer that they do not accumulate sufficient fat reserves. Although gravel extraction operations will remove some bear denning habitat, this is not expected to cause a reduction in the reproductive success or the overwinter survival of grizzly bears because of the large amount of suitable denning habitat available within the region.

RESEARCH AND MONITORING

Records of the number of grizzly bears observed or killed near camps should continue to be maintained in support of efforts to determine population sizes and mortality rates. The subgroup also recommended continued support of bear awareness programs and deterrent/detection research that is presently being conducted by the N.W.T. Wildlife Service. In addition, the N.W.T. Wildlife Service has been conducting a program that involves radio-collaring grizzly bears on Richards Island to update the population estimate and to investigate the movements and feeding patterns of bears in relation to industry activity. This research is expected to continue until 1987.

LITERATURE CITED

Clarkson, P. In press. Presented at the International Conference on Northern Hydrocarbon Development: Environmental Problem Solving. Banff, Alta. 24-26 September, 1985.

Harding, L.E. 1976. Den site characteristics of arctic coastal grizzly bears (Ursus arctos L.) on Richards Island, N.W.T. Canada. Can. J. Zool. 54:1357-1363.

Harding, L.E. and J.A. Nagy. 1980. Responses of grizzly bears to hydrocarbon exploration on Richards Island, NWT, Canada. Pages 277-280. In: Martinka, C.J. and K.L. McArthur. Bears - their biology and management. Bear Biology Assoc. Conf. Ser. No. 3. 375 p.

Herrero, S. 1985. Bear attacks - their causes and avoidance. Winchester Press. Piscataway, N.J. 287 p.

Miller, S.J., N. Barichello and D. Tait. 1982. The grizzly bears of the Mackenzie Mountains, N.W.T. Completion Rep. No. 3. N.W.T. Wildl. Serv. Yellowknife, N.W.T. 118 p.

Mychasiw, L. and S. Moore. 1984. Extrapolative methods for assessing barren-ground grizzly bear denning habitat and preliminary mapping of denning habitat in the Mackenzie Delta area. N.W.T. Wildl. Serv. MS Rep. Yellowknife, N.W.T. 23 p.

Nagy, J.A., R.H. Russell, A.M. Pearson, M.C.S. Kingsley and C.B. Larsen. 1983. A study of grizzly bears on the barren-ground of Tuktoyaktuk Peninsula and Richards Island, N.W.T., 1974 to 1978. Can. Wildl. Serv. Edmonton, Alta. 136 p.

Pearson, A.M. 1975. The northern interior grizzly bear (Ursus arctos L.). Can. Wildl. Serv. Rep. Ser. No. 34. 86 p.

Pearson, A.M. and J.A. Nagy. 1976. The arctic coastal grizzly bear and the potential impact of the proposed Inuvik-Tuktoyaktuk highway. Unpubl. Rep. CWS 24-76. Can. Wild. Serv. Edmonton, Alta. 9 p.

Reynolds, H.V., J.A. Curatolo and R. Quimby. 1976. Denning ecology of grizzly bears in northeastern Alaska. Pages 403-409. In: Pelton, M.R., J.W. Lentfor and G.E. Folk (eds.). Bears - their biology and management. Morges, IUCN Publ. New Ser. No. 40. 467 p.

Reynolds, T., H. Reynolds and E.H. Follman. 1983. Effects of seismic surveys on denning grizzly bears in north Alaska. Proc. I.B.A. Grand Canyon, Arizona.

Rogers, L.L. 1976. Effects of mast and berry crop failures on survival, growth and reproductive success of black bears. Trans. N. Am. Wildl. Nat. Resource. Conf. 41:431-438.

Stenhouse, G. 1982. Bear detection and deterrent study, Cape Churchill, Man. 1981. N.W.T. Wildl. Serv. File Rep. 23. 26 p.

Stenhouse, G. 1983. Bear detection and deterrent study, Cape Churchill, Man. 1982. N.W.T. Wildl. Serv. File Rep. 37. 65 p.

Taylor, M.K., D.P. DeMaster, F.L. Bunnell and R.E. Schweinsburg. In press. Sustainable harvest of polar bears. (Submitted to Oecologia).

Tietje, W.D. and R.L. Ruff. 1983. Response of black bears to oil development in Alberta. Wildl. Soc. Bull. 11(2):99-112.

HYPOTHESIS NO. 4

OIL AND GAS DEVELOPMENT ACTIVITIES WILL ALTER THE WATER REGIME AND DECREASE MUSKRAT POPULATIONS

PARTICIPANTS

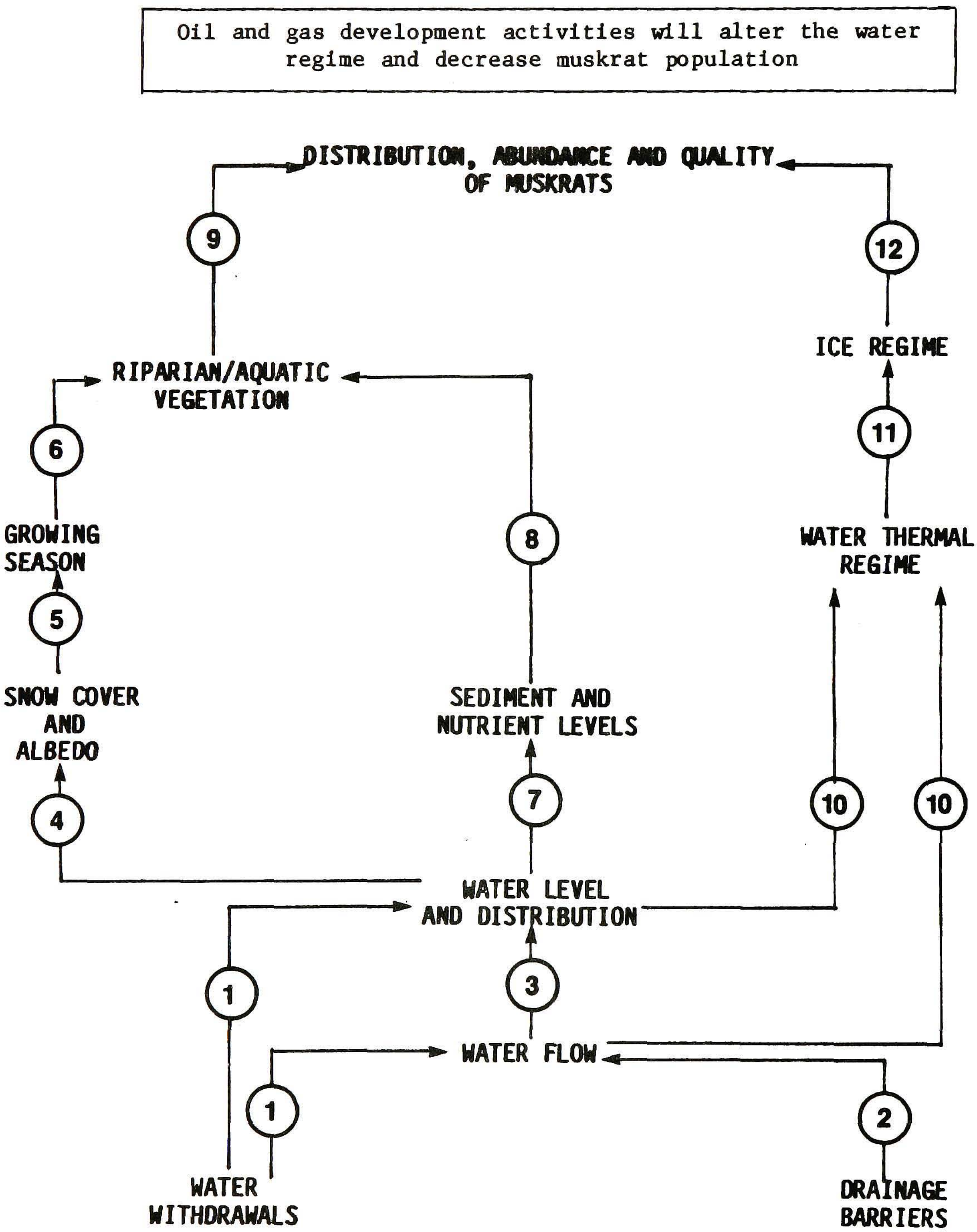
Lorraine Allison	John McDonald
Andrew Cullen	Maurice Mendo
Lee Doran	Mike Miles
Susan Fleck	Nicholas Sonntag
Harvey Jessup	Dave Sutherland
Steve Matthews	

INTRODUCTION

Within the study area, muskrats occur primarily on the Mackenzie Delta. The Delta has the highest concentration of good quality muskrat habitat in the Northwest Territories (Dennington et al. 1973). The best quality habitat is located in the upper Mackenzie Delta rather than in lower areas adjacent to the Beaufort Sea. Two long-term studies on muskrat populations in the Delta indicate that muskrat numbers fluctuate widely and possibly cyclically in this region (Stevens 1953; Hawley and Hawley 1975). Populations may be limited by: (1) food availability, particularly in winter: (2) lack of suitable denning sites; and (3) freezing of shallow lakes (Stevens 1953; Ambrock and Allison 1973). Although two litters are produced by some females in the Delta, (Stevens 1953), productivity is not as high as in temperate portions of their range where as many as three litters are produced in a single season (Fuller 1951; Ambrock and Allison 1973). Survival of young muskrats is very low, particularly over the winter (Stevens 1953; Hawley and Hawley 1975).

Every spring, hunters and trappers from Inuvik and Aklavik travel to traditional areas within the Delta to hunt and trap muskrats. Residents in other Mackenzie Valley communities harvest smaller muskrat populations which are located primarily along shallow rivers and lakes throughout the

FIGURE 4-1


Oil and gas development activities will alter the water regime and decrease muskrat population
DISTRIBUTION, ABUNDANCE AND QUALITY OF MUSKRATS
9
12
ICE REGIME
RIPARIAN/AQUATIC VEGETATION
11
6
GROWING SEASON
8
WATER THERMAL REGIME
5
SNOW COVER AND ALBEDO
SEDIMENT AND NUTRIENT LEVELS
4
7
10
10
WATER LEVEL AND DISTRIBUTION
1
3
WATER FLOW
1
2
WATER WITHDRAWALS
DRAINAGE BARRIERS

LINKAGES

Link 1: Water withdrawals will decrease water flow in smaller streams and water levels in smaller lakes.

Link 2: Physical drainage barriers across the Mackenzie Delta will interrupt the pattern of water flow.

Link 3: Patterns of water flow determine water levels and distribution.

Link 4: The timing and extent of overbank flooding determine the duration of snow cover and the albedo.

Link 5: The duration of snow cover and albedo influence the length of the growing season.

Link 6: The length of the growing season influences the growth and species composition of riparian and aquatic vegetation.

Link 7: The timing and extent of overbank flooding affect the levels and distribution of nutrients and sediments.

Link 8: The levels and distribution of nutrients and sediments influence the growth and species composition of riparian and aquatic vegetation.

Link 9: The growth and species composition of riparian and aquatic vegetation affect the population size and quality of muskrats through influences on feeding and survival.

Link 10: Changes in water flow and water level affect the water thermal regime.

Link 11: The water thermal regime affects the ice regime.

Link 12: The ice regime affects survival of muskrats.

study area. Between 1975 and 1980, the average value of the annual muskrat harvest was over $580,000 (Tinling 1982).

Suitable muskrat habitat depends upon predictable seasonal water levels. Increases to those water levels can result in flooding of breeding chambers and increased winter predation under the ice; decreases can result in loss of habitat. Although current oil and gas development scenarios should not result in large-scale water level changes in the Mackenzie Delta, some potential for local changes in water levels does exist due to site-specific water withdrawal requirements.

Although most of the detailed information on muskrat populations in the Mackenzie Delta is 15 years old or more, there is no reason to suspect that the biophysical conditions that produce such favourable muskrat habitat in this region have changed substantially over the last few years.

LINKAGES

Link 1: Water withdrawals will decrease water flow in smaller streams and water levels within smaller lakes.

Water withdrawals associated with hydrocarbon development are anticipated for: (1) hydrostatic testing of pipeline sections; (2) water re-injection at some production wells; and (3) water supplies at construction camps and processing facilities.

Hydrostatic Testing: The present technology in pipeline testing may allow the use of air rather than water as the medium during testing for pipeline integrity. The recently completed IPL oil pipeline from Norman Wells to Zama Lake was tested using air, except at the two large crossings across the Mackenzie mainstem and the Great Bear River. Air was approved as a suitable medium because the 324 mm diameter pipe was of 'high quality' and not subject to 'running fractures' (A. Pick, IPL, pers. comm.). Air testing of pipeline integrity is currently controlled in the south by a site-by-site approval process because of safety concerns and the higher human population densities. Air tests are not considered feasible for large-diameter, high-pressure pipelines of any considerable length. However, if suitable high-pressure gas is available, there is the possibility of its use as a test medium. If water testing is required for northern pipelines, the normal practice would be to withdraw water from larger streams or lakes to minimize the effects of this procedure on water levels. The pipeline companies are also investigating the possibility of "shuttle testing", which is the use of the same water or air for testing successive lengths of pipe. Approximately 65 m^3 of water per 100 m of pipe is the unit capacity of the proposed Polar Gas 914-mm gas pipeline. Lesser or greater amounts of water could be required depending on details of the procedure finally adopted. It is expected that larger water bodies will be available as a source over most of the proposed pipeline route. In the few locations where it may be necessary to withdraw water from smaller streams, changes in withdrawal rates could be used to alleviate effects.

Water Injection: Water injection requirements at production wells could also require relatively large amounts of water. However, this is not expected to result in large-scale water level changes since most of the production facilities will be located adjacent to large water bodies, i.e., main channels of the Mackenzie River and offshore of the Mackenzie Delta within Mackenzie Bay. Some potential exceptions are production wells located onshore along the Tuktoyaktuk Peninsula. However, this region is poor muskrat habitat and, therefore, was not considered an issue. Another region which is not currently part of future production plans (exploration only) is the Colville Lake area. Depending on the result of exploratory drilling and the prospects for future production, water injection sources for production facilities (if required) would likely be located at considerable distances from the larger water bodies in this area.

Human Consumption: Water required for construction camps and accommodation facilities at production fields will typically be taken from mainstem Mackenzie River channels, as was the case during construction of the Norman Wells IPL pipeline (S. Matthews, N.W.T. Renewable Resources, pers. comm.).

Link 2: Physical drainage barriers across the Mackenzie Delta will interrupt the pattern of water flow.

Physical barriers such as pipeline berms, well-site structures, staging areas and access roads have the potential to influence the distribution of floodwaters in the outer (New) Delta, which may, in turn, affect the structure of muskrat habitat. The only significant (but localized) effects are expected near the Taglu, Niglintgak and Adgo fields on the outer portions of Richards Island. Such barriers could alter the regular patterns of spring flooding in floodplain areas that are located some distance from the channels. Removal of the snow and ice cover by seasonal flooding in downstream areas behind pipeline berms may be delayed or, in some cases, may not occur at all. The most significant effects would be expected at a few small and intermittent locations (up to a few kilometres across) on the northern side of east-west pipeline berms from Taglu to Niglintgak and/or Adgo. In these regions, limited change in the species composition of riparian and aquatic vegetation could result. However, this potentially affected area of the outer Delta is not typically used for the harvest of muskrat (Milton Freeman Research Limited 1976). The harvest occurs primarily to the south within the inner Delta and extends only as far north as a line about 10 km south of the low relief Taglu-Niglintgak floodplain. It is postulated that smaller numbers of muskrats reside in the Taglu-Niglintgak floodplain area due to less suitable denning habitat because of poor bank conditions and unstable water levels caused by storm surges on the outer Delta (L. Allison, pers. comm.).

CONCLUSION

The working group concluded that the first two links of this hypothesis were invalid or inconsequential. As a result, discussion of the remaining links shown in Figure 4-1 was considered unnecessary. No significant decrease in the Mackenzie Delta muskrat populations are expected as a result of water withdrawal and drainage disruption associated with hydrocarbon development. Therefore, no research or monitoring is recommended.

The areas identified within the MEMP study region that could experience significant water withdrawal and/or floodplain alterations because of development-related activities or facilities are not located within principal muskrat habitat or harvest regions. Localized groups of muskrats could be affected by operations in the area that influence a few smaller lakes. However, these effects are expected to be short term, if they occur at all due to the high reproductive capacity of muskrats. A significant proportion of prime muskrat habitat would have to be affected (e.g., by long-term variations in water levels of the Mackenzie River) before effects at the population level could be detected. In localized areas where muskrats have been extensively harvested or where habitat has been altered or disturbed, the populations typically return to normal levels within a short period once suitable habitat has been re-established (L. Allison, pers. comm.).

LITERATURE CITED

Ambrock, K. and L.M. Allison. 1973. Status of muskrat on the Peace-Athabasca Delta. In: The Peace-Athabasca Delta Project. Technical Appendices Volume 2: Ecological Investigations. 67 p.

Dennington, M.C., D.E. Johnson and H.A. Stelfox. 1973. Atlas of beaver and muskrat habitat maps. In: Wildlife Habitat Inventory of the Mackenzie Valley and northern Yukon. Vol. 1 Prep. Can. Wildl. Serv. for Environ.-Social Prog. Northern Pipelines.

Fuller, W.A. 1951. Natural history and economic importance of the muskrat in the Athabasca-Peace Delta, Wood Buffalo Park. Can. Wildl. Serv. Wildl. Manage. Bull. Ser. 1 80 p.

Hawley, V. and L.A. Hawley. 1975. Mackenzie Delta muskrat management. Can. Wildl. Serv. Unpubl. rep. 103 p.

Milton Freeman Research Limited. 1976. Inuit land use and occupancy project. Volume 3: Land Use Atlas. Rep. prep. for Can. Dep. Indian and Northern Affairs.

Stevens, W.E. 1953. The northwestern muskrat of the Mackenzie Delta, Northwest Territories, 1947-48. Can. Wildl. Serv. Wildl. Manage. Bull., Ser. 1. 46 p.

Tinling, R. 1982. Northwest Territories fur production 1957-58 to 1978-79. N.W.T. Wildl. Serv., Info. Rep. No. 1. Yellowknife, N.W.T. 45 p.

HYPOTHESIS NO.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.

PARTICIPANTS

Lorraine Allison	Margaret McLaren
Lee Doran	Peter McNamee
Ron Graf	Maurice Mendo
David Krutko	Wendy Nixon
Steve Matthews	Archie Pick

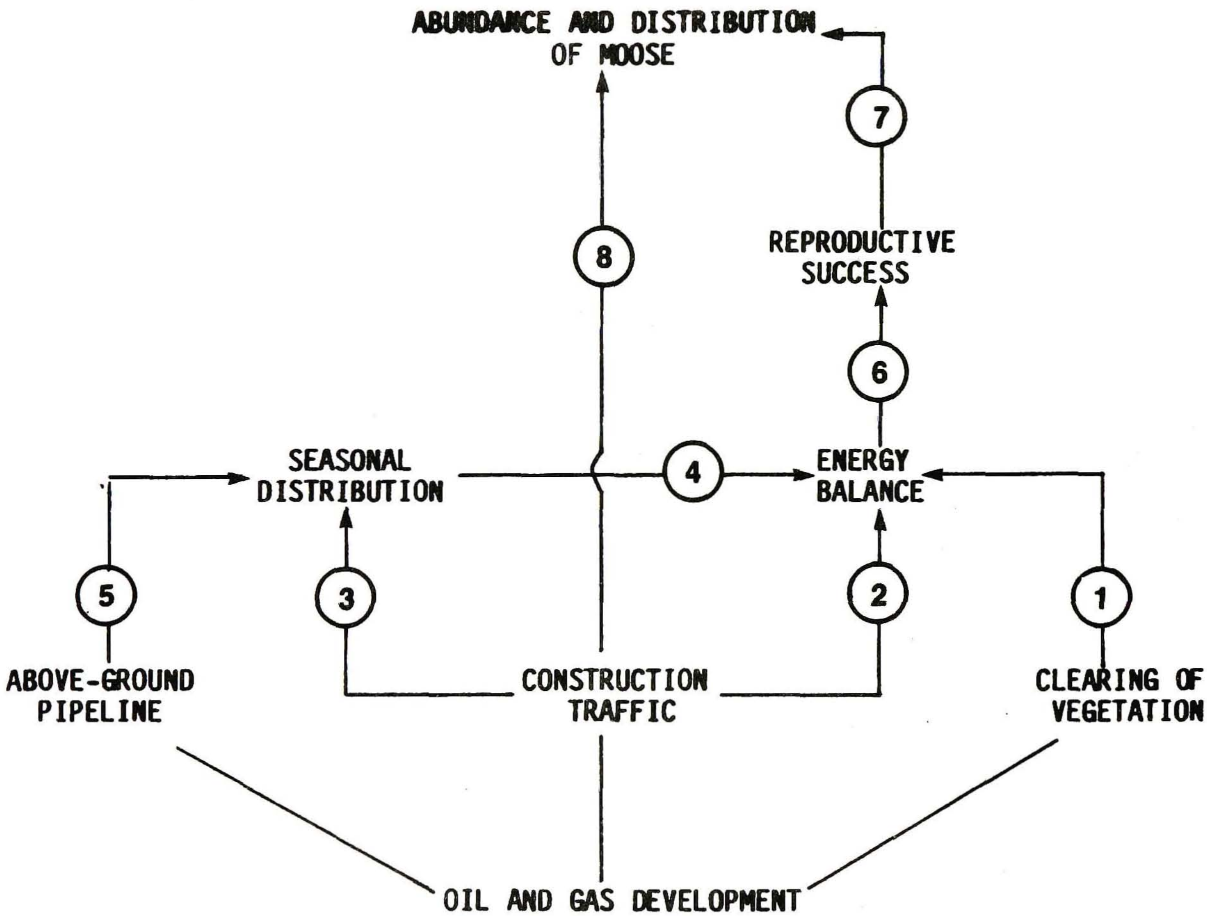
INTRODUCTION

Moose are widely dispersed throughout forested portions of the MEMP study area. During the summer months, they are also found on the North Slope where they occur primarily along streams (Doll et al. 1974). Moose generally calve in late May or early June in lowland riparian areas or alluvial islands. During the summer, some moose may remain near the rivers, but most move into adjacent upland areas where they feed primarily on aquatic vegetation. The rut occurs in September and October. Moose winter in riparian areas such as the Mackenzie River islands or burn areas where there is an abundant supply of food or, less frequently, in upland areas. The winter range consists of early successional areas where substantial shrub growth is interspersed with coniferous cover. In the Northwest Territories, prime winter habitat is maintained by periodic flooding and forest fires (Prescott et al. 1973; Watson et al. 1973). Such habitat is believed to occur between 11 and 50 years after a fire (Kelsall et al. 1977), depending on the intensity of the fire. After very intense fires, rootstocks of willows are destroyed and regeneration is slow (M. Mendo, pers. comm.).

There is limited information regarding moose populations in the MEMP study area. The few data that are available indicate that densities of moose in the Mackenzie Valley are considerably lower than those in other parts of North America (Treseder and Graf 1985). Within the study area, the lower

FIGURE 5-1

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



LINKAGES

Link 1: Wood-chipping operations, seismic lines, right-of-way, and other clearing will increase the amount of food available to moose in the short to medium term.

Link 2: Construction activities and associated traffic will disturb and harass female moose and their young and cause individuals to expend more energy to locate suitable habitat.

Link 3: Construction activities and associated traffic will disturb moose populations and lead to a change in distribution and the location of some individuals in alternative habitats and areas.

Link 4: Changes in the seasonal distribution of moose will increase the amount of energy required for some individuals to locate suitable habitat.

Link 5: An above-ground pipeline will prevent the passage of moose, which will lead to changes in migration patterns.

Link 6: The energy balance of an adult determines its reproductive success.

Link 7: Reproductive success determines, in part, the number of moose in the population.

Link 8: Increased traffic associated with development will result in increased numbers of moose killed through collisions with vehicles.

Mackenzie River valley from Fort Norman to Fort McPherson supports relatively high moose densities (Brackett et al. 1985). Islands in this region provide excellent winter range (Prescott et al. 1973), while there is lower quality range in the Mackenzie Delta. Although riparian vegetation is kept at an early stage of development by ice damage and flooding, thereby providing an abundant source of food for moose, coniferous cover used for shelter is limited on the Delta. Densities of moose in the Delta average less than 1/100 km^2 and the entire Delta population has been estimated at 300 animals (Brackett et al. 1985).

The impact hypothesis for moose addresses three sets of linkages: (1) effects of increased traffic levels on permanent roads, particularly the Dempster Highway, (2) potential effects of an above-ground pipeline on moose movements, and (3) effects of clearing forested areas.

LINKAGES

Link 1: Wood-chipping operations, seismic lines, right-of-way and other clearing will increase the amount of food available to moose in the short to medium term.

Optimum moose habitat, particularly winter habitat, consists of an interspersion of areas that provide food and cover. Moose browse on shrubs, particularly willows, and use nearby stands of coniferous trees for shelter. These conditions are often found in areas that have been affected by moderately intense forest fires or selective logging (e.g., Bergerud and Manual 1968; Watson et al. 1973; Krefting 1974). Telfer (1970) found that logging in eastern Canada resulted in a 50-fold increase in browse seven years after cutting. An increase in shrub growth of this magnitude in the Northwest Territories is unlikely because of harsher climatic conditions in the region. Nevertheless, it is expected that cutting trees for wood-chip production and creation of new 'edges' along pipeline right-of-way, seismic lines and around industry facilities will increase the amount of food available to moose.

Whether new habitat created by construction activities will be used by moose depends to some extent on the size and shape of the cleared areas.

Telfer (1974) suggested that moose will use openings of up to 128 ha (0.5 mi^2) in size. However, Hamilton and Drysdale (1975) found that moose seldom moved more than 40 m from cover, and never went beyond 100 m. It should be noted that neither of these studies was in the N.W.T. These observations may indicate that the behaviour of moose varies with location. It is expected that newly created habitat along seismic lines and rights-of-way will most likely be used by moose. However, use of the new habitat in areas cleared during wood-chipping operations may be variable and dependent on the size and shape of the clearing. Most areas cut for wood chips during construction of the IPL pipeline were 20-50 ha in size and will likely be used by moose. A few areas were up to 200 ha in size, but were selectively cut in irregular shapes to produce enhanced habitat for moose.

Table 5-1 provides estimates of the present total forested area and the amount of clearing projected in the current development plan for three regions within the MEMP study area. Since clearings along pipelines and, particularly, seismic lines will be created at different times, they will be at various stages of succession and will not all be of equal value as moose habitat at any one time. Although there is insufficient information regarding moose densities and the factors that control moose populations to make any predictions about the potential effects of this new habitat at the population level, it is clear that moderate amounts of feeding habitat may be created.

Table 5-1. Summary of major activities that will create clearings in three sections of the MEMP study area from 1985-2004.

	Mackenzie Delta	Colville Lakes	Norman Wells	Total
Total forest (km^2)	2830	97,200	27,200	127,230
Seismic lines (km x 1000)	381	278	52	711
Pipelines (km)	300	600	690	1590
Wood chipping	-	-	-	38 km^2 in 20-200 ha blocks

The length of time required for the regeneration of willows and other shrubs depends on the amount of ground disturbance that occurs, the initial floristic composition of the cleared area, and whether seeding and fertilization of disturbed areas is undertaken. For example, on pipeline right-of-way, seeding and maintenance of grasses could reduce the amount of browse that may otherwise be available. Similarly, seeding and fertilization may initially determine the composition of plant growth on spoil areas and borrow pits. In areas cleared for wood-chip production, willows may be cut, but will regenerate from the rootstock within one year. However, in areas where little or no willow is present (e.g., climax forests), it may take 3-5 years before browse for moose develops and growth of willow may never be extensive (W. Younkin, R. Graf, pers. comms.). In areas that are not cleared regularly (e.g., seismic lines that are not re-used, areas cut for wood-chip production), succession to coniferous forest would likely occur within 20-50 years (W. Younkin, pers. comm.). Therefore, these areas will only be of temporary value as feeding areas for moose.

The group concluded that Link 1 is valid, but that creation of additional moose habitat will not necessarily result in an increase in the abundance of moose.

Link 2: Construction activities and associated traffic will disturb and harass female moose and their young and cause individuals to expend more energy to locate suitable habitat.

There is little evidence to support this link. The subgroup agreed that moose were less likely to be affected by construction-related disturbances than more gregarious animals. During construction of the IPL pipeline, moose appeared to be relatively undisturbed (S. Matthews, pers.comm.). However, it was considered possible that in years with deep snow, moose may expend a greater amount of energy to locate suitable habitat as a result of disturbances caused by construction activities.

Link 3: Construction activities and associated traffic will disturb moose populations and lead to a change in distribution and location of some individuals in alternative habitats and areas.

There is no evidence for this link. The general habitat requirements for moose (i.e., food and shelter) are similar throughout their range and are not likely to change in response to construction activities. There is no evidence to suggest that the distribution of moose in the southern Northwest Territories has changed as a result of construction of the IPL pipeline or roads and highways. It was noted that moose are frequently observed along the margins of major highways in southern Canada. However, improved access via roads and highways may lead to increased hunter effort and thereby cause changes in the local abundance and distribution of moose.

Link 4: Changes in the seasonal distribution of moose will increase the amount of energy required for some individuals to locate suitable habitat.

This link was considered unlikely since the previous links were concluded to be invalid.

Link 5: An above-ground pipeline will prevent the passage of moose, which will lead to changes in moose migration patterns.

Present development scenarios do not include above-ground pipelines, but it is possible that in certain areas of discontinuous permafrost, segments of heated oil pipelines will have to be built above the ground, and thereby act as barriers to moose movements. However, experience in Alaska has shown that above-ground pipelines can be constructed so that the passage of moose is not obstructed. Van Ballenberghe (1978) and Eide and Miller (1979) both reported that moose crossed above-ground pipelines more frequently than expected when the pipe was raised to allow moose to pass underneath. Van Ballenberghe (1978) found significantly more crossings than expected at pipe heights of 6-8 ft (1.8-2.4 m), significantly fewer crossings at heights greater than 8 ft (2.4 m) and no difference from expected numbers at heights less than 6 ft (1.8 m). Eide and Miller (1979) based their observations on different height categories. They found significantly more crossings than expected at heights of 9-11 ft (2.7-3.6 m), significantly fewer crossings at heights less than 5 ft (1.5 m) and greater than 12 ft (3.7 m) and no difference from expected numbers for the other categories. The depth of snow cover was relatively low during both of the studies (less than 70 cm), and was not considered to be a factor in determining the location of the crossings. Of greater importance was the location of habitat with respect to the pipeline and the use of traditional migration routes. Despite the fact that many moose did cross the pipeline, Van Ballenberghe (1978) presented evidence from track counts that moose crossed a disused track about 100 m from the pipeline much more frequently than they crossed the pipeline itself. This suggested that some animals were avoiding the area of the pipeline. Eide and Miller's subsequent study did not address this question.

The working group concluded that the potential for moose migration patterns to be affected by above-ground pipelines does exist. In the event that above-ground pipelines become part of the hydrocarbon development plan, the group suggested that regulations controlling the distance between the pipe and the ground be implemented and that a monitoring program be initiated to examine the migrations of moose in the area of the pipeline.

Link 6: The energy balance of an adult determines its reproductive success.

General biological principles indicate that this link is valid. The energy balance of moose is generally negative from the fall through early spring (MacLennan 1974). It is expected that, in some years, the negative energy balance of some individuals affects calf production.

Link 7: Reproductive success determines, in part, the number of moose in the population.

Although this link is inherently valid, reproductive success may not be the most important factor controlling moose populations in the Northwest Territories. Information regarding the number of moose in the area is limited. Nevertheless, densities of moose are known to be considerably lower than those in other parts of North America, including the Yukon and northern Alberta.

This may be due to high calf mortality in late winter (Treseder and Graf 1985). Comparisons between studies in the N.W.T. and other parts of the North America indicate that calf survival is high until late fall. However, by late winter, the proportion of calves in moose populations in the N.W.T. is low compared to other areas. The authors emphasize that the data used for comparison were taken from different parts of the N.W.T. and that their conclusion is tentative.

[The existing data on moose populations in the N.W.T. have been collected largely from aerial surveys conducted in the past and are presently inadequate for the management of these populations. Additional data that are required include: (1) calf production and survival rates; (2) types and numbers of predators; (3) numbers, age and sex of moose harvested by native people; and (4) information on the effects of snow depth and severity of winter on reproduction and survival. The N.W.T. Department of Renewable Resources has initiated a research program to address some of these data gaps, but further information regarding population dynamics in the MEMP study area is needed for management.]

Link 8: Increased traffic associated with development will result in increased numbers of moose killed through collisions with vehicles.

The number of moose killed by collisions with vehicles is affected by many factors, including speed of traffic, size of vehicles, density of moose in the area, depth of snow and height of snow banks (i.e., ease of egress from the road corridor). The group concluded that only permanent roads, such as the Dempster Highway, were likely to result in serious or fatal collisions, because road conditions are maintained during winter months and traffic is not forced to slow down. Conversely, conditions on winter roads are poor and vehicles generally travel much more slowly. It was noted that there have been no reports of moose killed by collisions with vehicles on the Gordon Lake winter road in 5-6 years of operation. Similarly, there were no road kills reported during construction of the IPL pipeline from Norman Wells to Zama (S. Matthews, pers. comm.). On the other hand, at least three collisions have occurred on the Dempster Highway within the past year (D. Krutko, pers. comm.).

CONCLUSION

It was considered unlikely that construction activities and associated traffic would affect the seasonal distribution (Link 3) and energy balance (Link 4) of moose. Although the links relating effects of increased traffic levels to moose numbers (Links 2 and 3) were considered valid, no monitoring beyond existing programs was recommended. The consensus of the group was that new habitat created along seismic lines, right-of-way and other clearings (Link 1) would have neutral or beneficial effects on individual moose in these areas. However, this will not necessarily result in an increase in the number of moose in the population since food availability may not be the factor limiting moose production in the Northwest Territories (Link 7).

The workshop participants concluded that the overall hypothesis was valid. However, on the basis of existing knowledge, it was not possible to determine whether the cumulative effects of development will cause an increase or decrease in the abundance of moose.

RESEARCH

No research specifically related to the effects of hydrocarbon development on moose populations was recommended. However, the group recognized the importance of moose to the native harvest, and supported the continuation and expansion of basic research on the numbers, movements, recruitment and energetics of moose populations in the Northwest Territories.

MONITORING

Areas cleared for wood-chip production during construction of the IPL pipeline provide a unique opportunity to monitor the regeneration of woody browse on sites of varying topography and floristic composition. It was recommended that the appearance, growth and duration of woody browse suitable for moose consumption be monitored.

The subgroup recommended that the number of road kills be reported through existing monitoring programs. In the event that above-ground sections of pipeline more than 3-5 km long are proposed, it was also recommended that moose movements along the pipeline should be monitored for the first two or three years of operation to determine whether the movement of these animals is restricted.

LITERATURE CITED

Bergerud, A.T. and F. Manual. 1968. Moose damage to balsam fir - white spruce forest in central Newfoundland. J. Wildl. Manage. 32:729-746.

Brackett, D., W. Spencer, G. Baird, J.A. Snowshoe, E. Krutko, L. Males and P. Latour. 1985. Moose surveys in the Mackenzie River delta, valley and tributaries, 1980. N.W.T. Wildl. Serv. File Rep.

Doll, D., W.P. McCrory and J.D. Feist. 1974. Observations of moose, wolf and grizzly bear in the northern Yukon Territory. Arctic Gas Biol. Rep. Ser. 22, Ch. 3. 50 p.

Eide, S. and S. Miller. 1979. Effects of the Trans-Alaska pipeline on moose movements. Alaska Dep. Fish and Game. Final Rep. Fed. Aid Wildl. Rest. Proj. W-17-10. Job 1.15R. 27 p.

Hamilton, G.D. and P.D. Drysdale. 1975. Effects of cutover width on browse utilization by moose. 11th N. Amer. Moose Conf. and Workshop: 5-26.

Kelsall, J.P., E.S. Telfer and T.D. Wright. 1977. The effects of fire on the ecology of the boreal forest, with particular reference to the Canadian north: A review and selected bibliography. Can. Wildl. Serv. Occas. Pap. 32. 56 p.

Krefting, L.W. 1974. Moose distribution and habitat selection in north central North America. Nat. Can. 101:81-100.

MacLennan, R. 1974. Reasons for the decline in moose populations in Saskatchewan. 10th N. Amer. Moose Conf. and Workshop: 63-75.

Prescott, W.H., G.L. Erickson, L.E. Walton and D.G. Smith. 1973. Atlas of moose habitat maps. In: Wildlife Habitat Inventory of the Mackenzie Valley and Northern Yukon. Prep. by Can. Wildl. Serv. for Environ.-Social Prog. Northern Pipelines.

Telfer, E.S. 1970. Relationships between logging and big game in eastern Canada. Pulp Paper Mag. Can. Oct. 2:3-7.

Telfer, E.S. 1974. Logging as a factor in wildlife ecology in the boreal forest. Forest. Chron. 50:186-190.

Treseder, L. and R. Graf. 1985. Moose in the Northwest Territories - A discussion paper. N.W.T. Wildl. Serv. MS Rep.

Van Ballenberghe, V. 1978. Final report on the effects of the Trans-Alaska pipeline on moose movements. Spec. Rep. 23. Joint State/Federal Fish and Wildl. Team. 40 p.

Watson, G.H., W.H. Prescott, E.D. deBock, J.W. Nolan, M.C. Dennington, H.J. Poston and I.G. Stirling. 1973. An inventory of wildlife habitat of the Mackenzie Valley and Northern Yukon. Prep. for Environ.-Social Prog. Northern Pipelines. Task force on Northern Oil Develop. Rep. 73-27.

HYPOTHESIS NO. 6

OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITIES THAT ALTER HABITAT PERMANENTLY OR TEMPORARILY WILL INFLUENCE THE DISTRIBUTION AND ABUNDANCE OF MARTEN

PARTICIPANTS

Lee Doran	Steve Matthews
Robert Ferguson	Maurice Mendo
Susan Fleck	Archie Pick
Harvey Jessup	Walt Younkin
Peter McNamee	

INTRODUCTION

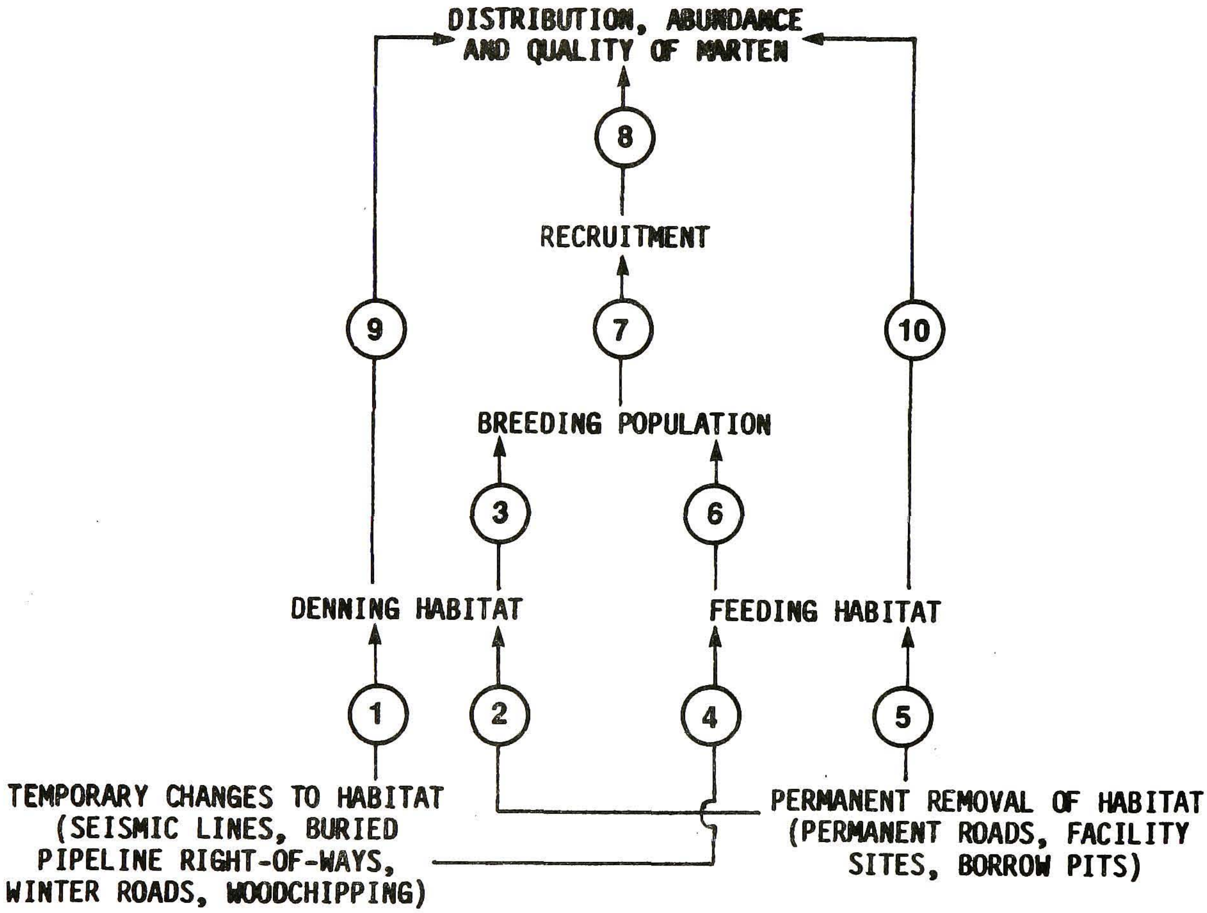
Marten (Martes americana) are solitary animals. They inhabit mature forests and tend to avoid areas with little ground cover such as muskeg, open pine forests and areas of recent fires (More 1978; Archibald and Jessup 1984; M. Mendo. pers. comm.). Although marten may travel across or hunt in open areas, their resting and natal dens are primarily restricted to hollow trees and fallen logs in mature forests. Females frequently demonstrate fidelity to natal dens (Archibald and Jessup 1984).

Adult marten are territorial. Home ranges of marten of the same sex do not overlap, although the territory of one male will overlap with that of several females. Immature marten are transient and may travel distances of up to 50 km to establish a territory (Archibald and Jessup 1984). Marten prey primarily on mice, but will also feed on snowshoe hares, red squirrels, birds and berries (More 1978). In winter, marten hunt microtines that are found in the subnivean layers (Archibald and Jessup 1984).

In the Yukon, the average size of a male and female home range is 6.2 and 4.7 km^2, respectively (Archibald and Jessup 1984). Estimates of the density of marten in the Mackenzie Valley vary between 0.13-0.86/km^2 (Wooley 1974). These values suggest that home ranges in the N.W.T. (1.2-7.6 km^2) may be

FIGURE 6-1

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



LINKAGES

Link 1: Seismic lines, wood-chip operations, temporary winter roads and pipeline rights-of-way will temporarily decrease marten denning habitat.

Link 2: Permanent roads, facility sites and borrow pits will permanently decrease marten denning habitat.

Link 3: A decrease in denning habitat will decrease the local breeding population of marten.

Link 4: Seismic lines, wood-chip operations, temporary winter roads and pipeline rights-of-way will temporarily increase marten feeding habitat.

Link 5: Permanent roads, facility sites and borrow pits will permanently decrease marten feeding habitat.

Link 6: An increase in feeding habitat will increase the local breeding population of marten through increased survival.

Link 7: The size of the breeding population of marten influences recruitment.

Link 8: Recruitment contributes to marten population levels.

Link 9: A decrease in denning habitat will increase the emigration of marten to surrounding areas.

Link 10: An increase in feeding habitat will increase the immigration of marten from surrounding areas.

smaller than those in the Yukon. Within the Mackenzie Valley, marten provide the largest source of income to full-time trappers (Dickinson and Herman 1979). With an average price of $60.00/pelt and an average annual harvest of 21,000 marten (N.W.T. Fur Records), this resource represents a source of substantial revenue.

Hypothesis No. 6 addresses the potential effects of hydrocarbon development on marten populations. The major concern is that activities associated with exploration and development will cause either temporary or permanent changes to marten habitat and subsequently lead to fewer marten (Fig. 6-1). The hypothesis was considered worth evaluating because of the value of the marten harvest to trappers and the specialized habitat requirements of the species.

LINKAGES

Link 1: Seismic lines, wood-chip operations, temporary winter roads and pipeline rights-of-way (ROWs) will temporarily decrease marten denning habitat.

Approximately 68% of the Colville Lakes and Norman Wells region (180,000 km^2) is covered with mature spruce or mixed spruce woodland, in comparison to 2% of the Mackenzie Delta region which is 50,000 km^2 (Hirvonen 1975; W. Younkin, pers. comm.). On the basis of existing knowledge regarding previous seismic operations and construction of the Norman Wells pipeline, potential changes to marten habitat were predicted by the subgroup and are presented in Table 6-1. As shown, between 1985 and 2005, 1856 km^2 or 1.5% of the total forested area will be removed due to seismic operations (Table 6-1). In contrast, construction of an entire pipeline ROW and associated wood-chipping operations will remove only 92 km^2 of forest. These estimates suggest that the loss of denning habitat as a result of construction of a pipeline is almost negligible in comparison to the amount of habitat lost due to seismic operations. However, seismic lines are usually only 8 m wide and well over 400 m apart. If the average size of marten home range is 4-7 km^2, less than 2% of it would be removed due to seismic operations. Although a female often displays fidelity to a natal den, it is expected that the animal would locate a new den within her territory if the old den was destroyed (H. Jessup, pers. comm.).

Clearcutting of forests has reduced marten populations in northern Maine and in B.C. according to Steventon and Major (1982) and Kelly (1982); however, these clearcut areas exceeded the size of individual marten home ranges. The average size of wood-chip blocks cut for the Norman Wells pipeline is 0.178 km^2 (range 0.002 - 1.5 km^2) (A. Pick, pers. comm.), which is much smaller than the home range of a marten.

The consensus of the subgroup was that construction of temporary roads, pipelines, seismic lines, and wood-chip operations will temporarily decrease marten denning habitat, although this will not be significant at the population level. (There is the potential for overharvest of populations as increasing development activities improve access to previously untrapped areas.)

Link 2: Permanent roads, facility sites and borrow pits will permanently decrease marten denning habitat.

During construction of a pipeline, less than 92 km^2 of forest cover will be removed (Table 6-1); however, individual areas involved will be less than the home range of a marten. It was expected that if a small portion of a home range is removed, a marten would not leave its territory (H. Jessup, pers. comm.).

The subgroup concluded that permanent roads, facility sites and borrow pits will permanently decrease marten denning habitat.

Link 3: A decrease in denning habitat will decrease the local breeding population.

A reduction in the local marten breeding population is not expected to occur, since a decrease in denning habitat is expected to affect only a very small portion of the home range of any female.

Table 6-1. Total forested area and projections of habitat disturbance associated with proposed Beaufort Sea region oil and gas exploration and development between 1985-2005

	Mackenzie Delta (km^2)	Colville Lakes (km^2)	Norman Wells (km^2)	Total (km^2)
Total area[1]	50,000	140,000	40,000	230,000
Total forested area	1,000[2]	95,200[3]	27,200[3]	123,400
Habitat permanently[4] removed by pipeline facilities	0.1	3.2	1.5	4.8
Forest removed by[5] pipeline ROW	0.4	16.2	7.5	24.1
Forest removed by[6] woodchip operations for pipeline	23	26	14	63
Forest removed by[7] seismic lines	61	1,512	283	1,856

[1] Extrapolated from Map 1 in Owens (1985).

[2] 2% of area is forested (W. Younkin, pers. comm.).

[3] 68% of area is forested (Hirvonen 1975).

[4] For each km of pipeline installed, approximately 0.5 ha of permanent facilities are constructed (Owens 1985).

[5] For each km of pipeline installed approximately 2.5 ha of land are required for a right-of-way (Owens 1985). This figure was then converted to km^2 and multiplied by 0.02 for the Mackenzie Delta area and 0.68 for the other two areas to determine the area of forest removed.

[6] During construction of the Norman Wells pipeline, 0.009 km^2 of forest were cleared for every km constructed to provide woodchips for insulation. This figure was tripled (0.027 km^2) to account for the lower productivity of forests north of Norman Wells (A. Pick and W. Younkin, pers. comms.). It was estimated that the lengths of mainline and gathering lines to be constructed will be 850, 950 and 440 km for the Mackenzie Delta, Colville Lakes and Norman Wells areas, respectively (Owens 1985).

[7] Total length of seismic lines from Owens (1985) was multiplied by 0.8 ha to derive total area of land affected and converted to km^2. To determine forest area removed, the figure was multiplied by 0.02 for the Mackenzie Delta and 0.68 for the other two regions.

Link 4: Seismic lines, wood-chip operations, temporary winter roads and pipeline ROWs will temporarily increase marten feeding habitat.

The extent to which habitat for the prey of marten improves as regeneration occurs on a seismic line or a pipeline ROW within the Mackenzie Valley is presently unknown. Riewe (1979) reported that seismic operations in the Mackenzie Valley caused the species composition of prey in the area to change, but the total number of mice and voles remained virtually the same.

Link 5: Permanent roads, facility sites and borrow pits will permanently decrease marten feeding habitat.

Given the amount of forested area that would be removed by each of these development facilities (see Link 2), a loss in marten feeding habitat will undoubtedly occur. However, this is expected to be insignificant at the population level.

Link 6: An increase in feeding habitat will increase the local breeding population of marten through increased survival.

Since marten territories are exclusive and contiguous, an increase in feeding habitat will not increase the recruitment of marten into the breeding population. This would occur only if territories became smaller. However, there is no evidence to suggest that or evaluate if territories of individual marten will change in response to a change in feeding habitat.

Link 7: The size of the breeding population of marten influences recruitment.

See Link 8.

Link 8: Recruitment contributes to marten population levels.

Links 7 and 8 are inherently valid. In the Yukon, females usually bear their first litter when they are 2 years old and produce an average litter of 3.3 young (Archibald and Jessup 1984). Because implantation of the fetus is delayed, the condition of the female marten in the fall dictates whether the fetus will implant. The effects of prey density on the condition of female marten are unknown. In trapped areas, the lifespan of a marten is usually only 4 - 5 years (H. Jessup, pers. comm.). The above suggests that the turnover of territories is relatively frequent and the recruitment rate is low.

Link 9: A decrease in denning habitat will increase the emigration of marten to surrounding areas.

Emigration of marten to surrounding areas will increase if removal of forest cover affects a large enough portion of the home range to cause marten to relocate. However, proposed exploration and development activities will not likely affect the majority of any individual home range.

Link 10: An increase in feeding habitat will increase the immigration of marten from surrounding areas.

Mature spruce forest offers a relatively stable environment for marten. As indicated earlier, an increase in marten feeding habitat will not result in an increase in marten density because territories are exclusive. However, local fluctuations caused by immigration of marten do occur (M. Mendo, pers. comm.). It is speculated that this may be due to local changes in prey density, which could cause an 'influx' of subadult and non-reproductive marten that do not establish territories. Although it is known that subadult marten will disperse as far as 50 km in search of food and/or a territory (Archibald and Jessup 1984), there is no further evidence to support this assumption.

CONCLUSION

Only changes in habitat that result in loss of a substantial part of the home range of a marten are expected to decrease marten numbers. Increases in feeding habitat are not expected to change the abundance or distribution of marten populations. Although activities associated with oil and gas development will result in both a temporary and permanent loss of forest cover, these habitat changes will affect only small portions of many marten territories and will be insignificant at the population level.

RESEARCH AND MONITORING

Provided that habitat alterations resulting from oil and gas development do not affect the majority of a marten home range, no impacts to marten populations are anticipated and, therefore, no monitoring is recommended. However, the size of marten's home ranges in the Northwest Territories is presently unknown. In 1986-87, the Department of Renewable Resources (Government of N.W.T.) will likely be conducting a 2-year study on the ecology and population dynamics of marten in the Brackett Lake area.

LITERATURE CITED

Archibald, W.R. and R.H. Jessup. 1984. Population dynamics of the pine marten (*Martes americana*) in the Yukon Territory. Pages 81-97. *In*: Olson, R., R. Hastings and F. Geddes. 1984. Northern Ecology and Resource Management. Univ. of Alta. Press., Edmonton. 438 p.

Dickinson, D. and T.B. Herman. 1979. Management of some terrestrial mammals in the N.W.T. for sustained yield. N.W.T. Science Advisory Board Rep. No. 4. Yellowknife. 71 p.

Hirvonen, R. 1975. Forest resources of the Mackenzie River Valley, N.W.T. For. Manage. Inst. Info. Rep. FMR-X-71. Ottawa.

Kelly, J. 1982. Impacts of forest harvesting on the pine marten in central interior B.C. M.Sc. Thesis. Univ. of Alta., Edmonton.

More, G. 1978. Ecological aspects of food selection in the pine marten (*Martes americana*). M.Sc. Thesis. Univ. of Alta., Edmonton. 94 p.

N.W.T. Fur Records. Department of Renewable Resources. Government of the N.W.T. Yellowknife.

Owens, R.A. 1985. Hydrocarbon development summary and scenario for a Mackenzie Environmental Monitoring Program. Prep. for Northern Environment Directorate, DIAND. Ottawa.

Riewe, R.R. 1979. Interactions between wildlife trappers and hunters and seismic lines in the Mackenzie Valley region, N.W.T., Canada. Part 1. Aubry - Colville Lakes. North of 60. Environ. Studies No. 9. DIAND. 114 p.

Steventon, D.J. and J.T. Major. 1982. Marten use of habitat in a commercially clear-cut forest. J. Wildl. Manage. 46(1): 175-182.

Wooley, D.R. 1974. A study of marten (*Martes americana*) in the Mackenzie District, N.W.T. *In*: R.A. Ruttan and D.R. Wooley (eds.). Studies of furbearers associated with proposed pipeline routes in the Yukon territories and Mackenzie River valley. Arctic Gas. Biol. Rep. Ser. Vol. 9: Chapter 3.

HYPOTHESIS NO. 7

DISTURBANCE ASSOCIATED WITH HYDROCARBON DEVELOPMENT IN OR NEAR WATERFOWL STAGING, MOULTING OR NESTING AREAS WILL AFFECT THE ABUNDANCE AND DISTRIBUTION OF WATERFOWL

PARTICIPANTS

Tom Barry	Dave Mossop
Robert Ferguson	Glen Sutherland
Peter McLaren	John Ward

INTRODUCTION

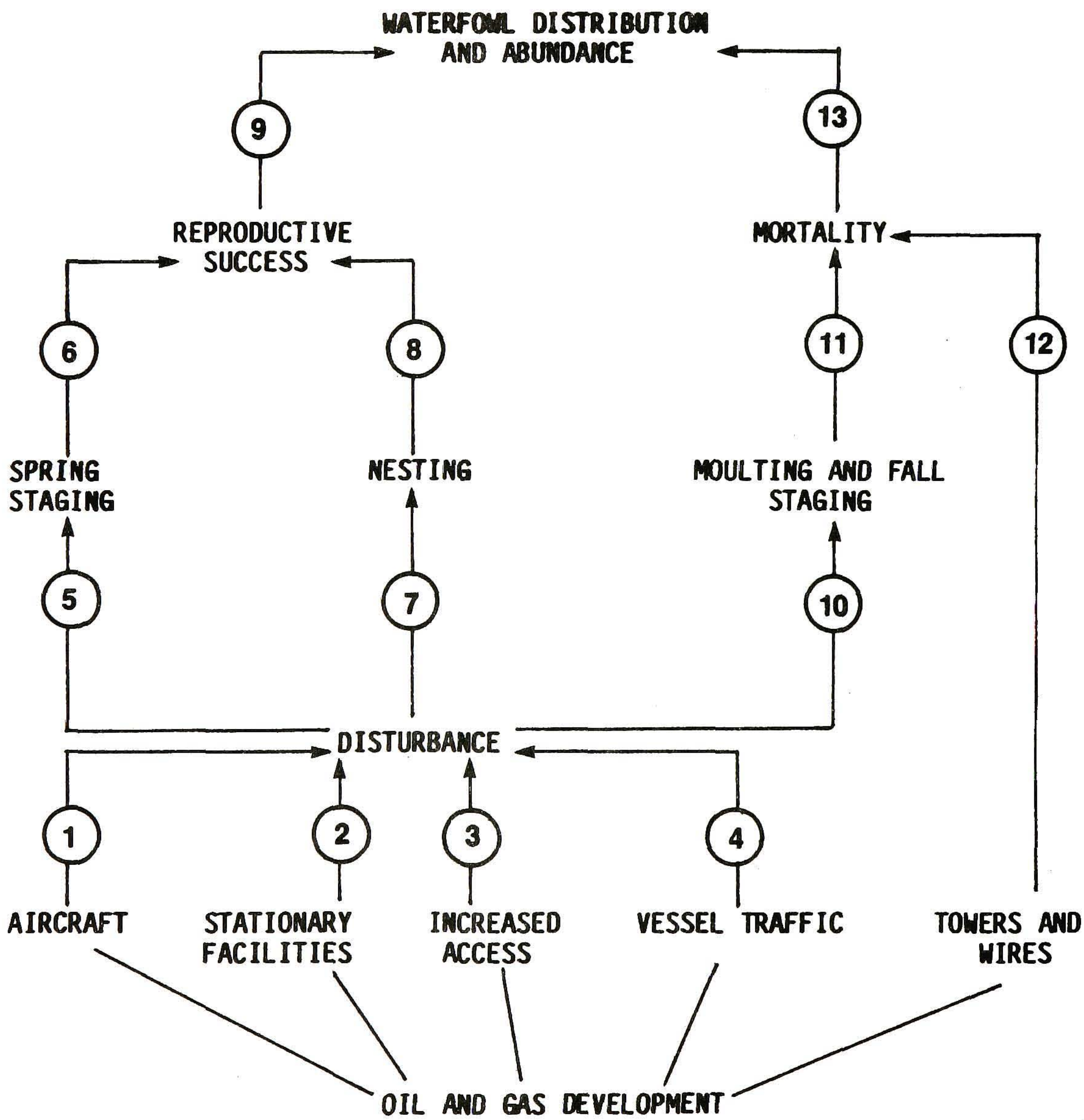
The Mackenzie Delta, Tuktoyaktuk Peninsula and Yukon North Slope provide important summer habitat for more than 20 species of waterfowl. About 20,000 tundra swans, 5000 snow geese, 3000 white-fronted geese, 600 brant and over 400,000 ducks nest and/or summer in this region (McCormick et al. 1984; Alliston 1984). Virtually all of the snow geese and most of the brant nest in the Kendall Island Bird Sanctuary; the swans, white-fronted geese and ducks nest in suitable habitat throughout the region. Birds arrive in the area in May, and begin nesting shortly afterwards. Moulting occurs in July and August. Although many birds moult near nesting areas while raising their broods, subadults, failed nesters and non-nesters may move to favoured moulting areas such as the outer Mackenzie Delta (McCormick et al. 1984).

In late August and September, several thousand snow geese and white-fronted geese move into the region to stage prior to fall migration. During this period, the outer Mackenzie Delta and Yukon North Slope are used extensively as feeding areas. By late September, southward migration has commenced. Most swans and geese follow the Mackenzie Valley, although few birds use the waterbodies in the valley as stopover areas. Most ducks also migrate south along the Mackenzie Valley; however, migration is generally protracted and the birds tend to be widely dispersed.

The major concern and basis for Hypothesis 7 is that disturbance due to activities associated with hydrocarbon development in the study area will

FIGURE 7-1

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



LINKAGES

Link 1: Increases in aircraft overflights will increase disturbance to waterfowl.

Link 2: The presence of exploratory, processing and distribution facilities will increase disturbance to waterfowl.

Link 3: Increased access will increase disturbance to waterfowl.

Link 4: Increased vessel traffic on the Mackenzie River will increase disturbance to waterfowl.

Link 5: Increased disturbance will displace waterfowl in spring staging areas, and interfere with feeding, courtship and nesting.

Link 6: Increased energy costs due to displacement during spring staging will decrease reproductive success.

Link 7: An increase in disturbance will cause an increase in nest desertion and brood loss.

Link 8: Increased nest desertion and brood loss will decrease reproductive success.

Link 9: A decrease in reproductive success will reduce the abundance and alter the distribution of waterfowl.

Link 10: Increased levels of disturbance will increase energy costs during moulting and fall migration.

Link 11: Increased energy costs during moulting and fall migration will cause an increase in mortality.

Link 12: The presence of towers and wires will increase mortality of waterfowl.

Link 13: Increased mortality will reduce local abundance and alter the distribution of waterfowl.

reduce the abundance and alter the distribution of waterfowl summering in the region. Conceptual steps linking industrial activities with potential effects on waterfowl populations (Fig. 7-1) are discussed in subsequent sections.

The subgroup also considered the issue of habitat loss as a result of increased levels of disturbance. Two types of habitat loss were considered: (1) direct or actual habitat loss, where suitable habitat is eliminated by industry facilities such as compressor stations and stockpiles; and (2) effective habitat loss, whereby an individual or individuals are excluded from suitable habitat by disturbance. The group concluded that both types of habitat loss were likely to occur as a result of development. However, it was expected that industry facilities will not (due to imposed regulations) be located in areas that are critical to waterfowl. Consequently, actual habitat loss was not directly addressed in the hypothesis, although the subgroup acknowledged that some loss of habitat will likely occur as a result of development.

LINKAGES

Link 1: Increases in aircraft overflights will increase disturbance to waterfowl.

Helicopters and fixed-wing aircraft are a necessary mode of transportation in the Canadian Arctic, and are used regularly by the petroleum industry in the Beaufort Sea-Mackenzie Delta region. As hydrocarbon exploration and production proceeds, a concomitant increase in aircraft activity will likely occur.

Some species of waterfowl are very susceptible to disturbance by aircraft. Salter and Davis (1974) reported that the number of waterfowl on a lake decreased as float-plane traffic on the lake increased. Similarly, snow geese were frequently flushed from summer feeding areas as a result of low flying aircraft (Gollop and Davis 1974; Schweinsburg 1974). However, the susceptibility of waterfowl to disturbances varies with the species, time of year, and type of aircraft. Recent studies by the Canadian Wildlife Service have suggested that different species of nesting waterfowl react differently to various types of helicopters and altitudes of overflight. White-fronted geese appear to be most sensitive to disturbances by aircraft overflight, whereas whistling swans seldom show any disturbance response (T. Barry, C.W.S., pers. comm.). The studies have also indicated that the sight of overflying aircraft may cause as much of a disturbance to waterfowl as the sound of the aircraft. The effects of aircraft overflights on waterfowl are also influenced by factors such as the time of year (e.g., elevated stress levels during the moulting stage, natural restlessness due to the migratory urge), and environmental conditions (e.g., cloud cover, wind speed and wind direction).

Link 2: The presence of exploratory, processing and distribution facilities will increase disturbance to waterfowl.

Hydrocarbon development in the study area will require that several types of facilities be constructed in areas that are presently utilized by waterfowl. In addition to buildings, wharves, stockpiles, compressor stations and communication towers, there will also be a need for connecting roads and highways. As previously discussed, the level of disturbance to waterfowl depends on the type and persistence of the disturbance, the susceptibility of the species in the area, and the time of year. There are few unequivocal data that document disturbances due to facilities per se. Barry and Spencer (1971) reported that the numbers of pintail, green-winged teal and scaup in an area adjacent to an active drill site on Richards Island were significantly lower than those in the surrounding area. Gollop and Davis (1974) noted that a sound simulating the noise of a compressor station caused a significant level of disturbance to snow geese. In contrast, studies by the Canadian Wildlife Service have detected few effects on the production and number of waterfowl as a result of the presence and operation of a drilling rig on Richards Island (T. Barry, pers. comm.).

As in the previous link, the subgroup agreed that disturbance may be both visual and noise-related but distinguishing between the two may be difficult or impossible.

Link 3: Increased access will increase disturbance to waterfowl.

Hydrocarbon development in the study area will result in an increase in the number of roads and facilities and thereby cause an increase in the number of people within the region. In addition to petroleum industry personnel and the employees of various support industries (e.g., transport companies) an increase in the number of tourists travelling in the area is likely to occur. The Dempster Highway has resulted in a large increase in the number of tourists in the Mackenzie Delta, and construction of a road from Inuvik to Tuktoyaktuk would allow access to areas that are presently inaccessible. The importance of the region as a waterfowl summering area may promote many tourists, hunters, bird watchers and naturalists to visit sensitive waterfowl areas and cause disturbance of birds in areas where such activities have not occurred in the past.

The working group considered increased access to birds and their summering and nesting habitat to be one of the greatest potential impacts of hydrocarbon development to birds in the MEMP study area. A negative impact on nesting success from disturbance during bird surveys has been demonstrated (MacInnes and Misra 1972; Ellison and Cleary 1978; Anderson and Keith 1980; MacInnes 1980). Helicopters that have, on occasion, landed near flocks of birds have not caused any apparent disturbance; however, subsequent emergence of passengers has caused birds to flush (T. Barry, pers. comm.). Although some direct effects of increased numbers of tourists on nesting waterfowl will likely occur it is expected that most of the impact will result from indirect effects such as increased predation on waterfowl (i.e., waterfowl eggs and young birds are extremely vulnerable to predation by gulls, jaegers and foxes, when the adults are forced to leave nests as a result of human presence) (MacInnes 1980).

Link 4: Increased vessel traffic on the Mackenzie River will increase disturbance to waterfowl.

The mainstem of the Mackenzie River is an important spring staging area for most species of waterfowl that summer in the study area. In May, several thousand tundra swans, snow geese, white-fronted geese and Canada geese, and several species of ducks use open water areas on the river (Barry 1967; Campbell and Shepard 1973; Salter 1974). These birds move to summering areas to the north when they become snow-free. During the summer and fall, the Mackenzie River is not used extensively by waterfowl.

Increases in vessel traffic on the Mackenzie River are expected to occur as a result of hydrocarbon development in the region. However, such increases in activity will occur during the open-water season after the important spring staging period for waterfowl. Consequently, the subgroup concluded that Link 4 is not valid.

Although the use of hovercraft was not discussed in the description of the development plan for the Mackenzie region, it was identified as an area of potential concern by the subgroup because hovercraft can cause a high degree of disturbance to waterfowl. In the event that hovercraft are proposed in future development plans, the validity of this link should be re-evaluated.

Link 5: Increased levels of disturbance will displace waterfowl in spring staging areas, and interfere with feeding, courtship and nesting.

Sources of disturbance that were considered relevant to the link included: (1) aircraft overflights; (2) the presence of stationary facilities and associated noise; and (3) the increased number of people in the region as a result of increased access. Within the MEMP study area, the principal spring staging habitat for waterfowl occurs along the Mackenzie River (Campbell and Shepard 1973; Salter 1974; Salter et al. 1974).

Recent studies conducted during development of the Norman Wells Project have been summarized by Sikstrom and Boothroyd (1985). Data from these studies indicate that: (1) use of the islands and shorelines of the Mackenzie River in the vicinity of Norman Wells by waterfowl, particularly snow geese, is highly variable; (2) the oil field and drilling activities on production islands in 1983, 1984 and 1985 had only minor and local effects on staging waterfowl; and (3) the distribution and abundance of staging waterfowl along the river were influenced to a greater extent by environmental factors, such as weather and river levels, than by drilling and support activities.

Sikstrom and Boothroyd (1985) also reported that geese most frequently reacted to aircraft overflights by taking flight, but that they usually returned to the same location within minutes.

During the spring migration of snow geese, the majority of their feeding occurs on the prairies (Wypkema and Ankney 1979; Hobaugh 1985). Consequently, feeding areas on the Mackenzie River are of less relative importance at this time. In addition to the above observations, the subgroup also noted that: (1) aircraft overflights appear to have only minor effects on staging waterfowl (Sikstrom and Boothroyd 1985); (2) spring staging habitat along the Mackenzie River is extensive (Sikstrom and Boothroyd 1985) and only a small portion of it is likely to be affected by development; and (3) the spring staging habitat is generally in areas that are inaccessible and unlikely to be affected by tourist-related types of disturbances. In view of the above and the current development plan for the region, it was concluded that Link 5 was improbable.

Link 6: Increased energy costs due to displacement during spring staging will decrease reproductive success.

This link was considered invalid, since it was previously concluded that disturbance would not interfere with feeding or staging to any detectable or appreciable extent (Link 5).

Link 7: An increase in disturbance will cause an increase in nest desertion and brood loss.

This link was considered theoretically valid. However, given the current development plan, the working group concluded that the effects of increased disturbance by aircraft or stationary facilities on nesting success of colonial waterfowl (geese) and solitary nesting species would be minor. There were two primary reasons for this conclusion. Firstly, current regulations governing land use activities and operating conditions include restrictions on aircraft altitudes. Existing regulations require that aircraft maintain an altitude of 152 m (500 ft) or greater over sensitive waterfowl areas. Recent studies by the Canadian Wildlife Service have indicated that this minimum altitude is adequate to prevent flushing of nesting geese under normal circumstances (T. Barry, pers. comm.). Disturbance of solitary nesters (particularly ducks) was considered unlikely to have significant effects on large numbers of individuals because of their widespread distribution.

Secondly, the current development plan does not include the construction of permanent facilities near known nesting colonies of geese and, therefore, direct effects of development on nesting success are not expected to occur. However, future changes in the development plans (e.g., siting of facilities) may significantly alter the degree of concern regarding this potential impact. Any alterations to the development plan should be evaluated to ensure that disturbance of nesting geese is potentially minimized, particularly any significant changes in aircraft flight patterns and altitudes.

The subgroup identified increased access by people (Link 3) to sensitive geese nesting habitat as one of the most serious potential impacts of hydrocarbon development in the study area. During the workshop, discussion focused on the effects of activities of tourists and non-consumptive users of wildlife. (The effects of access on waterfowl harvests are considered in a subsequent hypothesis.) Presently, all waterfowl nesting areas, including favoured nesting habitat such as islands and barrier beaches, are potentially susceptible to human intrusion because tourist-related activities are not regulated by federal legislation. This situation is unlike many other forms of land use activity. People who visit geese colonies during the incubation, hatching and early brood-rearing stages can indirectly cause considerable loss of eggs and young birds. There are documented cases where predators have destroyed waterfowl eggs and young birds while the females have left their nests in response to human interference (MacInnes 1980; Strang 1980). It is expected that separation of broods and subsequent loss of young may also occur at this time. Tourism in the study area is projected to increase within the next decade, although the magnitude of this increase and its potential impact on nesting waterfowl are difficult to predict.

Link 8: Increased nest desertion and brood loss will decrease reproductive success.

Although this link is not universally applicable, the subgroup concluded that it is theoretically valid especially for arctic-nesting waterfowl. Re-nesting by waterfowl after failure of an initial nesting attempt is not believed to occur during the short arctic summer (Calverley and Boag 1977). Consequently, any loss of a nest or brood by a nesting pair will result in reproductive failure for that pair in that breeding season.

Link 9: A decrease in reproductive success will reduce the abundance and alter the distribution of waterfowl.

The subgroup agreed that this link is logical, but pointed out that effects on long-lived and short-lived species of arctic waterfowl may be different. The loss of a nest or brood as a result of disturbance is not expected to have long-term effects on the population of a long-lived species, since the breeding pair are capable of nesting again in subsequent years. Although shorter-lived species of ducks may not be capable of nesting in subsequent years, it was concluded that the localized effects of disturbance would affect too few birds, due to their dispersed nature, to have a significant impact on the regional population.

The subgroup expected that the link is most applicable to colonial nesting waterfowl, which include snow geese and brant at the Kendall Island Bird Sanctuary (McCormick et al. 1984). However, decreases in reproductive success at nesting colonies would have to be substantial and occur over a period of several years to have any significant effect on population levels. The Kendall Island snow goose colony has varied in size from near zero to almost 9000 birds since the 1950's (Barry and Barry 1982; Kerbes 1983). Furthermore, during a period of four consecutive years in the 1970's reproductive success of the colony was virtually zero, and likely due to various factors including storm surges, predation by grizzly bears, and disturbance from a barge grounding; the colony presently consists of about 2500 breeding pairs of snow geese (T. Barry, pers. comm.). There are virtually no data describing the relationship between a threshold level of reduction in reproductive success and abandonment of a colony (T. Barry, pers. comm.), although it was suggested that reproductive failure would have to persist over the adult life span of the species before a colony is likely to be abandoned.

In summary, the subgroup concluded that with specific reference to the present development plan and birds in the study area, this link is only valid for colonial nesting species. It does not apply to waterfowl species that are widely dispersed nesters.

Link 10: Increased levels of disturbance will increase energy costs during moulting and fall migration.

Moulting waterfowl (both non-breeders and adults with young) are at the most vulnerable phase of their life cycle. During the moult, these birds are physiologically stressed and are flightless. Therefore, waterfowl are very susceptible to predation from air, land and water and are also very sensitive to any type of disturbance. The faster that individuals can regrow flight feathers, recover the weight lost during nesting, and regain flight muscles, the less susceptible they become to predation. At this time, it is important that moulting grounds provide an adequate food supply as well as protection from disturbances. Moulting areas are generally marshy and flat (for good visibility), near shallow lakes, rivers or mud flats, and have an ample supply of food (i.e., *Carex*, *Equisetum*, grasses, insects). In the Mackenzie Delta, nesting geese do not generally disperse more than 35 km from their nest sites to moult (T. Barry, pers. comm.).

Moulting geese react quickly to any disturbance or threat by massing into tight flocks on water or by running overland. However, they normally return to feeding activities shortly after the source of disturbance has disappeared. Disturbances resulting from human intrusion (which is likely to occur infrequently due to the general inaccessibility of moulting areas) or by predators or aircraft overflights, would have to persist for extended periods of time to cause serious impact on the usually continuous feeding activity of flightless geese. Give the present development plan, the subgroup concluded that persistent disturbance is unlikely to occur. The group also concluded that any effects of disturbance associated with development would be difficult, if not impossible, to measure and distinguish from the effects of natural events.

The subgroup agreed that it is most unlikely that increased disturbance will cause increased energy costs to fall staging geese. Fall staging generally occurs in the late summer and fall (i.e., the period of increasing darkness) when disturbance is less likely to occur. Furthermore, geese are capable of full flight at this time and, therefore, can avoid persistent disturbances.

Link 11: Increased energy costs during moulting and fall migration will cause an increase in mortality.

The subgroup concluded that this link was invalid because Link 10 was considered unlikely. Moreover, any changes in energy costs resulting from increased levels of disturbance would be too difficult to distinguish from the variability caused by natural factors. The breeding success of arctic geese is known to be highly variable from year-to-year (Barry 1967; McLaren and McLaren 1982). The percentage of young in flocks arriving in the fall staging areas on the outer Mackenzie Delta and Yukon North Slope can range from near 0% to 60%. Similarly, the physical condition of the geese leaving the fall staging areas can vary widely.

The cause of fluctuations in the number and the physical condition of geese is related to the lateness of nesting seasons (i.e., snow clearance); cycles in fox abundance (as well as cycles of other predators); and early snow cover and freeze-up (Barry 1967; Koski 1975, 1977a,b). When any one or a combination of these events occur, fall migrating geese are in poor condition and weak during flight. The flocks (particularly those made up of families) must, therefore, land frequently to rest and feed, often in marginal habitat, and are subject to increased hunting and predation pressures. The effects of disturbance caused by development might have to be of a large magnitude and persistent to be distinguishable from those caused by natural events. Such disturbances are considered unlikely, given the current development plan. However, it can also be argued that relatively small disturbances to already heavily stressed birds could have disproportionate effects.

Link 12: The presence of towers and wires will increase mortality of waterfowl.

Some species of birds are known to be susceptible to collisions with towers and wires and, in most cases, such collisions are fatal. Substantial mortality can occur during the fall migration when birds are in large flocks. Several studies have shown that a large number of birds (primarily passerines) are lost each year as a result of collisions with TV towers and light-houses (Weir 1976; Avery et al. 1978). In Great Britain, mortality of swans due to collisions with towers is regularly reported (T. Barry, pers. comm.). Although it is a rare occurrence, eider mortality as a result of collisions with boats in the Beaufort Sea has also been reported (J. Ward, pers. comm.).

It is most likely that construction of communication and navigation towers and other tall structures will take place as part of hydrocarbon development in the study area. These towers may be located in the Mackenzie Valley and along the coast of the Beaufort Sea and, thereby, represent a hazard to waterfowl in the region.

The subgroup concluded that this link was valid, since mortality of waterfowl due to collisions with project facilities is possible. However, such losses were expected to be small and undetectable at the regional population level.

Link 13: Increased mortality will reduce local abundance and alter the distribution of waterfowl.

The subgroup concluded that local changes in the abundance and distribution of waterfowl were possible, but highly unlikely given the present development plan and the mitigative measures that are expected to accompany development in the region.

CONCLUSION

Although the subgroup concluded that Hypothesis No. 7 was in general valid, the localized effects of disturbance usually would be small and impossible to detect at regional population levels due to natural variability in the distribution, production levels and population levels of waterfowl in the region. The linkages concerning increased mortality resulting from development were considered possible or even probable. However, the potential impacts were expected to be regionally insignificant and not worth testing (Links 11 and 12). Increased energy costs during moulting and fall migration due to increased levels of disturbance was considered unlikely.

The only area of concern that was expected to warrant serious attention was increased human access to nesting areas of colonial species and to brood-rearing and moulting areas, which could result in reduced reproductive success of waterfowl. The subgroup suggested that for certain situations and areas (specifically the Kendall Island snow goose colony), appropriate measures should be employed to reduce the likelihood of impacts occurring.

RESEARCH AND MONITORING

Although the subgroup agreed that evaluation of the effects of increased human access on specific important breeding colonies was desirable, it concluded that a research program to determine cause-effect relationships was not warranted. It was noted that the Canadian Wildlife Service is presently conducting a study of the effects of aircraft disturbance on nesting geese at the Anderson River colony (east of the study area). It was suggested that a program could be designed and initiated to quantitatively evaluate the effects of human disturbance on nesting waterfowl, perhaps at the same colony. However, this suggested research was not accepted by the majority of the subgroup because several studies have already provided qualitative evidence that such effects can occur.

Other approaches to evaluate and mitigate the impact of human access were considered. Information regarding land-use activities of residents and reduce the abundance and alter the distribution of waterfowl summering in the region. Conceptual steps linking industrial activities with potential effects on waterfowl populations (Fig. 7-1) are discussed in subsequent sections.

The subgroup also considered the issue of habitat loss as a result of increased levels of disturbance. Two types of habitat loss were considered: (1) direct or actual habitat loss, where suitable habitat is eliminated by industry facilities such as compressor stations and stockpiles; and (2) effective habitat loss, whereby an individual or individuals are excluded from suitable habitat by disturbance. The group concluded that both types of habitat loss were likely to occur as a result of development. However, it was expected that industry facilities will not (due to imposed regulations) be located in areas that are critical to waterfowl. Consequently, actual habitat loss was not directly addressed in the hypothesis, although the subgroup acknowledged that some loss of habitat will likely occur as a result of development.

LINKAGES

Link 1: Increases in aircraft overflights will increase disturbance to waterfowl.

Helicopters and fixed-wing aircraft are a necessary mode of transportation in the Canadian Arctic, and are used regularly by the petroleum industry in the Beaufort Sea-Mackenzie Delta region. As hydrocarbon exploration and production proceeds, a concomitant increase in aircraft activity will likely occur.

Some species of waterfowl are very susceptible to disturbance by aircraft. Salter and Davis (1974) reported that the number of waterfowl on a lake decreased as float-plane traffic on the lake increased. Similarly, snow geese were frequently flushed from summer feeding areas as a result of low flying aircraft (Gollop and Davis 1974; Schweinsburg 1974). However, the susceptibility of waterfowl to disturbances varies with the species, time of year, and type of aircraft. Recent studies by the Canadian Wildlife Service have suggested that different species of nesting waterfowl react differently visitors is currently available from community wildlife offices, economic development field personnel and tourism offices, and could be quantified on a community-by-community basis. This information is not adequate by itself to determine cause-effect relationships between nesting failures and specific disturbance effects. However, in conjunction with the results of existing routine monitoring of colonies, it could alert government biologists of the potential for access-related impacts. In addition, public awareness programs (e.g., the use of brochures, guiding activities or information available at bird colonies) could greatly reduce the impact of unregulated human presence in the region.

LITERATURE CITED

Alliston, W.G. 1984. A monitoring study of the species, numbers, habitat use and productivity of waterfowl populations on two study areas in the wooded Mackenzie Delta, summer 1983. Rep. by LGL Ltd., King City, Ontario, for B.C. Hydro, Vancouver.

Anderson, D.W. and J.O. Keith. 1980. The human influence on seabird nesting success: conservation implications. Biol. Cons. 18:65-72.

Avery, M.L., P.F. Springer and N.S. Dailey. 1978. Avian mortality at man made structures: an annotated bibliography. U.S. Fish. Wildl. Serv., Washington, D.C. FWS/OBS 78/58. 108 p.

Barry, T.W. 1967. Geese of the Anderson River Delta, N.W.T. Ph.D. thesis. Univ. of Alberta, Edmonton. 212 p.

Barry, S.J. and T.W. Barry. 1982. Seabird surveys in the Beaufort Sea, Amundsen Gulf, and Prince of Wales Strait, 1981 season. Rep. by Can. Wildl. Serv., Edmonton, for Dome Petroleum Ltd. and Esso Resources Canada Ltd., Calgary. 52 p.

Barry, T.W. and R. Spencer. 1971. Wildlife response to oil well drilling. Unpubl. MS, Can. Wildl. Serv., Edmonton. 39 p.

Calverley, B.K. and D.A. Boag. 1977. Reproductive potential in parkland- and arctic-nesting populations of mallards and pintails (Anatidae). Can. J. Zool. 55:1242-1251.

Campbell, R.W. and M.G. Shepard. 1973. Spring waterfowl migration on the Mackenzie River from Norman Wells to Arctic Red River, N.W.T., 1972. 49 p. In: Towards an environmental impact assessment of the portion of the Mackenzie gas pipeline from Alaska to Alberta. Appendix 3. Environment Protection Board, Winnipeg.

Ellison, L.N. and L. Cleary. 1978. Effects of human disturbance on breeding of double-crested cormorants. Auk 95:510-517.

Gollop, M.A. and R.A. Davis. 1974. Autumn bird migration along the Yukon Arctic Coast; July, August, September 1972. Arctic Gas Biol. Rep. Ser. 13:83-162.

Hobaugh, W.C. 1985. Body condition and nutrition of snow geese wintering in southeastern Texas. J. Wildl. Manage. 49:1028-1037.

Kerbes, R.H. 1983. Lesser snow goose colonies in the western Canadian Arctic. J. Wildl. Manage. 47:523-526.

Koski, W.R. 1975. Study of the distribution and movement of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slope and Alaskan North Slope in August and September, 1974, including a comparison with similar data from 1973. Arctic Gas Biol. Rep. Ser. 30(1):58 p.

Koski, W.R. 1977a. A study of the distribution and movements of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slope, and Alaskan North Slope in August and September, 1975. Arctic Gas Biol. Rep. Ser. 35(2). 54 p.

Koski, W.R. 1977b. A study of the distribution and movements of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slope and eastern Alaskan North Slope in August and September 1976. Rep. by LGL Ltd., Toronto, for Canadian Arctic Gas Study Ltd., Calgary. 69 p.

MacInnes, C.D. 1980. Comment: observer-induced predation is real. J. Wildl. Manage. 44:222-224.

MacInnes, C.D. and R.K. Misra. 1972. Predation on Canada Goose nests at McConnell River, Northwest Territories. J. Wildl. Manage. 36:414-422.

McCormick, K.H., M.E. Adams, C.J. Stephenson and A.S. Goodman. 1984. Key migratory bird terrestrial habitat sites in the Northwest Territories. Can. Wildl. Serv., Tech. Rep. 84-6.

McLaren, P.L. and M.A. McLaren. 1982. Migration and summer distribution of lesser snow geese in interior Keewatin. Wilson Bull. 94:494-504.

Owens, R.A. 1985. Hydrocarbon development summary and scenario for a Mackenzie environmental monitoring program. Rep. by R.A. Owens Environmental Services Ltd. and LGL Ltd. for Indian and Northern Affairs, Canada.

Salter, R.E. 1974. Aerial surveys of bird populations along the proposed gas pipeline route and along the adjacent Norman Wells to Richards Island and In-and-Out Lake to Fort McPherson areas, Northwest Territories, June 1-August 2, 1973. Arctic Gas Biol. Rep. Ser. 28(1). 127 p.

Salter, R.E. and R.A. Davis. 1974. Surveys of terrestrial bird populations in Alaska, Yukon Territory, Northwest Territories and northern Alberta, May, June, July 1972. Arctic Gas Biol. Rep. Ser. 12:36-384.

Salter, R.E., W.J. Richardson and C. Holdsworth. 1974. Spring migration of birds through the Mackenzie Valley, N.W.T., April-May 1973. Arctic Gas Biol. Rep. Ser. 28(2). 168 p.

Schweinsburg, R.E. 1974. Snow geese disturbance by aircraft on the North Slope, September 1972. Arctic Gas Biol. Rep. Ser. 14:258-279.

Sikstrom, C.B. and P.N. Boothroyd. 1985. Resolving production drilling restrictions and waterfowl disturbance concerns during spring migration at Norman Wells, Northwest Territories, Canada. Unpubl. MS.

Strang, C.A. 1980. Incidences of avian predators near people searching for waterfowl nests. J. Wildl. Manage. 44:220-222.

Weir, R.D. 1976. Annotated bibliography of bird kills at man-made obstacles: a review of the state of the art and solutions. Can. Wildl. Serv., Ottawa, Ontario. 85 p.

Wypkema, R.C.P. and C.D. Ankney. 1979. Nutrient reserve dynamics of lesser snow geese staging at James Bay, Ontario. Can. J. Zool. 57:213-219.

HYPOTHESIS NO. 8

DISTURBANCE AND HABITAT ALTERATIONS DUE TO HYDROCARBON DEVELOPMENT WILL ALTER THE DISTRIBUTION AND/OR ABUNDANCE OF RAPTOR SPECIES

PARTICIPANTS

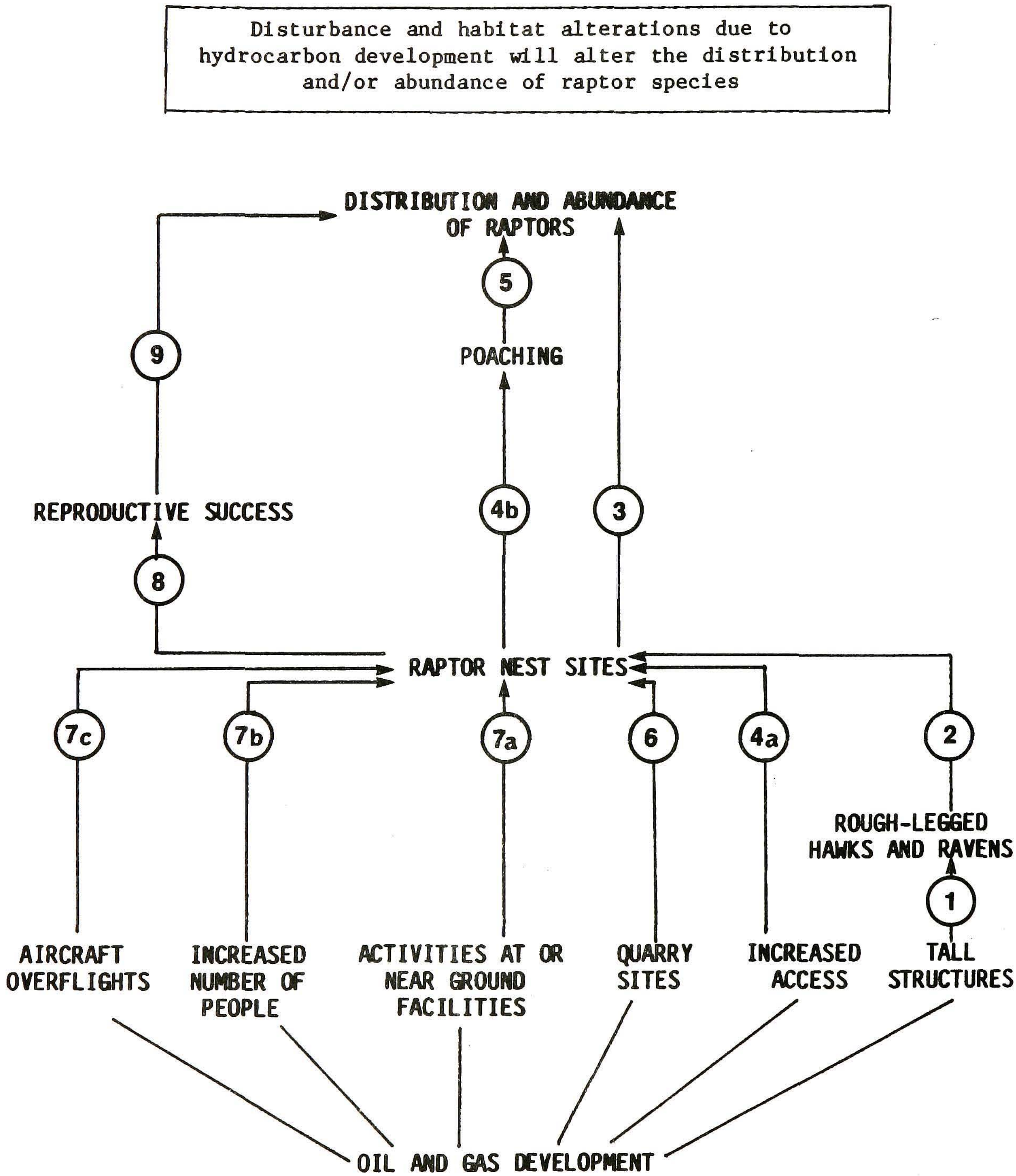
Tom Barry	Dave Mossop
Steve Matthews	Glen Sutherland
Peter McLaren	John Ward

INTRODUCTION

The MEMP study area provides nesting habitat for the peregrine falcon (Falco peregrinus), gyrfalcon (F. rusticolus), golden eagle (Aquila chrysaëtos) and bald eagle (Haliaeetus leucocephalus). Only about 15 pairs of peregrine falcons are known to nest in the region and all of these are found in the Northwest Territories (B. Bromley, GNWT, pers. comm.). These nesting pairs belong to the subspecies anatum, which is considered endangered under U.S. Legislation and by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Peregrines formerly nested on the Yukon North Slope, although no nest sites are known to exist there at present (D. Mossop, pers. comm.). Nests are generally located on cliffs that are associated with water bodies; the locations of most sites are known. Nesting occurs from mid- to late April through to late August. Peregrines feed mostly on shorebirds, waterfowl and passerines, which are caught in flight (Roseneau et al. 1981).

About 100 pairs of gyrfalcons nest in the Yukon. This population is well known and is monitored annually by the Yukon Territory Government. Fewer than 15 pairs of gyrfalcons are known to nest in the NWT portion of the study area (B. Bromley, pers. comm.). This species nests primarily on rocky cliffs, bluffs or outcrops and often in riparian habitats. Some individuals remain in the region throughout the year at or near their nests, and nesting generally occurs from April to late August. Their principal prey is ptarmigan, although arctic ground squirrels and jaegers may also be important food (White and Cade 1971; Roseneau 1972). The gyrfalcon is a preferred species for falconry.

FIGURE 8-1


Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species
DISTRIBUTION AND ABUNDANCE OF RAPTORS
9
5
POACHING
REPRODUCTIVE SUCCESS
4b
3
8
RAPTOR NEST SITES
7c
7b
7a
6
4a
2
ROUGH-LEGGED HAWKS AND RAVENS
1
AIRCRAFT OVERFLIGHTS
INCREASED NUMBER OF PEOPLE
ACTIVITIES AT OR NEAR GROUND FACILITIES
QUARRY SITES
INCREASED ACCESS
TALL STRUCTURES
OIL AND GAS DEVELOPMENT

LINKAGES

Link 1: Ravens and rough-legged hawks will establish nest sites in tall structures.

Link 2: Gyrfalcons will take over some of the nests of ravens and/or rough-legged hawks that are in the tall structures.

Link 3: The presence of gyrfalcon nests in tall structures will result in an increase in the abundance and/or range of this species.

Link 4a: Roads, pipeline rights-of-way and seismic lines will allow access to raptor nest sites.

Link 4b: Increased access by people will result in increased poaching of eggs and young.

Link 5: Increased poaching will result in a reduction of peregrine falcon and gyrfalcon populations.

Link 6: Borrow sites can either create or destroy raptor nesting habitat.

Link 7a: Persistent aircraft activity at low altitudes will disturb nesting raptors.

Link 7b: An increase in the number of people in the area will result in disturbance to nesting raptors.

Link 7c: Activities at or near ground facilities will disturb nesting raptors.

Link 8: Disturbance at raptor nest sites will result in decreased reproductive success.

Link 9: A decrease in reproductive success will result in a reduction of raptor populations.

About 300 immature golden eagles and 150 breeding pairs are present on the Yukon North Slope (D. Mossop, pers. comm.). A smaller population is present in the Northwest Territories' portion of the study area, but the exact size of the population is unknown. Golden eagles nest primarily on cliffs, cutbanks and rock outcrops. The nests are widely dispersed and are generally difficult to reach. Although some eagles will remain in the study area throughout the entire year, the majority of the population is usually only present from late March to late September. Golden eagles are both predators and scavengers, and prey primarily on small mammals and birds. Non-breeding birds often feed on caribou carrion and will occasionally kill caribou calves (Roseneau and Curatolo 1976).

Bald eagles are relatively common within the study area and across Canada. Because they are tree-nesters, they are found only in wooded areas in the Mackenzie Valley. Unlike cliff-nesting species, the bald eagle has greater flexibility and choice of nest sites and is potentially less vulnerable to disturbances. They feed primarily on fish and, in some areas, the distance between nests may be an indicator of fish abundance.

Several species of raptors in the Arctic have high national and international profiles because of the relatively low numbers in the region and their general rarity elsewhere on the North American continent. There is concern that hydrocarbon development in the Mackenzie Delta and Valley and on the Yukon North Slope could jeopardize the continued viability of these populations. Various activities associated with hydrocarbon development could affect the population levels of raptors in the study area in different ways. As a result, the subgroup found that a general hypothesis regarding the effects of development on raptor populations was unworkable and, therefore, developed four different sub-hypotheses. The conceptual steps linking industry activities with their potential effects on raptor populations are presented in Figure 8-1 and are discussed in the following sections.

SUB-HYPOTHESIS 8A

The presence of tall structures constructed during hydrocarbon development will increase gyrfalcon populations.

LINKAGES

Link 1: Ravens and rough-legged hawks will establish nest sites in tall structures.

Rough-legged hawks and ravens are common and widespread nesting residents of the Tuktoyaktuk Peninsula and outer Mackenzie Delta. Although rough-legged hawks will nest on the ground on hillsides and ravens will nest in 3- to 4-m tall willows along tundra streams (T. Barry, pers. comm.), they appear to prefer to build nests on taller structures if they are available. (Even if development-related structures do not serve as suitable nesting sites, they may be used by hawks and ravens for perching and possibly during hunting.) The group expected that tall man-made structures would be used to some degree by hawks and ravens as nesting sites.

Link 2: Gyrfalcons will take over some of the nests of ravens and/or rough-legged hawks that are in the tall structures.

Gyrfalcons do not build nests of their own, but instead use old "stick nests" of ravens and rough-legged hawks, or use suitable cliff ledges (White and Cade 1971). The availability of nest sites may be the limiting factor in the number of gyrfalcons that occur in certain tundra areas (e.g., the Tuktoyaktuk Peninsula). In the Mackenzie Delta-Anderson Plains region and in the Yukon Territory, gyrfalcons nest in trees, in old nests built by other birds, or on cliff ledges where no nests need to be built. However, on the tundra of the Tuktoyaktuk Peninsula and the outer Mackenzie Delta there are few suitable nesting sites, although there is an abundant supply of prey (ptarmigan, waterfowl, and shorebirds). Because gyrfalcons nest earlier in the year (March-April) than most ravens and all rough-legged hawks, and may stay on or in the vicinity of their nesting territory throughout the year, they are able to co-opt suitable nests of other species, which were built in previous seasons. Gyrfalcons on the tundra have also been observed to nest on fuel tanks, a wing of a crashed airplane, power poles, scatterwave reflector supports, and a radar tower (T. Barry, pers. comm.).

Link 3: The presence of gyrfalcon nests in tall structures will result in an increase in the abundance and/or range of this species.

This link was considered valid. There was some discussion concerning whether an increase in the number of gyrfalcon nests would result in an increase in the number of nesting pairs or merely in the occupation of new areas by the population. It is thought that the availability of nest sites in the Yukon Territory is not currently limiting to the gyrfalcon population but this is not the case in tundra areas of the Northwest Territories. Although there is limited information on gyrfalcon populations in the region, the subgroup assumed that these populations consist of a non-breeding surplus of adults (as do most bird populations), and that it would be theseindividuals that could occupy these new nest sites.

Conclusion

The working group concluded that the sub-hypothesis comprising Links 1, 2 and 3 was valid and testable. Assuming a nesting density of 1 breeding pair/170 km^2, as has been found on the Yukon North Slope (D. Mossop, pers. comm.) and that a sufficient number of tall structures would be built in unoccupied habitat to support a comparable density, the maximum increase in the number of gyrfalcons would not likely exceed 10 nesting pairs. Raptor populations in the region are routinely monitored by both the Government of the Northwest Territories and the Yukon Territory Government. The subgroup recommended that locations of new man-made potential nest sites be reported and be included as part of the existing monitoring programs.

SUB-HYPOTHESIS 8B

Hydrocarbon development will result in increased poaching of peregrine and gyrfalcon eggs and young and cause a decrease in the abundance of the local populations of these species.

Link 4a: Roads, pipeline rights-of-way and seismic lines will allow access to raptor nest sites.

Link 4b: Increased access by people will result in increased poaching of eggs and young.

Nest sites used by peregrine falcons and gyrfalcons in tundra areas are generally located on cliff or rock outcrops and, therefore, are relatively conspicuous. Although there may be a substantial degree of relocation of nest sites from year to year (Platt and Tull 1977), highly preferred sites that provide shelter from severe weather conditions or from disturbance may be occupied by falcons for many years (D. Mossop, pers. comm.). Platt and Tull (1977) suggested that disturbance may determine whether gyrfalcons re-occupy the same nest sites in the following year.

Improved access to raptor nest sites will likely occur as a result of hydrocarbon development in the area. For example, a new all-weather road leading from the Dempster Highway to the Yukon North Slope has been proposed (Dome et al. 1982). Easy boat access to the Peel River system was provided in the 1970s as a result of the construction of the Dempster Highway, which crosses the headwaters of the river. Use of roads and waterways does not require expensive machinery or logistics (e.g., helicopters) and, therefore, such routes are used by a relatively large number of people. Because raptor nest sites are permanent or semi-permanent, new roads and highways could lead to an increasing number of people becoming aware of and subsequently gaining access to these areas.

Annual reports of the Government of the Yukon Territory indicate that an increasing number of falcon sites are being visited as they become more accessible and that poaching has subsequently occurred at the sites (D. Mossop, pers. comm.). Removal of young birds and/or eggs from raptor nests by casual explorers gaining access to such areas has already occurred to some degree (YTG file data), and will increase the number of birds lost from the population beyond those taken by professional poachers (D. Mossop, pers. comm.).

Link 5: Increased poaching will result in a reduction of peregrine falcon and gyrfalcon populations.

The subgroup considered this link to be theoretically valid. However, whether it is applicable to the regional population of gyrfalcon in the northern Yukon and Mackenzie Delta and Valley is unknown and would also be difficult to test. Poaching of eggs and/or young could result in the loss of one year's production, but the potential long-term impact of this loss on the regional population is not known. Gyrfalcons do not breed every year, and numbers of breeding pairs in a region can fluctuate widely (Platt and Tull 1977), often by an order of magnitude from high to low abundance years (White and Cade 1971). Moreover, it is considered most unlikely that poaching would increase to a level which would cause a reduction in the size of the regional population. Although raptor populations may be more vulnerable to over-harvesting than other more commonly harvested bird species (Mossop and Hayes 1981), there is no evidence that poaching has caused a major impact on a population, or on the local occupancy of nesting habitat. The group expected that incremental effects of development-induced poaching would be difficult or impossible to separate from the effects of present poaching activities in the region.

Conclusion

The subgroup agreed that this sub-hypothesis (Links 4 and 5) was theoretically valid, but would not be testable. The effects on falcon populations would be difficult to detect, given the difficulty of establishing cause-effect relationships between population changes and poaching activity.

No monitoring or research programs that specifically address this area of concern were recommended. However, the subgroup supported the continuation of the existing raptor monitoring programs to evaluate the status of the populations.

SUB-HYPOTHESIS 8C

Excavation sites created during development will alter the number of raptor nest sites.

Link 6: Borrow sites can either create or destroy raptor nesting habitat.

The working group expected that this link is only applicable to rock quarries. If a rock quarry were to be located at or near a rock face that was actively used as a nest site, nesting birds may abandon this site because of physical destruction of the nest or because of a persistent high-level disturbance. The level of disturbance required to cause nest abandonment and the subsequent reaction of the bird would likely vary with different species of raptors and the time of the nesting cycle.

On the other hand, quarries that are located in areas that do not presently provide suitable nesting habitat for raptors could provide new habitat following their abandonment. Golden eagles are known to nest in abandoned quarries in the Yukon (D. Mossop, pers. comm.) and the Northwest Territories (B. Bromley, pers. comm.).

Conclusion

The subgroup concluded that the sub-hypothesis involving Link 6 was valid, although it was expected that the amount of suitable nesting habitat created at rock quarries would be insignificant to raptor populations. It is possible that a quarry could be located at an existing raptor nest site. However, protection measures conducted as a part of routine mitigation would minimize the potential of this occurring.

SUB-HYPOTHESIS 8D

Nesting raptors will be disturbed by persistent low-altitude aircraft activity, increased numbers of people and activities at ground facilities, and this will lead to reduced reproductive success and population sizes.

Link 7a: Persistent aircraft activity at low altitudes will disturb nesting raptors.

Although aircraft overflights may disturb nesting falcons, the susceptibility of these birds to disturbances varies with species and individuals of the same species. Boeker and Ray (1971) reported that golden eagles rarely showed any disturbance responses due to approaching aircraft, and Hickman (1972) documented that golden eagles would seldom flush from nests, even after repeated aircraft passes. On the other hand, Platt and Tull (1977) suggested that helicopter traffic may have been a factor contributing to the abandonment of a nest site by gyrfalcons, and Campbell and Davies (1973) and White (1969) both noted that peregrine falcons often reacted strongly to disturbances at nest sites.

Link 7b: An increase in the number of people in the area will result in disturbance to nesting raptors.

During the planning, construction and operation phases of hydrocarbon development, an increasing number of industry and support personnel will move into, and reside in the MEMP study area. Consequently, an increase in the number of people visiting raptor nest sites will likely occur. Disturbance caused by tourists (Campbell and Davies 1973), rock climbing expeditions (Snow 1972), and oil exploration teams (Craig, cited in Snow 1972) has led to nest abandonment and chick mortality. Similarly, people using the Dempster Highway have caused disturbance of golden eagles at nests in the Yukon Territory (D. Mossop, pers. comm.).

Link 7c: Activities at or near ground facilities will disturb nesting raptors.

Depending on the location and nature of industrial facilities, noise and human activity at these sites may disturb nesting raptors. This has been reported to have caused nest abandonment by peregrine falcons in New York (Herbert and Herbert 1969), and trapper activity below nest sites along the Anderson River was sufficient to cause adult gyrfalcons to desert nest sites, leading to chick mortality (Hickey 1969).

Link 8: Disturbance at raptor nest sites will result in decreased reproductive success.

Disturbance at raptor nest sites may 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 by parents or exposure; and (4) decreased fitness of young, resulting from insufficient feeding during the nestling stage or from premature fledging. However, several studies have indicated that raptors can habituate to some disturbances such as aircraft overflights (Platt and Tull 1977; Campbell and Davies 1973) and human activity and noise (Hickey 1969; White and Roseneau 1970). The subgroup concluded that decreased reproductive success due to disturbances at nest sites is possible, although the likelihood of this occurring depends on the level and persistence of the disturbance, the susceptibility of the species or individual to disturbances, and the ability of that species or individual to habituate to the disturbance.

Link 9: A decrease in reproductive success will result in a reduction of raptor populations.

This link is self-evident, at least on an empirical level; a long-term reduction in raptor productivity has led to a reduction in the number of peregrine falcons on the North American continent (Hickey 1969). Given the widespread nature of raptor nest sites and the localized nature of most disturbances that are expected in view of the current development plan, a reduction in the reproductive success of raptors would most likely be local (i.e., one nest site) and would be insignificant in terms of the regional population.

Conclusion

The subgroup concluded that Links 7, 8 and 9 were theoretically valid, but the sub-hypothesis was extremely unlikely given that industry facilities and activities associated with hydrocarbon development in the region will probably not be located in known nesting habitat of raptors. Mitigative measures to prevent disturbances due to aircraft overflights, human activity industry facilities would be identified and employed prior to initiation of development. However, it should be noted that the subgroup identified human (tourist) activity as one of the most serious potential concerns in relation to raptor populations in the region.

CONCLUSION

The subgroup concluded that, although all of the links in Hypothesis No. 8 were theoretically valid, the cumulative effects of all links would most likely be inconsequential at the population level. The effects of disturbance on local populations (or even individual breeding pairs) of raptors would also be difficult to detect given both the natural variability in the Yukon Territory-Mackenzie Delta raptor populations, natural mortality, and the difficulty in establishing cause-effect relationships in 'uncontrolled' field studies.

RESEARCH AND MONITORING

No research or monitoring programs to address this hypothesis were recommended. However, the subgroup supported the continuation of routine monitoring of raptor populations that is presently being conducted by federal and territorial governments. Because of the sensitivity of raptors to disturbance at nest sites, the subgroup also recommended that specific operating conditions (regulations) to mitigate potential disturbances resulting from development should continue to be enforced by government agencies.

A possible future regulated harvest of gyrfalcons was not included in the conceptual model, but was a subject of considerable discussion during the workshop. The value of gyrfalcons on world and domestic markets is substantial and very well known among most local residents. The governments of both the Yukon and Northwest Territories have been examining the potential for harvest of falcons as a method of capitalizing on their value. The harvest of young from nest sites is considered feasible and not likely to adversely affect existing population levels (Mossop and Hayes 1981; Newton 1985). Management agencies have been experimenting with both regulated 'wild' harvests (N.W.T., Yukon) and captive breeding programs (Yukon) as possible methods of obtaining saleable birds. However, the costs associated with a regulated harvest are expected to be high, and presently range up to $8000 to either raise a captive bird or to obtain a wild bird legally. In view of this high cost the group concluded that it would be difficult to compete with poachers. Concern was also expressed that any decrease in the size of raptor populations due to disturbance (Sub-hypothesis 8D) or increased poaching (Sub-hypothesis 8B) could reduce or eliminate a legal allotment of harvestable birds. Such an elimination could result in the termination of management programs, a component of which are the ongoing monitoring programs.

LITERATURE CITED

Boeker, E. and T. Ray. 1971. Golden eagle population studies in the southwest. Condor 73:463-467.

Campbell, R.A. and B. Davies. 1973. Nesting raptor survey in the western Canadian Arctic, 1972. Sect. 1, 49 p. In: Towards an environmental impact assessment of the portion of the Mackenzie Gas Line from Alaska and Alberta. Appendix 3. Envir. Prot. Board, Winnipeg.

Dome Petroleum Ltd., Esso Resources Canada Ltd. and Gulf Canada Resources Ltd. 1982. Beaufort Sea-Mackenzie Delta Environmental Impact Statement. 7 vols. Calgary.

Herbert, R.A. and K.G.S. Herbert. 1969. Extirpation of the Hudson River peregrine falcon population. Pages 133-154. In: J.J. Hickey (ed.). Peregrine falcon populations: their biology and decline. Univ. Wisconsin, Madison.

Hickey, J.J. (ed.). 1969. Peregrine falcon populations: their biology and decline. Univ. Wisconsin Press, Madison. 596 p.

Hickman, G.L. 1972. Aerial determination of golden eagle nesting status. J. Wildl. Manage. 36:1289-1292.

Mossop, D. and R. Hayes. 1981. The Yukon Territory gyrfalcon harvest experiment, 1974-1980. Pages 263-280. In: W. Ladd and P. Schempf (eds.). Raptor management and biology in western Canada. Anchorage, Alaska.

Newton, I. 1985. Recommendations for research pertaining to the harvest of gyrfalcons *Falco rusticolus* for falconry. Workshop Rep. Dep. of Renew. Res., Yellowknife, N.W.T. MS. 9 p.

Platt, J.B. and C.E. Tull. 1977. A study of wintering and nesting gyrfalcons on the Yukon North Slope during 1975 with emphasis on their behaviour during experimental overflights by helicopter. Arctic Gas Biol. Rep. Ser. 35(1). 90 p.

Roseneau, D.G. 1972. Summer distribution, numbers, and feeding habits of the gyrfalcons (*Falco rusticolus* L.) on the Seward Peninsula, Alaska. M.S. thesis, Univ. Alaska, Fairbanks. 124 p.

Roseneau, D.G. and J.A. Curatolo. 1976. Distribution and movements of the Porcupine caribou herd in northeastern Alaska and Yukon Territory, 1975. Arctic Gas Biol. Rep. Ser. 36(1). 82 p.

Roseneau, D.G., C.E. Tull and R.W. Nelson. 1981. Protection strategies for peregrine falcons and other raptors along the planned northwest Alaska gas pipeline route. Rep. by LGL Ecol. Res. Assoc., Inc., Fairbanks, for Northwest Alaska Pipeline Co. and Fluor Northwest Inc., Fairbanks. 332 p.

Snow, C. 1972. Habitat management series for endangered species. Rep. No. 1. American peregrine falcon and arctic peregrine falcon. U.S. Dep. of Interior, Washington. 35 p.

White, C.M. 1969. Breeding Alaskan and arctic migrant populations of the peregrine. Pages 45-51. *In*: J.J. Hickey (ed.). Peregrine falcon populations: their biology and decline. Univ. Wisconsin Press, Madison.

White, C.M. and T.J. Cade. 1971. Cliff-nesting raptors and ravens along the Colville River in arctic Alaska. Living Bird 10:107-150.

White, C.M. and D.G. Roseneau. 1970. Observations on food, nesting and winter populations of large North American falcons. Condor 72:113-115.

HYPOTHESIS NO. 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

PARTICIPANTS

Lynne Dickson	Dave Mossop
Robert Ferguson	Wendy Nixon
David Krutko	Glenn Sutherland
Fred McFarland	John Ward
Margaret McLaren	

INTRODUCTION

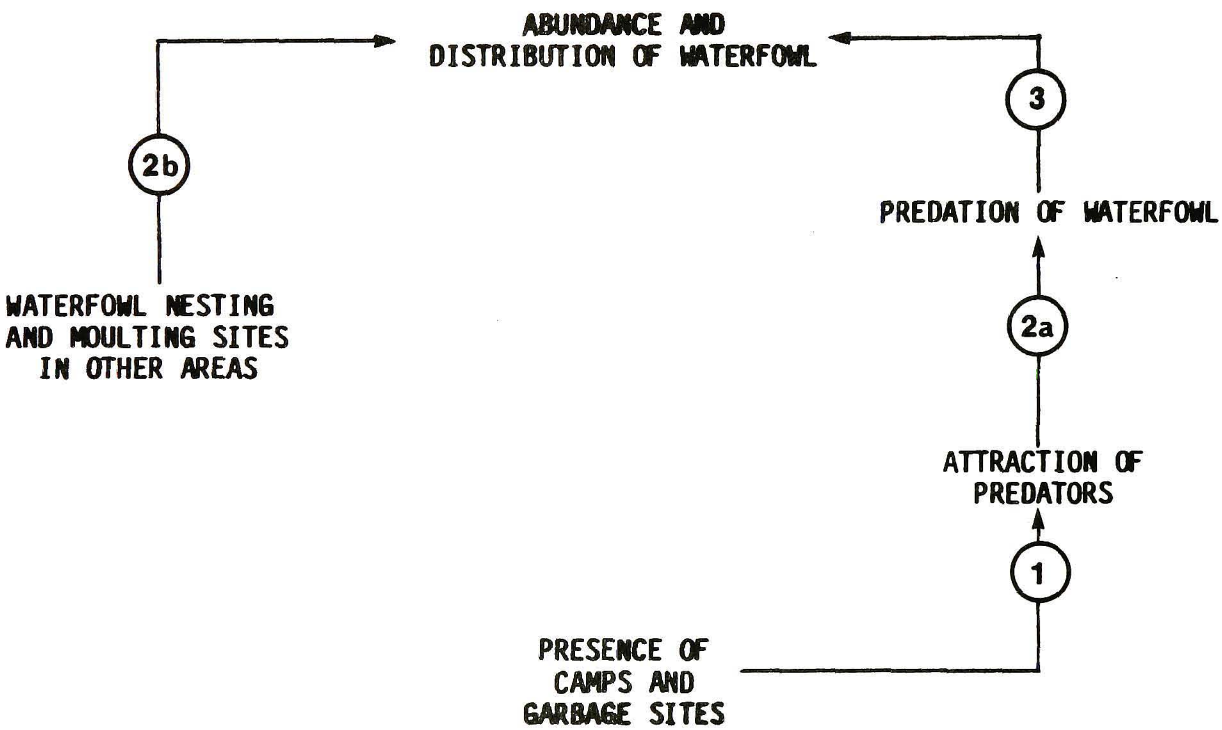
The Mackenzie Delta, Tuktoyaktuk Peninsula and Yukon North Slope provide summer habitat for large numbers of waterfowl, including approximately 20,000 tundra swans, 5000 snow geese, 3000 white-fronted geese, 600 brant and over 400,000 ducks (McCormick et al. 1984; Alliston 1984). Most of the snow geese and brant nest in the Kendall Island Bird Sanctuary, while the remaining species nest in suitable habitat throughout the region. Moulting generally occurs in July and August near the nesting areas.

The presence of industrial camps and garbage disposal sites in the region may result in an increase in the number of waterfowl predators in local areas. If these sites are located in or near areas with high waterfowl densities, increased predation of birds may result.

The workshop participants agreed that the general wording of the hypothesis statement was satisfactory. However, the original wording of the linkages prepared prior to the workshop was amended to include ravens as a potential predator. The working group also considered including domestic dogs in the list of predators; however, because company policies generally prohibit dogs in camps, they were not considered a likely threat to waterfowl population in the area.

FIGURE 9-1

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



LINKAGES

Link 1: The presence of camps and garbage disposal sites in an area will result in localized increases in the number of potential waterfowl predators (including bears, foxes, jaegers, gulls and ravens).

Link 2:(a) Nesting or moulting waterfowl near camps and garbage disposal sites will be subject to increased predation.

(b) Waterfowl nesting or moulting away from camps and garbage disposal sites will be subject to reduced predation.

Link 3: Increased predation of nesting and moulting waterfowl near camps and garbage disposal sites will cause a decrease in the abundance and alter the distribution of waterfowl.

LINKAGES

Link 1: The presence of camps and garbage disposal sites in an area will result in localized increases in the number of potential waterfowl predators, including bears, foxes, jaegers, gulls and ravens.

Link 1 was considered valid in the absence of proper handling and disposal of domestic garbage. In the Yukon and the Northwest Territories, it is well known that animals are attracted to camps and garbage disposal sites, where they scavenge on domestic wastes. Examples of such occurrences include the presence of black bears at Norman Wells, wolves and foxes at the Whitehorse city dump, and gulls and ravens at the Yellowknife city dump. Foxes may also be attracted to camps because the raised buildings and trailers often provide suitable denning sites beneath their floors (D. Mossop, pers. comm.). Regulations concerning proper handling and disposal of garbage and domestic waste are usually specified in the operating conditions attached to land-use permits. Although most permit holders are required to incinerate garbage on a daily basis, it may still be available to scavengers before it is burned.

Animals are attracted to camps and garbage sites if they provide an easily accessible source of food. Some animals, particularly bears and foxes, may be destroyed if they become a nuisance or safety hazard (see Links 1 and 3). Although direct evidence is lacking, it was suggested that the local abundance of bears may be reduced due to the occasional need to destroy nuisance animals. This, in turn, could reduce predation on nests.

Bears have been known to destroy a large number of snow goose nests in the Kendall Island Bird Sanctuary over several nesting seasons (T. Barry unpubl. data). Gulls, jaegers and ravens are opportunistic feeders that prey on waterfowl eggs and young birds (Godfrey 1966; Nettleship 1972; Pitelka et al. 1955), and often attack nests when the adults are forced to leave their nests as a result of disturbances (e.g., human interference). Under normal circumstances, waterfowl eggs and young birds are not particularly vulnerable to avian predators because the nests are widely dispersed and generally well concealed (ducks) or are actively defended by both parents (geese). When threatened by arctic fox, snow geese may be more effective than brant in defending the nest due to their size. However, neither species is successful when defending nests against red foxes (T. Barry, pers. comm.).

Link 2(a): Nesting or moulting waterfowl near camps and garbage disposal sites will be subject to increased predation.

The subgroup agreed that congregations of moulting waterfowl are not particularly vulnerable to predators. Similarly, solitary nesting species (e.g., ducks) are unlikely to experience significant losses due to a localized increase in the number of predators because of their highly dispersed nature and the widespread availability of suitable habitat.

The validity of this linkage for the study area was difficult to assess in the absence of detailed information concerning the locations of development facilities. Colonial nesting geese are most susceptible to increased predation through Link 2a. However, the development scenario anticipates no major camps or garbage sites near the snow goose colonies within the Kendall Island Bird Sanctuary, although a gas plant may be located nearby. In any event, oil and gas development will not necessarily cause localized increases in predators if preventive methods to eliminate garbage are practised. Daily incineration of domestic wastes is considered a normal part of operation in the development scenario (R.A. Owens Environmental Services Ltd. 1985).

Link 2(b): Waterfowl nesting or moulting away from camps and garbage disposal sites will be subject to reduced predation.

Nesting or moulting waterfowl in areas away from camps and garbage sites would be subject to reduced predation only if (1) predators vacate their established home ranges or territories to re-direct their feeding/scavenging activities near camps and garbage sites, and (2) vacated areas are not reoccupied by other predators. The workshop participants concluded that this is highly unlikely.

Link 3: Increased predation of nesting and moulting waterfowl near camps and garbage disposal sites will cause a decrease in the abundance and alter the distribution of waterfowl.

This link was not formally discussed by the subgroup since it was added to the hypothesis after the workshop for consistency within the MEMP framework. This link is theoretically valid but measurable significant decreases in the abundance of waterfowl would not occur because of the conclusions reached in Link 2a.

CONCLUSION

The participants of the workshop concluded that Hypothesis No. 9 is valid. However, in view of the locations of proposed facilities and if proper handling procedures for domestic waste are undertaken, camps and garbage disposal sites will not likely affect the number of waterfowl lost through increased predation. Disposal of domestic wastes associated with land-use activities in the region is currently regulated under the Territorial Lands Act.

RESEARCH AND MONITORING

No research or monitoring programs that directly involve studying predator-prey relationships were recommended. The group agreed that monitoring of the nesting success of waterfowl in the area would most likely cause disturbance of nesting birds, and may actually increase the number of nests lost to predators as a result of the monitoring study. Preventive and remedial actions to eliminate problems associated with attraction of wildlife to garbage were considered to be most practical and economical. Any initial efforts should be devoted to monitoring the degree to which garbage problems develop.

LITERATURE CITED

Alliston, W.G. 1984. A monitoring study of the species, numbers, habitat use and productivity of waterfowl populations on two study areas in the wooded Mackenzie Delta, summer 1983. Rep. by LGL Ltd., King City, Ontario, for B.C. Hydro, Vancouver.

Godfrey, W.E. 1966. The birds of Canada. National Museum of Natural Sciences, National Museums of Canada, Ottawa. 428 p.

McCormick, K.J., M.E. Adams, C.J. Stephenson and A.S. Goodman. 1984. Key migratory bird terrestrial habitat sites in the Northwest Territories. Canadian Wildlife Service, Western and Northern Region, Habitat Management Section Technical Report No. 84-6. 175 p.

Nettleship, D.N. 1972. Breeding success of the common puffin (*Fratercula arctica* L.) on different habitats at Great Island, Newfoundland. Ecological Monographs 42(2): 239-268.

Pitelka, F.A., P.Q. Tomich and G.W. Treichel. 1955. Ecological relations of jaegers and owls as lemming predators near Barrow, Alaska. Ecological Monographs 25(3): 85-117.

HYPOTHESIS NO. 10

CHRONIC (EPISODIC) SPILLS OF CRUDE OIL AND DIESEL FUEL NEAR STAGING AND MOULTING AREAS OF NESTING COLONIES WILL REDUCE THE ABUNDANCE OF WATERFOWL

PARTICIPANTS

Bob Ferguson	Dave Mossop
David Krutko	Wendy Nixon
Steve Matthews	Glen Sutherland
Margaret McLaren	John Ward

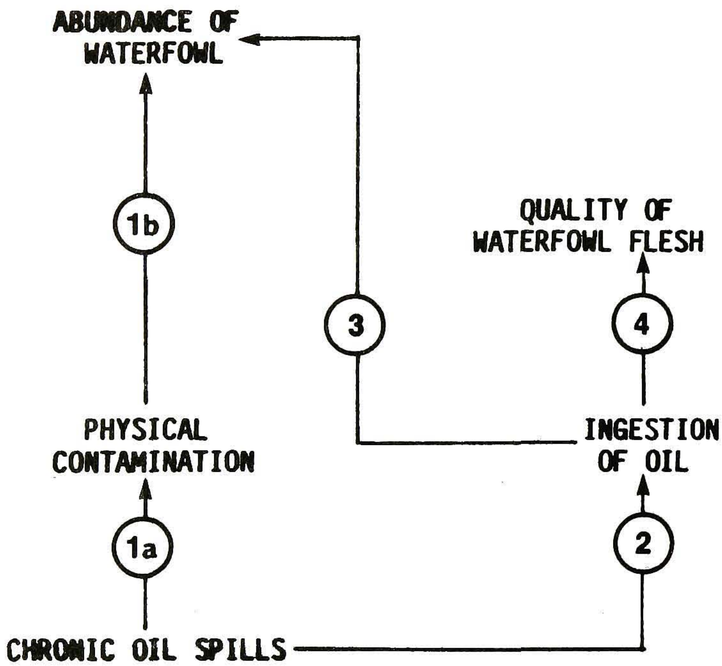
INTRODUCTION

Small oil spills occur during routine operations by the petroleum industry in the study area. At present, these spills are restricted largely to fuels, but in the future will likely include crude oil spills at production facilities and along pipelines. Information available from report files on past oil spills indicate that volume of chronic spills is inversely related to the frequency of spills and that the majority of spills involve oil losses of less than one barrel. Currently, the most frequent and largest oil spills are associated with existing shorebases in the Beaufort development region (Dome Petroleum, unpubl. data). It is expected that development of additional production and transportation facilities in the Mackenzie Delta and Tuktoyaktuk Peninsula area and along the Mackenzie River Valley will increase the frequency of chronic spills in these areas.

Information available for offshore production areas and from the oil spill case history literature both indicate that the vast majority of oil spills are caused by human error and equipment failure (Dome Petroleum et al. 1982). Table 10-1 tabulates oil spills in 1984 in the Beaufort region. There has been a decrease in the occurrence and volume of chronic oil spills over the last few years (Dome Petroleum, unpubl. data) as a result of: (1) increased awareness by industry personnel; (2) more thorough training programs; and (3) improved technology. Nevertheless, the frequency and

FIGURE 10-1

Chronic (episodic) spills of crude oil and diesel near staging and moulting areas of nesting colonies will reduce the abundance of waterfowl



LINKAGES

Link 1:(a) When susceptible bird species co-occur in space and time with the presence of an oil slick, physical contamination of the bird will occur.

Link 1:(b) Mortality of waterfowl will occur following physical contamination by oil.

Link 2: Waterfowl will consume oil through ingestion of contaminated food sources and preening of fouled plumage.

Link 3: Mortality of waterfowl will occur if oil is ingested.

Link 4: The quality of waterfowl flesh will be reduced if oil is ingested.

Table 10-1. Volumes and locations of oil spills during 1984 operation of the petroleum industry[1] (from INAC and Environment Canada 1985).

Locations		No. of Spills
Tuktoyaktuk Harbour[2]		10
Open Ocean		12
Land Spills		3
McKinley Bay		2
Wise Bay		2
Herschel Basin		9
	TOTAL	38

Volumes (litres)		No. of Spills
45 and less		21
46 - 225		6
226 - 450		3
451 - 900		1
901 - 2250		1
> 2250		-
	TOTAL	38

[1] Dome, ESSO and Gulf

[2] Three spills were of unknown origin; these were in the '45 and less' category

cumulative volume of chronic oil spills will likely increase with future hydrocarbon production and transportation in the study area.

Most contact of birds with oil has been associated with spills in offshore and coastal waters, but oil spills will also be associated with onshore development in the MEMP study area. Due to the location of most facilities away from waterbodies, most onshore chronic spills would only affect terrestrial habitats, where concerns related to bird contamination are relatively insignificant. However, there is a potential for oil to be released into rivers and lakes (i.e., fuel transfer docks along the river and pipeline river crossings) that may result in effects on waterfowl.

LINKAGES

Link 1(a): When susceptible bird species co-occur in space and time with the presence of an oil slick, physical contamination of the bird will occur.

Link 1(b): Mortality of waterfowl will occur following physical contamination by oil.

The following discussion in relation to Link 1 is based on the conclusions presented in relation to BEMP Hypothesis No. 10 (INAC and Environment Canada 1984, 1985). For the present study, only chronic oil releases into the Mackenzie River and into lakes were considered. Spills in the terrestrial environment were considered inconsequential to waterfowl and, therefore, did not warrant further discussion at the workshop.

Many species of birds are highly susceptible (due to behaviour and life history) to oil spills, and have suffered mortality following contamination by petroleum hydrocarbons (Duval et al. 1981; Brown 1982). This mortality results principally from the physical effects of oil on thermoregulatory capacity and buoyancy, as well as from the toxicity of petroleum hydrocarbons ingested during preening or feeding activities (see Link 2) (Brown 1982). When birds are fouled through direct contact with oil slicks, the plumage becomes matted and loses some of its waterproofing properties. Although this loss of buoyancy may be sufficient to cause a bird to drown, hypothermia caused by the loss of insulation normally provided by the plumage is the primary cause of death. A third possible pathway through which oil effects bird populations is contamination of eggs. It has been demonstrated that oil can be transferred from the plumage of an adult oiled bird to the surface of the egg and cause a toxic effect on the embryo (King and Lefever 1979; Albers 1980). The group considered this form of mortality to be an unlikely consequence of chronic spills in the region.

Relatively small spills can cause extensive bird mortality under some circumstances (Barrett 1979), such as when large concentrations of susceptible bird species occur within a restricted area. On the other hand, large episodic spills do not necessarily result in an oil slick that is capable of fouling birds. Because there are few locations in the study area where concentrations of waterfowl could be exposed to oil from chronic spills, most waterfowl species are not expected to be at major risk. Waterfowl were considered most susceptible to oil spills during the period of spring migration when waterfowl 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 actually contacting oil slicks is expected to be small in relation to the regional populations.

Link 2: Waterfowl will consume oil through ingestion of contaminated food sources and preening of fouled plumage.

Waterfowl may ingest hydrocarbons either directly through preening of fouled plumage or indirectly through consumption of oiled prey. It has been demonstrated that invertebrates and fish accumulate hydrocarbons and store potentially toxic compounds in their tissues (Thomson et al. 1981). It has also been demonstrated that captive mallards (*Anas platyrhynchos*) will consume oil-contaminated grain (Holmes et al. 1978, 1979). The subgroup considered it likely that waterfowl would feed in an area where an oil spill had occurred and thereby ingest hydrocarbons through consumption of contaminated food. It was noted, however, that ingested hydrocarbons are metabolized and depurated fairly rapidly; thus, contamination might be relatively brief after an episodic spill.

Link 3: Mortality of waterfowl will occur if oil is ingested.

Several studies have indicated that ingestion of oil can be fatal for several species of ducks, and that consumption of sublethal quantities of oil will increase the susceptibility of waterfowl to environmental stress such as cold temperatures (Hartung and Hunt 1966; Holmes 1978, 1979).

Link 4: The quality of waterfowl flesh will be reduced if oil is ingested.

There is no evidence for or against this link. Uptake and accumulation of hydrocarbons due to ingestion of contaminated food has not been shown to cause tainting in waterfowl. The subgroup agreed that the amount of oil required to cause perceived tainting in waterfowl flesh would most likely be lethal to the bird before it was harvested.

CONCLUSION

It was concluded that there is sufficient information to accept the hypothesis that chronic oil spills will cause mortality of birds under some circumstances. The combination of circumstances that may lead to bird mortality (i.e., volume of spill, oil type, time of year, type of habitat contaminated, slick thickness and movement, and the behaviour of contaminated birds) is complex and effects can be highly variable. The significance of oil-related mortality to waterfowl populations was expected to be low. Nevertheless, it was recommended that any mortality of birds resulting from chronic oil spills in the study area be documented.

RESEARCH AND MONITORING

No research in relation to this hypothesis was recommended.

Since episodic oil spills in the MEMP study area were considered unlikely to result in significant mortality of birds, no extensive monitoring program was recommended. INAC and Environment Canada (1985) reported that there have been no reports of bird mortality to date following chronic spills. If large-scale mortality of birds was occurring in the Beaufort region, this would have been noted by government and oil spill response personnel. It is thought that because many northerners are actively employed in various aspects of petroleum industry operations in this region, and because of the interests of native communities in protection of wildlife resources, any significant mortality of birds due to chronic spills observed by these people would be reported to industry environmental coordinators, government agencies or a local Hunters and Trappers Association. It was also emphasized that bird mortality due to chronic oil spills is not considered a problem in other areas (e.g., Gulf of Mexico, North Sea) where oil production has occurred for many years (INAC and Environment Canada 1985) or in onshore production areas (e.g., Alberta).

It was concluded that the only monitoring that is required at the present time is the documentation of the numbers and species of oil-contaminated birds in oil spill reports. It was recommended that oil spill report forms should be redesigned to include wildlife information but it was noted that some petroleum industry companies already collect this information. If chronic spills increase substantially in frequency and volume from present levels, implementation of a systematic monitoring program may be justified.

LITERATURE CITED

Albers, P.H. 1980. Transfer of crude oil from contaminated water to bird eggs. Environ. Res. 22:307-314.

Barrett, R.T. 1979. Small oil spills kills 10-20,000 seabirds in north Norway. Mar. Poll. Bull. 110:253-255.

Brown, R.G.R. 1982. Birds, oil and the Canadian environment. pages 105-112. In: J.R. Sprague, J.H. Vandermeulen and P.G. Wells (eds.). Oil and Dispersants in the Canadian seas--Research Appraisal and Recommendations. Envir. Can., Envir. Prot. Serv. Rep.

Dome Petroleum Ltd., Esso Resources Canada Ltd. and Gulf Canada Resources Inc. 1982. Beaufort Sea-Mackenzie Delta Environmental Impact Statement. Vol. 6. Accidental Spills, Calgary, Alberta.

Duval, W.S., L.C. Martin and R.P. Fink. 1981. A prospectus on the biological effects of oil spills in marine environments. Prepared by ESL Environmental Sciences Ltd. for Dome Petroleum Ltd., Calgary, Alta. Beaufort EIS Support Document. 92 p. + appendices.

Hartung, R. and G.S. Hunt. 1966. Toxicity of some oils to waterfowl. J. Wildl. Manage. 30:564-570.

Holmes, W.N., J. Cronshaw and J. Gorsline. 1978. Some effects of ingested petroleum on seawater adapted ducks (Anas platyrhynchos). Environ. Res. 17:177-190.

Holmes, W.N., J. Gorsline and J. Cronshaw. 1979. Effects of mild cold stress on the survival of seawater adapted mallard ducks (Anas platyrhynchos) maintained on food contaminated with petroleum. Environ. Res. 20:425-444.

Indian and Northern Affairs Canada and Environment Canada. 1984. Beaufort Environmental Monitoring Project 1983-1984 Final Report. Unpubl. rept. by LGL Limited, ESL Environmental Sciences Limited and ESSA Limited. 292 p.

Indian and Northern Affairs Canada and Environment Canada. 1985. Beaufort Environmental Monitoring Project. 1984-1985 Final Report. Unpubl. rept. by ESL Environmental Sciences Limited, LGL Limited, ESSA Limited, Arctic Laboratories Limited and Arctic Sciences Limited. 162 p.

King, K.A. and C.A. Lefever. 1979. Effects of oil transferred from incubating gulls to their eggs. Mar. Pollut. Bull. 10:319-321.

Thomson, D.H., M.A. McLaren and A.D. Sekerak. 1981. Review of the effects of oil on marine flora and fauna with special reference to arctic regions. Rep. by LGL Ltd., Toronto, for Petro-Canada Explorations, Inc., Calgary. 120 p.

HYPOTHESIS NO. 11

LAND SUBSIDENCE RESULTING FROM HYDROCARBON WITHDRAWAL WILL CHANGE THE ABUNDANCE AND DISTRIBUTION OF WATERFOWL, FISH AND MUSKRAT

PARTICIPANTS

Terry Antoniuk	John McDonald
Bob Ferguson	Mike Miles
Alan Gell	Aaron Sekerak
Mike Jones	Walt Younkin
Peter McCart	

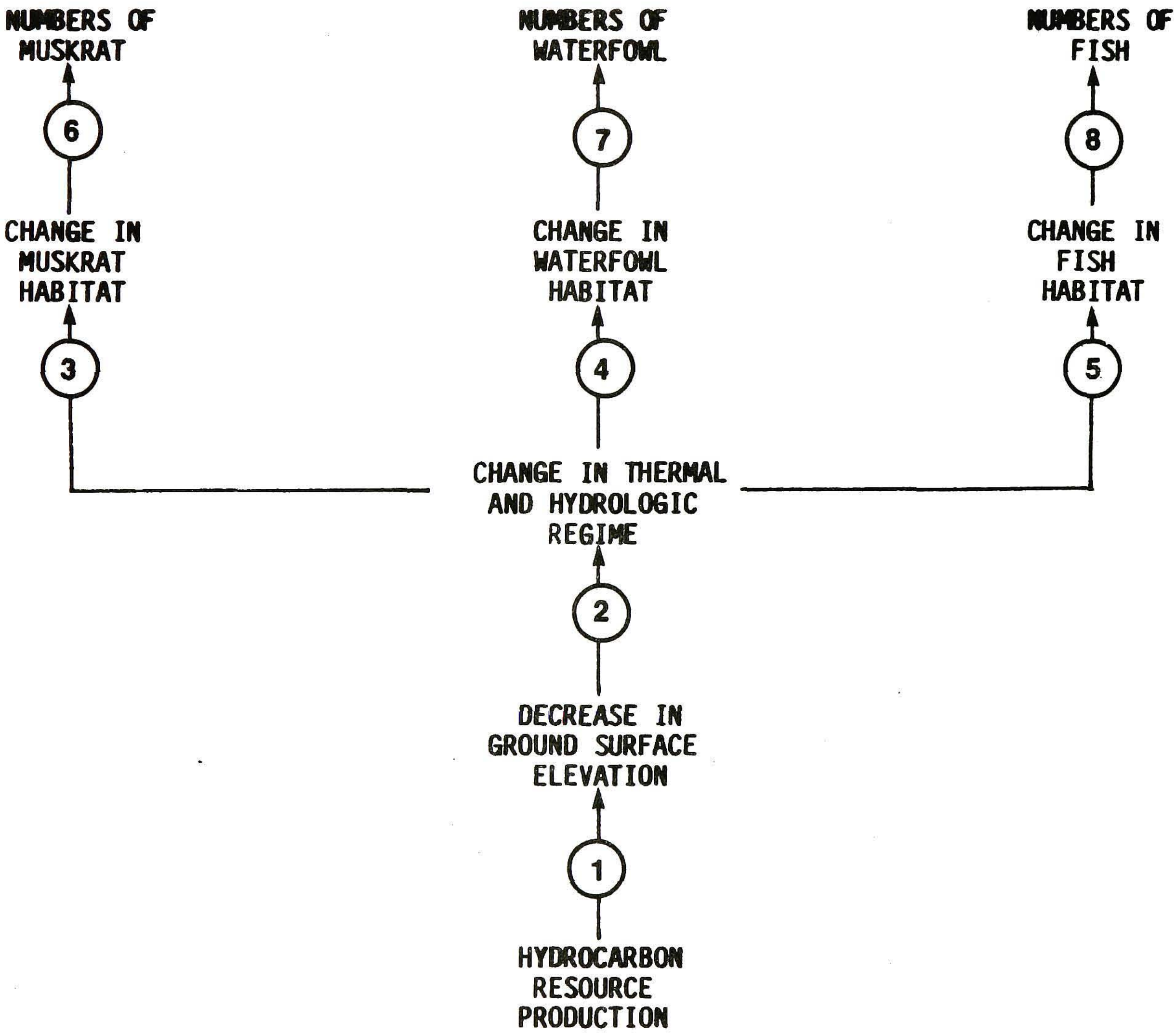
INTRODUCTION

The active (Outer) Mackenzie Delta is generally a low, flat area underlain by discontinuous permafrost. The Tuktoyaktuk Peninsula and the majority of Richards Island (part of the Pleistocene Coastal Plain), are predominantly low-lying and are underlain by continuous permafrost. Many of the positive relief features in the area are due to the presence of large quantities of underground ice. Within the active and Pleistocene Delta area, the currently anticipated gas production sites are located at Parsons Lake and YaYa (North and South) - Gulf; Niglintgak - Shell; and Taglu - Esso.

Subsidence is the lowering of the land surface either locally or regionally, and may result from natural processes or be directly or indirectly induced by man's activities. The potential for land subsidence as a result of hydrocarbon reservoir pumping has been identified as a concern in relation to waterfowl, fish and muskrat habitat (see Fig. 11-1), particularly in low-lying areas of the Outer Mackenzie Delta. Background information on the complexity of natural deltaic processes, the natural changes in land and sea levels, the influence of permafrost, and the effects of development-induced subsidence is provided below. In addition, a more detailed discussion of the potential for subsidence in the Mackenzie Delta due to reservoir pumping is provided in Appendix B (McComiskey 1985).

FIGURE 11-1

> Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat



LINKAGES

Link 1: Hydrocarbon production will cause subsidence of the ground surface overlying the Mackenzie Delta oil and gas fields.

Link 2: Subsidence of the ground surface will cause a change in the thermal and hydrologic regime.

Links 3,4,5: A change in the thermal and hydrologic regime will cause a change in the area and quality of habitat for muskrat (Link 3), waterfowl (Link 4) and fish (Link 5).

Links 6,7,8: A change in the area and quality of habitat will cause a change in the numbers of muskrat (Link 6), waterfowl (Link 7) and fish (Link 8).

Natural Subsidence

Natural subsidence of the Mackenzie Delta area is continuing as regional submergence occurs in the southern Beaufort Sea (Forbes 1980). Some of the potential causes are subsidence of the Mackenzie sedimentary basin, subsidence due to the weight of accumulated sediment and subsidence due to consolidation of sediments. Hill et al. (1985) found that sea level at the margins of the Canadian Beaufort has risen 140 m in the last 27,000 years. They attributed 35 m of the relative sea level change to basin subsidence. The current rise of the monthly mean tide level may be 1.67 mm/y (Forbes 1980) or as much as 1.0 cm/y (Forbes and Frobel 1985, after Harper et al. 1984).

Induced Subsidence

Underground fluids fill intergranular spaces and support sediment grains. Consequently, the withdrawal of fluids such as oil and gas results in a loss of support and causes compaction to occur. The land surface may subside where such compaction occurs. This is direct subsidence. In many oil and gas reservoirs, only a small degree of reservoir compaction and surface subsidence are experienced. On the other hand, the harbour at Long Beach, California has subsided as much as 9 m due to oil and gas extraction (Mayuga and Allen 1970). Smaller amounts of subsidence have been documented elsewhere such as in the Houston-Galveston area, where a 30-cm subsidence occurred throughout an area of 6500 km^2 and as much as 2.25 m in local areas (Lee and Nichols 1981). Martin and Serdengecti (1984) concluded that "As yet, no reliable method has been established to ... accurately predict large-scale reservoir compaction and subsidence."

In the Mackenzie Delta, subsidence may cause a change in the ground thermal regime which could subsequently result in an increase in the spatial extent of both natural and man-induced subsidence. This could occur if increased flooding or direct effects result in extensive thawing of ice rich sediments. If this occurred, surface elevation would be influenced to a greater extent than would be predicted from an analysis of the reservoir geology.

LINKAGES

Link 1: Hydrocarbon production will cause subsidence of ground surface overlying the Mackenzie Delta oil and gas fields.

In the Mackenzie Delta, land surface subsidence and a concomitant rise in the relative sea level is naturally occurring. The following discussion addresses the potential for directly- and indirectly-induced subsidence in the area due to hydrocarbon production.

Directly-induced subsidence: Direct surface subsidence most likely occurs to a certain degree over all oil and gas reservoirs where pressure is not maintained. Of the oil and gas fields in the study area, the Niglintgak reservoir is considered to be the most susceptible to substantial subsidence (McComiskey 1985). Subsidence is not anticipated at the other reservoirs in the Delta because (1) pressure will be maintained during production, and/or (2) it is thought that the specific reservoir characteristics would prevent subsidence from occurring (see Appendix B). For this reason, effects of subsidence are considered only at the Niglintgak field in the following discussion.

Due to site-specific variations in hydrocarbon reservoir properties, fluid pressure, reservoir geometry and mechanical properties of the rock, it is very difficult to predict the extent of ground surface subsidence (Martin and Serdengecti 1984). Kyles et al. (1979) provide two estimates of the depth of potential subsidence at Niglintgak. Their conclusions are provided verbatim.

> (1) A subsidence bowl will form at the surface as the Niglintgak field is depleted.
>
> (2) There is a high probability (some 90%) that maximum subsidence after 25 years of production will be about 1/2 metre. This level of subsidence can be accommodated by minor changes in design of well casing and foundations for surface facilities. If subsidence were as great at 2.6 metres (10% chance), drastic alterations to surface topography would occur (see Section VII).
>
> The final subsidence which is realized will depend on whether or not the reservoir has been pre-stressed to levels above current effective stress by the presence of a large ice cap in the recent past (90% chance the ice was there, 10% chance it wasn't).

(3) Maximum subsidence will occur under the river channel about 0.3 kilimeters S-SE of the B-19 well.

Maximum subsidence of currently 'dry' land will occur over the point of land south of B-19.

(4) The principal unknown in the calculation of surface subsidence caused by reservoir compaction is the reservoir rock uniaxial compaction coefficient Cm. Lab work done by KSEPL on core from B-19 was intended to define this parameter, however this work was successful only in defining a reasonable upper limit to the value of Cm. (yields the afore-mentioned 2.6 metre subsidence).

Detailed examination of lab-measured Cm values and field performance from several fields where compaction is monitored did not yield a consistent relation between Cm (lab) and Cm (in situ).

(5) The one facet of the compaction phenomenon which appears certain is: if the reservoir has been subjected to greater stresses at some time in the past than currently exist in the rock framework, compaction during depletion will be extremely small until effective stress increases beyond this previous maximum value.

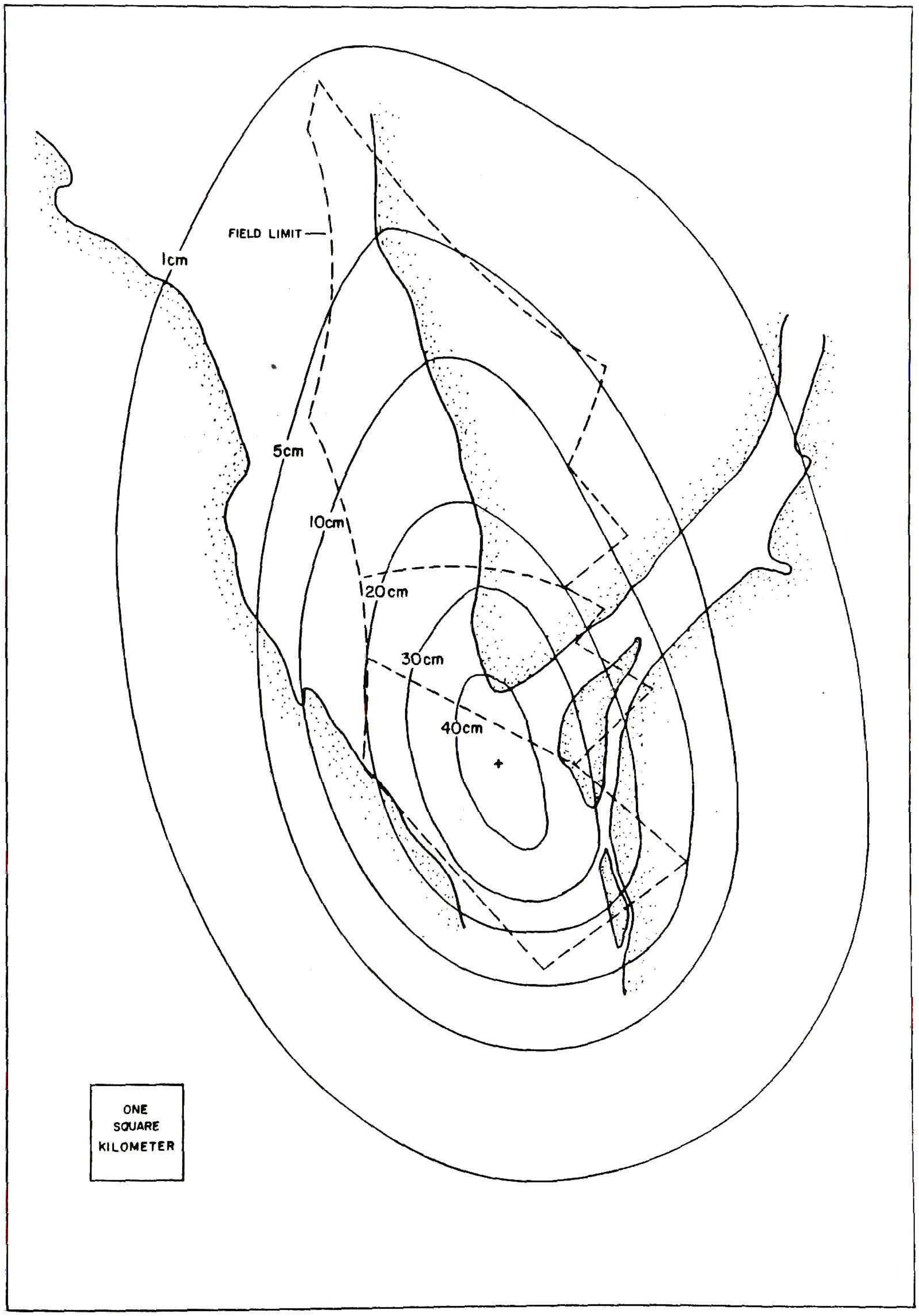
It should be noted that the above assessments were predicated on a 90% probability that a large ice cap was present in the recent past (Kyles et al. 1979). However, no evidence in support of these probabilities was provided by these researchers.

The Niglintgak area is located within the zone of discontinuous permafrost. However, is is not known whether the Niglintgak field itself is underlain entirely or partially by permafrost. If permafrost is present, it may influence the rock mechanical properties of the reservoir and thereby affect the rate of direct subsidence.

Indirectly-induced subsidence: There are no site-specific data available on the distribution of permafrost and its associated ground ice in the Niglintgak area. Pollard and French (1980) attempted to calculate the volume of ground ice in the Richards Island area. They found that immediately below the top of permafrost (i.e., at a depth of 1-2 m) ice may occupy over 60% by volume of the ground. In a low-lying area, thawing of this layer could cause subsidence of the ground surface to below the present water level.

FIGURE 11-2

Potential land surface subsidence at the Niglintgak field (from Kyles 1979).



Link 2: Subsidence of the ground surface will cause a change in the thermal and hydrologic regime.

Approximately 80% of the outer Delta area floods each spring (Slaney and Company Ltd. 1976). More of the Delta may flood as a result of land surface subsidence; however, these effects will be minor and localized if only a small degree of subsidence occurs.

Direct Effects: Currently there is a lack of information concerning natural hydrologic processes in the area (e.g., changes in the water level), although it is apparent that the magnitude and duration of flooding is highly variable from area to area within the Delta. However, if the "worst case" situation is assumed (i.e., 10% probability that subsidence will be as great as 2.6 m), the southern edge of the island on which most of the Niglintgak reservoir is located would be submerged throughout the summer. Considering the "best case" (i.e., 90% probability that maximum subsidence will only be 0.5 m), the effects of flooding would be more localized.

If subsidence occurs, storm surges may transport salt water into areas where it has not previously occurred. The salinity of this water would be low, and it would most likely be flushed out of such areas during the subsequent spring freshet.

Indirect Effects: The indirect effects of land surface subsidence on the thermal and hydrologic regime cannot be predicted quantitatively due to the lack of site-specific information regarding the distribution of permafrost and ground ice. However, the potential does exist for thermokarst processes to occur along with associated changes in hydrologic conditions (i.e., an increase in area submerged). Depending on the extent and distribution of ice, the indirect effect could influence a larger area than originally predicted on the basis of reservoir geology.

Links 3,4,5: A change in the thermal and hydrologic regime will cause a change in the area and quality of habitat for muskrat, waterfowl and fish.

According to the 'best case' scenario presented by Kyles et al. (1979), an elliptical subsidence bowl, with an area of approximately 100 km^2 and a maximum depth of 0.5 m at the well site, will form at Niglintgak due to direct subsidence. If the spatial extent of direct subsidence is restricted to that predicted in this scenario and indirectly induced subsidence does not occur, the subgroup concluded that the loss of muskrat and waterfowl habitat would be inconsequential relative to total available habitat in the area. It was also expected that no critical habitat for muskrat and waterfowl would be lost. Subsidence would increase water depths and permanency of shallow water areas, and thereby increase the total amount of potential aquatic habitat for fish. Particular habitats could be positively affected (e.g., overwintering areas) or negatively affected (e.g., shallow water feeding areas). It is thought that the overall effect on fish habitat in the study area would be inconsequential.

Given the 'worst case' scenario presented by Kyles et al. (1979), an elliptical bowl with an area of approximately 100 km^2 and a maximum depth of 2.6 m near the southern field limit will form due to direct subsidence. Substantial alterations to surface topography would also occur (Kyles et al. 1979). The subgroup assumed that these alterations would be due to indirect effects such as thermokarst and thermal erosion. Indirectly-induced subsidence is a potential cause of land submergence (see Link 1). Thermokarst activity has occurred naturally on the Delta, and many of the large lakes in the Niglintgak area are considered to be of thermokarst origin; this includes Big Lake, which has an area of 16 km^2 (C.P. Lewis, pers. comm.). However, it is not suggested that induced thermokarst activity at Niglintgak would necessarily be of such a magnitude. It was concluded that the indirect effects of subsidence on the area and the quality of muskrat, waterfowl and fish habitat could not be assessed on the basis of available information. As discussed in a subsequent section, a research program would be necessary to address this area of present uncertainty.

Links 6,7,8: A change in the area and quality of habitat will cause a change in the numbers of muskrat, waterfowl and fish.

In the 'best case' subsidence scenario, the subgroup expected that changes in terrestrial and aquatic habitats would be inconsequential in terms of their effect on muskrat, waterfowl and fish populations. However, given the 'worst case' scenario, it was not possible to assess the indirect effects of subsidence on the area and quality of habitat or its subsequent potential impact on the numbers of muskrat, waterfowl and fish. It was recognized that the creation of large lakes (e.g., Big Lake) and other topographic features in the area were a result of past thermokarst activity, and that the potential exists for substantial alterations to the land surface due to geomorphological processes induced by hydrocarbon extraction (Kyles et al. 1979).

CONCLUSION

On the basis of existing information and the current development scenario, the working group conditionally concluded that changes in the area and quality of available habitat and the numbers of muskrat, waterfowl and fish due to subsidence associated with hydrocarbon reservoir depletion would likely be inconsequential at population levels. This conclusion was conditional because there is no reliable method to accurately predict reservoir compaction and direct subsidence (Martin and Serdengecti 1984). The workshop subgroup based their conclusion on the premise that (1) the two probability estimates of potential direct subsidence at Niglintgak (Kyles et al. 1979), and (2) evidence that direct subsidence over other reservoirs in the MEMP study area would be negligible were correct. It was agreed that the potential exists for indirect effects, although the extent of this could not be accurately predicted. To evaluate current predictions concerning potential subsidence in the Niglintgak area, the following research and monitoring programs were recommended.

RESEARCH

(1) Reservoir geology of the Niglintgak area should be reviewed and compared to that in areas of known subsidence.

(2) The importance of permafrost on mechanical properties of reservoir rock and, therefore, on potential direct subsidence should be examined.

(3) The vertical and horizontal distribution of permafrost in the area of hydrocarbon reservoirs should be determined.

MONITORING

Production at Niglintgak will provide an excellent opportunity to conduct a monitoring program on the effects of subsidence in an area of permafrost. The program could initially include collection of site-specific topographic, hydraulic, surficial and geological data, which could be used to quantitatively predict the potential effects of subsidence and also serve as a baseline for the assessment of actual effects and accuracy of predictions. Site-specific biological data may also have to be collected since detailed base line information is lacking in most instances.

Due to the inherent difficulty in predicting the extent of directly-induced subsidence, and the effects of permafrost and contained ice, it was recommended that monitoring of ground surface elevations be initiated prior to and continued during production around the Niglintgak reservoir area. It is anticipated that the oil and gas industry will establish a geodetic baseline in order to monitor these elevation changes. The monitoring program should be conducted on a regular basis to ensure that subsidence is detected as early as possible and should be designed to differentiate between natural and production-related subsidence. If subsidence occurs, its significance in terms of the habitat and fish and wildlife populations should be re-evaluated. Additional research and monitoring may be necessary if actual effects are significantly greater than those anticipated.

LITERATURE CITED

Forbes, D.L. 1980. Late quaternary sea lands in the southern Beaufort sea. In: Current Research, Part B. Geological Survey of Canada, Paper 80-1B p. 75-87.

Forbes, D.L. and D. Frobel. 1985. Coastal erosion and sedimentation in the Canadian Beaufort sea. In: Current Research, Part B. Geological Survey of Canada, Paper 85-1B, p. 69-80.

Hill, P.R. et al. 1985. Sea level curve for the Canadian Beaufort Shelf. Canadian Journal of Earth Sciences. 22(11)

Kyles, J.D., R.M. Gies, H.M. Howells and G.M. Durham. 1979. Surface subsidence resulting from reservoir compaction, Niglintgak Field, Mackenzie Delta. Internal report prepared for Shell Canada Resources Limited.

Lee, S. and D.R. Nichols. 1981. Subsidence. In: W.W. Hayes (ed.) Facing geologic and hydrologic hazards - earth science considerations. U.S. Geological Survey. Professional Paper 1240-B. p. 73-85.

Martin, J.C. and S. Serdengecti. 1984. Subsidence over oil and gas fields. Pages 23-34. In: T.L. Hozer (ed.) Man-induced Land Subsidence. Reviews in Engineering Geology, Volume IV. Geological Society of America, Boulder, Colorado.

Mayuga, M.N. and D.R. Allen. 1970. In: Proceedings of the Tokyo Symposium of Land Subsidence. I.A.S.H. p. 66-79.

McComiskey, J.E. 1985. Land subsidence as a result of fluid withdrawal. Prepared for Mackenzie Environmental Monitoring Program by Gulf Canada Resources Inc. Unpublished manuscript.

Pollard, W.H. and H.M. French. 1980. A first approximation of the volume of ground ice, Richards Island, Pleistocene Mackenzie Delta, Northwest Territories, Canada. Canadian Geotechnical Journal, v. 17 p. 509-516.

Slaney, F.F. and Company Limited. 1976. 1975 Hydrology survey, Niglintgak, Mackenzie Delta, Northwest Territories. Prepared for Shell Canada Limited, Calgary, Alberta.

HYPOTHESIS NO. 12

AIR EMISSIONS RESULTING FROM OIL AND GAS DEVELOPMENT AND OPERATION WILL ADVERSELY AFFECT AIR QUALITY

PARTICIPANTS

This hypothesis was prepared prior to the MEMP workshop by one of the participants (T. Jandali) and was presented during a plenary session. Unlike the other hypotheses, it was not the subject of a subgroup meeting and open discussion.

INTRODUCTION

Future development of hydrocarbon resources in the study area will result in gaseous and particulate emissions to the atmosphere. The objective of this review was to determine if these emissions could adversely affect regional air quality. The degree of potential impact of air emissions was assessed using the following steps:

a) A 'worst-case' production scenario within a sub-region of the study area was assumed in order to estimate the quantity and composition of air emissions that could be associated with hydrocarbon development activities;

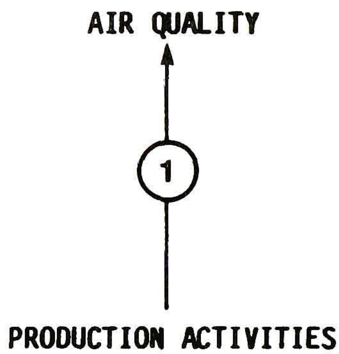
b) Dispersion calculations were completed to estimate ground level concentrations of pollutants likely to prevail within the defined sub-region during worst case meteorological conditions; and

c) Estimated maximum ground level concentrations were compared with regulatory guidelines established by Environment Canada.

Three locations of possible intensive exploration and production activity were identified. These are the Mackenzie Delta, Norman Wells and Colville Lake regions. Of these, the Mackenzie Delta region has the greatest potential for intensive development and therefore was selected for use in the worst-case scenario.

FIGURE 12-1

Air emissions resulting from oil and gas development and operation will adversely affect air quality



Link 1: Air emissions from a number of sources will adversely affect air quality.

It was assumed that, in a full development situation in the Mackenzie Delta region, active production facilities would be located at Mayogiak, Parsons Lake, Taglu, Niglintgak, Adgo, Ivik, and Kumak, and production drilling would reach a maximum of 60 wells per year. The presence of one major support base at Tuktoyaktuk was also assumed for the purpose of air emission determinations. In addition, a maximum of 3 major pipelines were assumed to originate from the Mackenzie Delta area, a 924 mm gas pipeline (including 2 compressor stations within the sub-region), a 500 mm oil pipeline (including 2 pumping stations), and a 200 mm oil pipeline (including 2 pumping stations). It was assumed that camps would be located on Richards Island and at Parsons Lake and would provide facilities for up to fifty personnel at each site.

The primary source of atmospheric emissions associated with oil and gas production in the Mackenzie Delta region are outlined in the following sections. These sources and their corresponding emission factors were used to estimate the quantity of pollutants emitted to the atmosphere under a worst-case situation. Unless otherwise stated, data regarding the amount and composition of air emissions were adapted from the 1983-84 report of the Beaufort Environmental Monitoring Project (INAC and Environment Canada 1984).

1. **Solid Waste Incineration:** Incineration of solid waste at production facilities, support bases, and camps would result in air emissions containing the following quantities of pollutants (expressed as percent weight of combustible solid waste):

Carbon Monoxide (CO)	- 1.49%
Nitrogen Oxides (NO_x)	- 0.22%
Sulphur Oxides (SO_x)	- 0.12%
Hydrocarbons (HC)	- 0.12%
Particulates (TSP)	- 0.62%

2. **Diesel Fuel Combustion:** The combustion of diesel fuel at development wells, support bases, and camps would result in the emission of the following pollutants (expressed as percent weight of fuel used).

Carbon Monoxide (CO)	- 0.92%
Nitrogen Oxides (NO_x)	- 3.38%
Sulphur Oxides (SO_x)	- 0.69%
Hydrocarbons (HC)	- 4.92%
Particulates (TSP)	- 1.69%

3. **Separated Gas Combustion:** Emissions of NO_x resulting from the combustion of gas for power generation at each production facility was estimated to be approximately 570 kg/day.

4. **Gas Flaring:** Gas flaring at production facilities was assumed to result in emissions of NO_x at the rate of 3.68 tonnes per million cubic metres of gas burned.

5. **Fuel Tanks:** Evaporative losses from storage fuel tanks at the major support base in Tuktoyaktuk were estimated to be about 50 tonnes of hydrocarbons per year.

6. **Natural Gas Combustion:** Natural gas would be used to power pipeline compressor stations. The following emission rates were assumed to occur as a result of natural gas combustion in heavy-duty gas turbine compressors (U.S. EPA 1977).

CO	- 0.7 g/kWh
NO_x	- 1.7 g/kWh
SO_x	- 0.003 g/kWh
HC	- 0.1 g/kWh
TSP	- n/a (1.0 g/kWh assumed)

7. **Propane Combustion:** The use of propane at support camps was assumed to result in the following pollutant emissions expressed as kilograms per 1000 litres of propane (U.S. EPA 1977).

CO	- 0.23 $kg/10^3L$
NO_x	- 1.3 $kg/10^3L$
SO_x	- 0.01 $kg/10^3L$
HC	- 0.084 $kg/10^3L$
TSP	- 0.22 $kg/10^3L$

LINKAGES

Link 1: Air emissions from a number of sources will adversely affect air quality.

The link between air emissions and air quality is direct. Therefore, in order to assess the significance of this hypothesis, the following information is presented:

1. quantitative estimates of total emissions of each pollutant during peak production;
2. identification of the spatial distribution of emission sources;
3. description of the dispersion calculations that were completed using the "box model" approach; and
4. comparison of estimated ground level pollutant concentrations with regulatory guidelines.

1. Total Emissions During Peak Production

Production Facilities Air emissions at production facilities would result from incineration of solid waste, combustion of separated gas, and gas flaring.

(i) The amount of solid waste incinerated at each facility was assumed to be equivalent to one offshore production platform - 700 kg/day/facility (INAC and Environment Canada 1984). Therefore, the total solid waste incinerated was estimated to be 4900 kg/day.

(ii) Separated gas used to operate power generation turbines at all production facilities was estimated to result in 4000 kg/day of NO_x emissions.

(iii) Flaring was expected to consume 4.5×10^5 m^3 of gas per day for all production facilities. Resulting emissions of NO_x would amount to an estimated 1656 kg/day.

Therefore, the operation of seven production facilities in the Mackenzie Delta region would likely result in the following emissions:

SUMMARY OF EMISSIONS FROM PRODUCTION FACILITIES
(kg/day)

	Solid Waste	Separated Gas	Gas Flaring	Totals
CO	73	-	-	73
NO_x	11	4000	1656	5667
SO_x	6	-	-	6
HC	6	-	-	6
TSP	30	-	-	30

Development Wells Air emissions from development wells are expected to be due entirely to diesel fuel combustion at the wellsite. It is estimated that each well will produce 2000 kg/day of emissions; these are conservatively assumed to consist entirely of pollutants. Furthermore, assuming that all 60 wells will be drilled simultaneously, the following quantities of emissions to the atmosphere would be expected:

SUMMARY OF EMISSIONS FROM DEVELOPMENT WELLS
(kg/day)

CO	9,500
NO_x	35,000
SO_x	7,100
HC	50,900
TSP	17,500

Support Base Emissions of atmospheric pollutants at the support base located in Tuktoyaktuk will result from incineration of solid waste, combustion of diesel fuel, and release of hydrocarbons from fuel storage tanks. Estimates of the quantity of emissions from this base were derived from data presented in the 1983-84 BEMP report (INAC and Environment Canada 1984) for the total quantities of emissions expected from four bases, given the expectation that Tuktoyaktuk, the largest base, would account for one-half of these total emissions. The estimated emissions from all sources due to year-round operation of the support base at Tuktoyaktuk are tabulated below:

SUMMARY OF ESTIMATED EMISSIONS AT TUKTOYAKTUK SUPPORT BASE (kg/day)

CO	265
NO_x	739
SO_x	157
HC	1,337
TSP	404

Pipelines The operation of pumping and compressor stations for oil and gas pipelines, respectively, will result in emissions to the atmosphere. Compressor and pumping stations for the three pipelines identified in the production scenario were assumed to have the following power requirements:

SUMMARY OF PIPELINE POWER REQUIREMENTS

Pipeline	Type of Station/Power	No. of Stations
924 mm gas	compressor/20,000 HP	2
500 mm oil	pumping/ 5,000 HP	2
200 mm oil	pumping/ 1,000 HP	2

The estimates of air emissions assume that all stations use natural gas as a fuel source and that the quantities used are proportional to the horsepower requirements. These estimates are summarized below:

SUMMARY OF EMISSIONS FROM COMPRESSOR/PUMPING STATIONS
(kg/day)

	924 mm gas pipeline	500 mm oil pipeline	200 mm oil pipeline	Totals
CO	501	125	25	651
NO_x	1,217	304	61	1,582
SO_x	2	1	0	3
HC	72	18	4	94
TSP	716	179	36	931

Camps Air emissions from camps would result from solid waste incineration, power generation, and propane combustion. The following consumption rates were assumed.

Solid waste incineration	3.6 kg/person/day
Power generation (diesel)	5 kg/person/day
Propane combustion	4 gal/person/day

Therefore, the following emissions were estimated for two camps (50 persons at each) located within the Mackenzie Delta region:

SUMMARY OF EMISSIONS FROM TWO CAMPS
(kg/day)

	Solid Waste	Diesel	Propane	Totals
CO	5	5	-	10
NO_x	1	17	2	20
SO_x	-	3	-	3
HC	-	25	-	25
TSP	2	8	-	10

Summary of Emissions In combination, the various activities associated with the peak production scenario in the Mackenzie Delta region are projected to result in the following total daily emissions to the atmosphere.

SUMMARY OF OVERALL DAILY EMISSIONS TO THE ATMOSPHERE
(kg/day)

	Production Facilities	Development Wells	Support Base	Pipelines	Camps	Totals
CO	73	9,500	265	651	10	10,499
NO_x	5,667	35,000	739	1,582	20	43,008
SO_x	6	7,100	157	3	3	7,269
HC	6	50,900	1,337	94	25	52,362
TSP	30	17,500	404	931	10	18,875

2. Spatial Extent of Development Region

The locations of assumed production facilities, support base, pipelines and camps within the Mackenzie Delta region are depicted in Figure 12-2. These facilities are all located within an area that extends 165 km in an east-west direction and 115 km in a north-south direction.

3. Dispersion of Emissions

Simple dispersion calculations were completed using the "Box model" concept to estimate maximum regional ambient ground level concentrations of various pollutants. This approach provides <u>order of magnitude</u> estimates of pollutant concentrations averaged over a 24-hour period. The following assumptions were made in order to undertake this analysis.

(i) Pollutants will be uniformly distributed in a mixed layer (100 m deep) below an elevated inversion, and will be spacially distributed due to the separation of sources and transport of emissions by light wind.

(ii) The lateral dimensions of the "box" are 165 km in the east-west direction and 115 km in the north-south direction (Figure 12-2). Given a 100 m mixing layer, the resultant "box" volume is 1.9×10^{12} m^3, and encompasses all scenario activities in the Mackenzie Delta.

(iii) Emissions will be confined within this space for up to four consecutive days, which represents worst-case calm and/or light wind conditions.

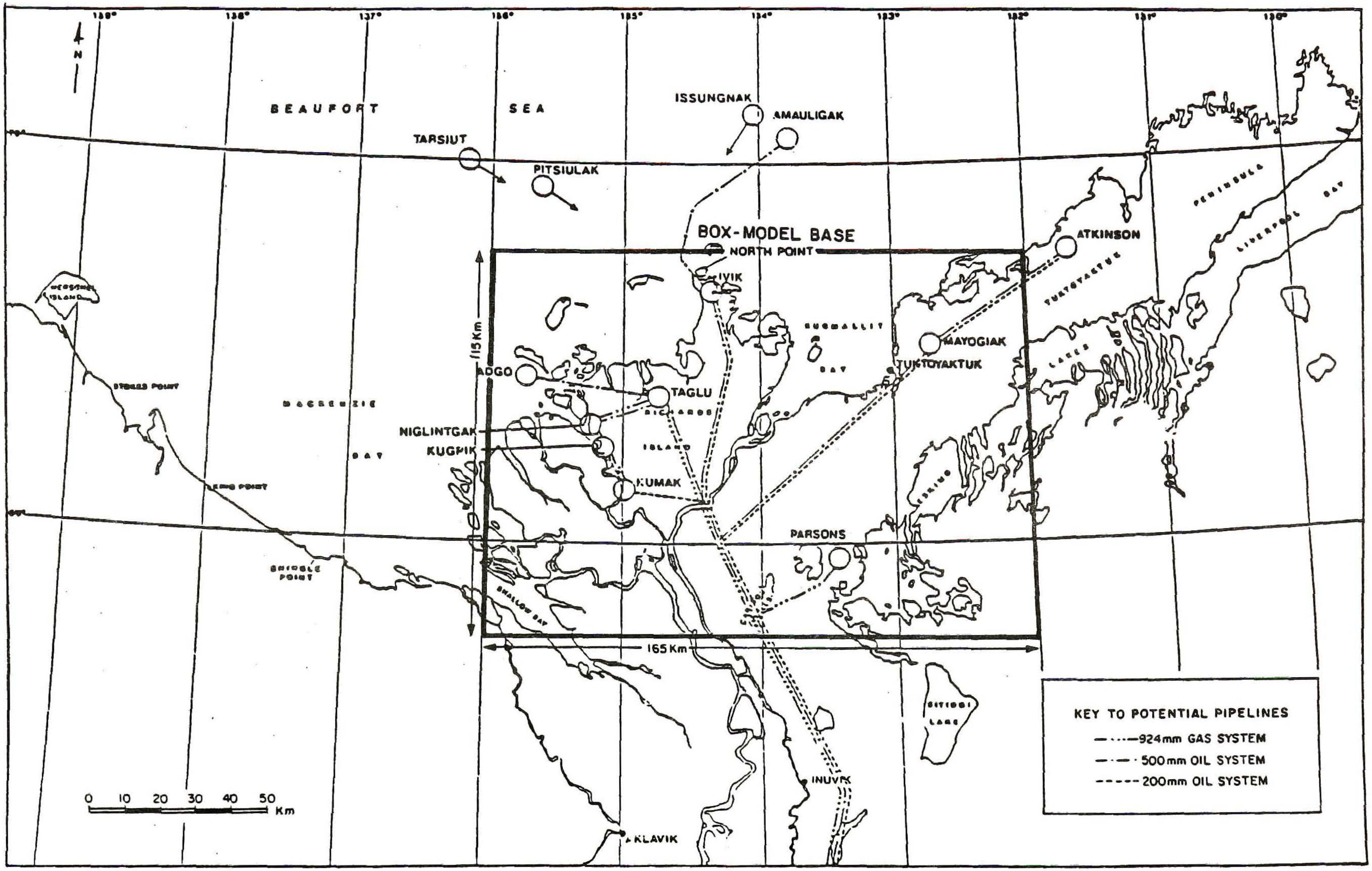


Figure 12-2 Development activities and extent of box-model base in the Mackenzie Delta Region.

4. Estimated Concentrations

Results of dispersion calculations are summarized in the following table which shows predicted maximum 24-hour average ground level concentrations of the five primary pollutants. It must be emphasized, however, that these estimates reflect two considerations.

(i) Predictions of maximum ground level concentrations are regional average values and, therefore, are not applicable to site-specific situations where plume impingement may occur; and

(ii) The regional estimated concentrations were derived by assuming worst-case emissions (maximum scale of development) and worst case meteorological conditions (prolonged confinement of pollutants).

ESTIMATED MAXIMUM 24-HOUR GROUND LEVEL CONCENTRATIONS OF PRIMARY POLLUTANTS (g/m^3)

	CO	NO_x	SO_x	HC	TSP
Estimated 24-hr average	22	91	15	110	40
Regulatory guidelines (averaging time)	6,000 (8 h)	200 (24 h)	150 (24 h)	n/a	120 (24 h)

The regulatory guidelines for each pollutant, as established by Environment Canada, are also shown in the above table. In all cases, the regional maximum average concentrations are well below the regulatory guidelines.

5. Ice Fog

The potential impact of ice fog formation due to water vapour emissions was not considered during the evaluation of Hypothesis No. 12. This was because the effects of ice fog will be very localized and, therefore, unlikely to affect the region as a whole. However, the following comments are presented for general information:

(i) Ice fog will begin to form when ambient air temperatures are lower than -20°C, and will definitely form when temperatures are lower than -40°C.

(ii) Formation of ice fog is caused by the emission of large quantities of water vapour from combustion processes. The formation is enhanced at warmer temperatures, (i.e. near -20°C) by the presence of particulate matter in the atmosphere.

(iii) Ice fog can accumulate locally (within 1 to 5 km of the water vapour emission source) during prolonged periods of calm and cold temperatures, thereby obstructing visibility and potentially affecting transportation activities.

(iv) There are no mitigative measures available to reduce ice fog formation other than stopping combustion and/or eliminating the source of water emission vapours.

CONCLUSION

Based on the foregoing analyses, 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. This conclusion, however, should not preclude the possible need to implement air quality monitoring program(s) near major emission sources to monitor local effects as part of required operational permits.

LITERATURE CITED

Indian and Northern Affairs Canada and Environment Canada. 1984. Beaufort Environmental Monitoring Project 1983-84 Final Report. Unpubl. rep. by LGL Limited, ESL Environmental Sciences Limited and ESSA Limited. 292 p.

U.S. Environmental Protection Agency. 1977. Compilation of air pollutant emission factors. Third edition (including supplements 1-7). 509 p.

HYPOTHESIS NO. 13

INCREASED LOCAL DISTURBANCE DUE TO ACTIVITIES RELATED TO HYDROCARBON DEVELOPMENT WILL RESULT IN DECREASES IN FISH QUALITY

PARTICIPANTS

Mike Jones	Aaron Sekerak
Peter McCart	Cal Sikstrom
Chris O'Brien	Jeff Stein
Archie Pick	Dave Thomas

INTRODUCTION

The links that comprise this hypothesis are shown in Figure 13-1. Palatability was used as an indicator of fish quality during discussion of this hypothesis by the subgroup.

CONCLUSIONS

The group concluded that this hypothesis was not valid for the following reasons:

1) There is no evidence to indicate that disturbance has ever affected the palatability of northern fishes;

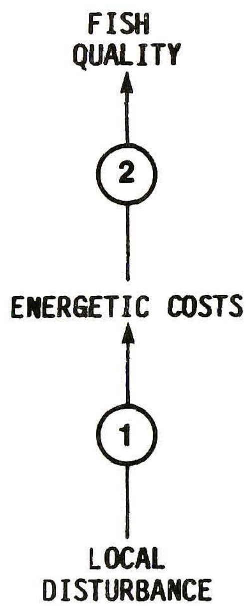
2) No potential activity could be identified that could cause sufficient disturbance to increase the energy expenditure of fish.

3) Substantially greater sources of disturbance (e.g., noise, vessel traffic) in southern waters have never been identified as a cause of decreased fish quality; and

4) Sport fishing can be considered an extreme source of disturbance, since it results in thorough exhaustion of fish. Nevertheless, decreased quality of sport-caught fish has not been reported.

FIGURE 13-1

Increased local disturbance due to activities related to hydrocarbon development will result in decreases in fish quality



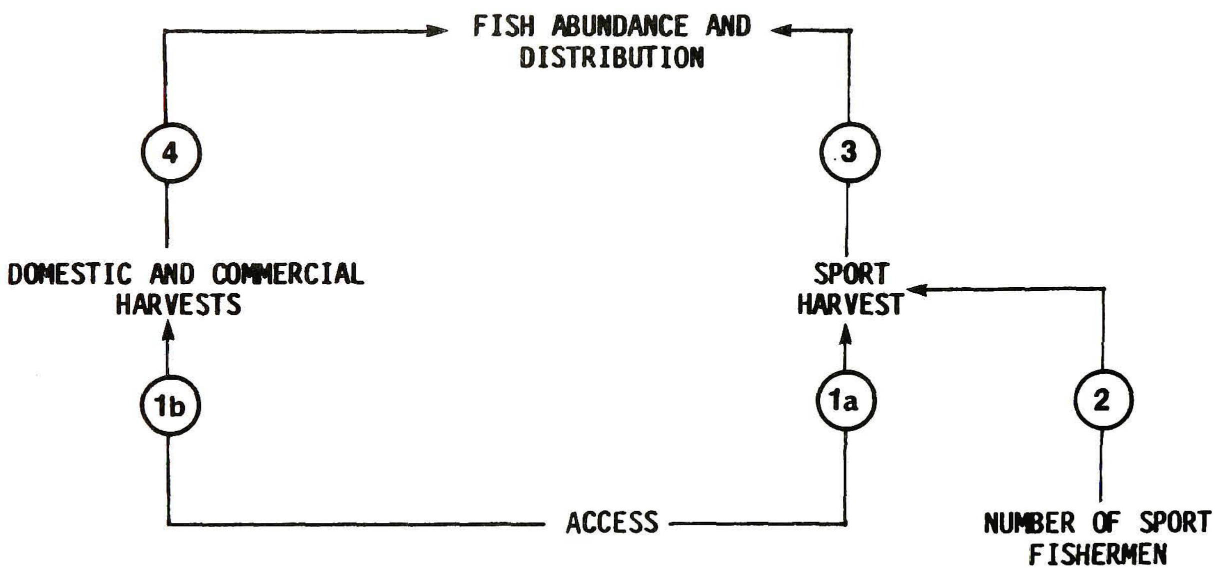
LINKAGES

Link 1: Increased local disturbance (e.g. from additional barge traffic) will result in energetic costs to fish in the areas of disturbance.

Link 2: Higher energy expenditure will result in decreased fish quality.

FIGURE 14-1

Improved access and fishing pressure will decrease the abundance of fish and affect their distribution



LINKAGES

Link 1: Improved access will increase sport, commercial and domestic harvests of fish.

Link 2: The number of recreational fishermen will increase due to industrial development; this will increase harvests of sport fish.

Link 3: Increased sport harvest will reduce local and regional populations of sport fish.

Link 4: Increased domestic and commercial harvests will reduce local and regional populations of fish, and alter their distribution.

trout and inconnu also occurred at Kelly Lake, Great Bear Lake and along the Great Bear River. In the past, domestic fishing for Arctic grayling occurred at Stewart Creek and the mouth of the Three Day Lake drainage system which is located 11 km upstream from Norman Wells. Local fishermen also harvested small numbers of humpback and broad whitefish, inconnu, Arctic cisco, pike and yellow walleye at other locations in the Mackenzie River.

The pattern of fish resource use changed little during and following the Norman Wells Expansion Project. However, the intensity of fishing increased during the 1983 to 1985 period when as many as 1300 construction workers were located at Norman Wells. Sport-fishing pressure increased slightly at Kelly Lake and Great Bear Lake, although no data are available to quantify the change. Domestic fishing in the Norman Wells area is not thought to have been significantly affected by the development. Some fishermen may have been forced to set nets at locations away from the boat traffic associated with the development, although no concerns were expressed by the local Hunters and Trappers Association. Information on domestic fishing in the region from Norman Wells to Fort Good Hope was obtained from the local Hunters and Trappers Association and is included on environmental maps for the Norman Wells Spill Containment and Recovery Plan. Areas of relative importance to domestic fishermen and fish are identified and documented on these maps.

LINKAGES

Link 1: Improved access will increase sport, commercial and domestic harvests of fish.

Sport Fishing Harvest: Increased access will undoubtedly increase the sport fishing harvest in the study area. Arctic char and lake trout are most likely to be affected because they are highly prized by anglers and have a limited distribution within the study area. The harvest of grayling will also increase, particularly where they congregate in the vicinity of culverts and other in-stream obstructions. However, this species is the most widely distributed and most abundant sports species in the study area. Therefore, the increased harvest as a proportion of the total regional population is not likely to be as great as for Arctic char and lake trout. Sport fishing for whitefishes, other than infrequent efforts for inconnu, is not practised in the study area and these species are not expected to be a target of recreational fisheries in the foreseeable future.

Domestic and Commercial Harvests: Recent commercial fishing within the study area has been limited to the harvest of whitefish in the Mackenzie Delta and then only to supply local markets. Attempts at expanding to southern markets have been unsuccessful, primarily due to high transportation costs (Corkum and McCart 1981). It is anticipated that development activities in the region will support or even perhaps lead to an expansion in the existing fishery. If development results in improved access to southern markets particularly by highway, transportation costs may be reduced to the point where a major expansion of the commercial fishery could become economically viable. Improved access to the Yukon North Slope may also result in the entry of local Arctic char to the marketplace.

A number of species are taken in the domestic harvest, including lake and broad whitefish, Arctic char, lake trout, burbot, inconnu and Arctic grayling. Although Arctic char and lake trout are highly desirable species, they have limited distributions and most populations are relatively inaccessible from communities within the study area. Improved access to populations of these two species is expected to result in increased fishing pressure from the domestic fishery. The remaining species taken in the domestic harvest are most common in the mainstem Mackenzie River and its major tributaries where access by boat is already good. The populations of these species are, therefore, less likely to be affected by further improvements in access. However, should a road be established along the Tuktoyaktuk Peninsula, additional whitefish fisheries could occur and thereby increase the harvest pressure on these species.

Link 2: The number of recreational fishermen will increase due to industrial development; this will increase harvests of sport fish.

It appears to be an indisputable fact that sport fishing will increase as the size of human populations increase in the north. As was the case in Norman Wells, establishment of temporary or semi-permanent work camps will also result in increased numbers of sport fishermen. It should be noted, however, that construction workers often have little leisure time and construction often occurs in winter. Therefore the contribution of the construction workforce to increases in sport fishing may not be proportional to its size. Nevertheless, it is concluded that the sport harvest will increase as a consequence of a greater number of fishermen in the region.

Link 3: Increased sport harvest will reduce local and regional populations of sport fish.

Some fish species within the study area are sensitive to exploitation by sports fisheries due to their slow growth rates, late maturity and extended life histories. Populations will likely be reduced in areas where angling pressure is intense. Lake trout are expected to be the most sensitive species for the following reasons:

1. they are popular target species among recreational fishermen;

2. they occur in a relatively small number of lakes within the study area; and

3. evidence to date suggests that populations recover very slowly, if at all, following major declines in abundance due to overharvesting (Healey 1977, 1978).

Sport fishing has led to significant changes in lake trout population structure, including a marked reduction in the proportion of older, larger fish that are sought by trophy fishermen, even in a lake as large as Great Bear Lake (Falk et al. 1974).

Arctic char populations can also be reduced by angling pressure, as observed in the Tree River east of the study area (Moshenko et al. 1984). However, information presented in Johnson (1976) suggests that populations of this species recover relatively quickly once exploitation ceases.

Grayling are the most widespread and most abundant of the major fish species harvested in sport fisheries within the study area. While local populations may be reduced due to fishing pressure (there are unstudied cases of such effects in the Fort Simpson area and elsewhere in the Mackenzie Basin), regional effects of increased harvest pressure are expected to be less than the impact on either Arctic char or lake trout.

Link 4: Increased domestic and commercial harvests will reduce local and regional populations of fish, and alter their distribution.

It is well documented that domestic and especially commercial fisheries can reduce the size of fish populations. This has been observed with stocks of Pacific salmon throughout their range (Archibald and Graham 1981), lake trout in Great Slave Lake (Healey 1978), Arctic char in the Silvia Grinnell River (Kristofferson and Sopuck 1983), lake whitefish in Lake Winnipeg (Davidoff et al. 1973) and with numerous other species of fish in waterbodies throughout the world. The most susceptible species within the study area will be Arctic char and lake trout; these species have limited distributions, populations are relatively small and they are the targets of considerable harvest activity by fishermen. The concern is compounded by the inadequacy of the existing database which, for most populations would be insufficient to predict the collapse of a fishery.

CONCLUSIONS

The group concluded that Hypothesis 14 was valid and, in fact, is a commonly observed result of increased human access. It was also noted that changes in the abundance of fish stocks (or overfishing) can theoretically be controlled to a certain degree by imposing quotas, catch limits, seasons, etc. on the various types of fisheries. However, such regulations have historically proved to be difficult to establish and enforce, particularly in the Arctic, due to overriding social and economic considerations.

RESEARCH

Research needs were discussed on an individual species or species group basis because they vary considerably for different fishes in the region.

Arctic Char: A considerable amount of information is available on the response of populations of eastern Arctic char to exploitation in various fisheries. However, similar data for western Arctic char (which is considered a separate species by a few authorities) is presently lacking. This type of information would be of obvious value in the management of local and regional fisheries. However, the number and size of western Arctic char populations in Canada is limited and further disturbance to these populations through scientific study may not be justified.

Lake Trout: Documentation of the distribution of lake trout is the main research requirement for this species. This could be accomplished by a compilation of available records and knowledge, accompanied by limited field sampling to address gaps in knowledge. Data on fishing activities should be collected as part of such an inventory.

Whitefishes: Research is required on all species of whitefish but particularly on broad whitefish due to their abundance in the region and the fact that they are the primary target of domestic fisheries. The Mackenzie River system appears to be the most important river in North America in terms of broad whitefish populations, with only the Yukon River system approaching the importance of the Mackenzie to this species.

A high priority for research is the differentiation of stocks of broad whitefish in terms of movements, locations of rearing, overwintering and spawning areas and other critical life history events or habitats. Available information indicates that this species has a complicated life-history pattern which involves long-distance migrations, reliance on different locations and habitats at different stages in their life history, and a vulnerability to several different fisheries in various parts of the study area. Therefore, it will be very difficult to document the direct and indirect effects of industrial development on this species.

Stock differentiation studies have been initiated by DFO (Western Region) and include collection of samples from populations near spawning areas and examination and use of a variety of techniques (electrophoresis, morphometrics, parasites, growth patterns) to distinguish separate stocks. Migration studies are also in progress to determine movement patterns. The group recommended that both of these studies should be continued.

Arctic Grayling: It was concluded that over-exploitation of Arctic grayling in streams was a commonly observed result of improved road access in the north. An experimental harvest study to determine response of grayling populations to fishing would provide some of the data required to assess the effects of increased fishing pressure on grayling. The response of grayling populations to fishing, and population recovery times are presently unknown. It is also unknown if grayling form discrete populations (or stocks) and spawn in their natal areas. Since it is suspected that this is the case, local populations may be small and vulnerable to overfishing.

MONITORING

The group agreed that there was a need to determine the total annual catch of major fish species in sport, domestic and commercial fisheries on a waterbody-by-waterbody basis. The effects of future increases in catch cannot be accurately predicted without knowledge of present harvest levels and distribution of fishing effort. There is also a need for index monitoring of catch and fish populations. This could be accomplished by determining 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 type of monitoring could aid in identification of trends in population sizes caused by harvest activities. If adverse effects related to fishing pressure are identified, appropriate resource management decisions can be made on the basis of a more extensive database.

LITERATURE CITED

Archibald, D.M. and C.C. Graham. 1981. Populations of Pacific salmon in British Columbia, 1970-1979. Can. MS Rep. Fish. Aquat. Sci. 1616. 64 p.

Corkum, L.D. and P.J. McCart. 1981. A review of the fisheries of the Mackenzie Delta and nearshore Beaufort Sea. Can. MS Rep. Fish. Aquat. Sci. 1613. 55 p.

Davidoff, E.B., R.W. Rybicki and K.H. Down. 1973. Changes in the population of lake whitefish (*Coregonus clupeaformis*) in Lake Winnipeg from 1949 to 1969. J. Fish. Res. Board Can. 30: 1667-1682.

Esso Resources Canada Ltd. 1980. Norman Wells Oilfield Expansion, Environmental Impact Statement, Oilfield Development. Volume 2.

Falk, M.R., D.V. Gillman and L.W. Dahlke. 1974. Data on the biology of lake trout from Great Bear and Great Slave lakes, Northwest Territories 1973. Fish. Mar. Serv. Oper. Div. Data Rep. Ser. CEN/D-74-4. 39 p.

Healey, M.C. 1977. Characteristics of northern trout and lake whitefish populations. Pages III-97 - III-102. *In*: Circumpolar Conf. Northern Ecol., Sept. 1975, Ottawa. NRC, Ottawa.

Healey, M.C. 1978. The dynamics of exploited lake trout populations and implications for management. J. Wildl. Manage. 42: 307-328.

Johnson, L. 1976. Ecology of arctic populations of lake trout, *Salvelinus namaycush*, lake whitefish, *Coregonus clupeaformis*, Arctic char, *S. alpinus*, and associated species in unexploited lakes of the Canadian Northwest Territories. J. Fish. Res. Board Can. 33: 2459-2488.

Kristofferson, A.H. and R.D. Sopuck. 1983. The effects of exploitation on the Arctic charr population of the Sylvia Grinnell River, Northwest Territories. Can. MS Rep. Fish. Aquat. Sci. 1721. 35 p.

Moshenko, R.W., R.F. Peet, L.N. Dahlke and D.H. Dowler. 1984. The Arctic charr sport fishery at Tree River, Northwest Territories, Canada., 1968-78. Pages 349-364. *In*: L. Johnson and B.L. Burns (eds.) Biology of the Arctic charr. Proc. Int. Symp. on Arctic charr, Winnipeg, Manitoba, May 1981. Univ. Manitoba Press, Winnipeg.

HYPOTHESIS NO. 15

WASTE DISCHARGES AND ACCIDENTAL OIL/CHEMICAL SPILLS WILL LEAD TO UNPOTABLE WATER AND DECREASED ACCEPTABILITY OF FISH AS A FOOD SOURCE

PARTICIPANTS

Andrew Cullen	Rob Owens
Mike Jones	Cal Sikstrom
Peter McCart	Jeff Stein
Mike Miles	Dave Sutherland
Chris O'Brien	Dave Thomas

The original statement of Hypothesis No. 15 included both fishes and water quality (potable water) as VECs. The subgroup chose to divide the hypothesis into two parts, one dealing with potable water (15A) and the other dealing with fishes (15B Figures 15-1 and 15-2). However, due to the overlapping nature of many aspects of Hypotheses 15A and 15B, they share a common introduction.

INTRODUCTION

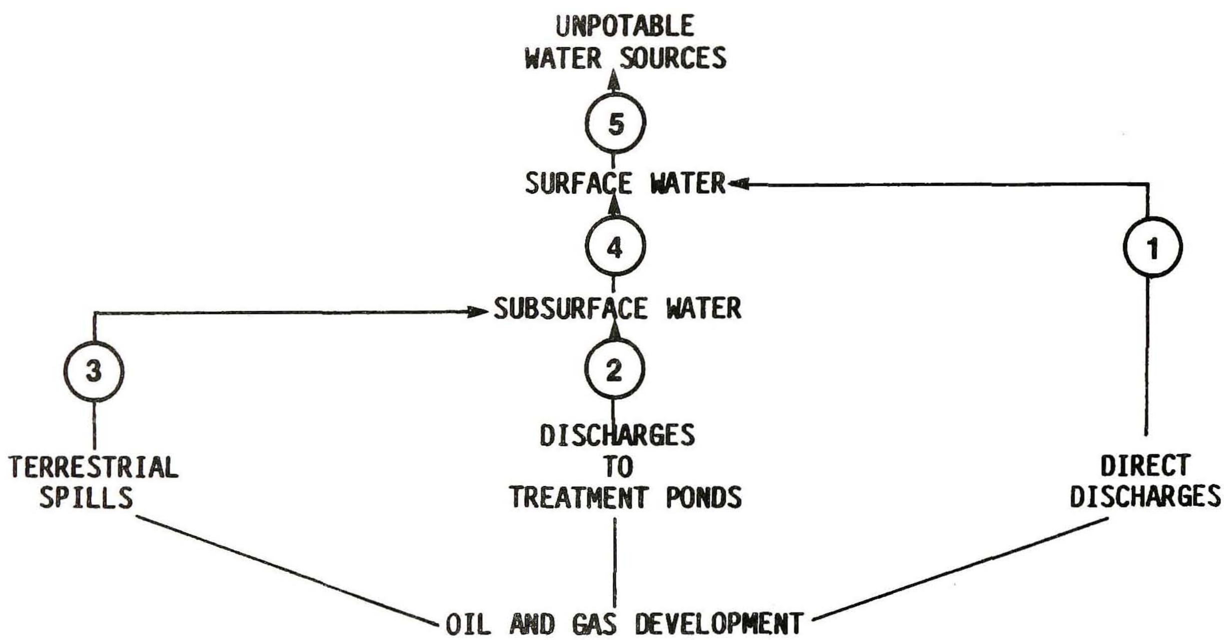
The extraction of hydrocarbon resources in the study area would result in the introduction of contaminants into the environment through various waste discharge streams. In the Mackenzie River system in or near the study area, the primary inputs of contaminants from industrial development are associated with the exploration for and production of oil at Norman Wells. In addition, input of petroleum hydrocarbons to the Mackenzie River also occurs from natural sources, primarily the oil seeps at various locations within the river basin such as the Athabasca Tar Sands.

The contaminants of concern include crude and refined oils, heavy metals, bacteria and viruses in sewage, and various chemicals that are now, or would be used during the exploration, development, production and transportation phases of a project. Occurrence or build-up of some of these substances in

FIGURE 15-1

Waste discharge and accidental oil/chemical spills will lead to unpotable water.

HYPOTHESIS 15A



LINKAGES

Link 1: Direct discharges of contaminants to rivers, streams and lakes will increase their concentrations in water.

Link 2: Discharges of contaminants to treatment ponds will lead to increased contaminant concentrations in subsurface water.

Link 3: Terrestrial spills of contaminants will lead to increased contaminant concentrations in subsurface water.

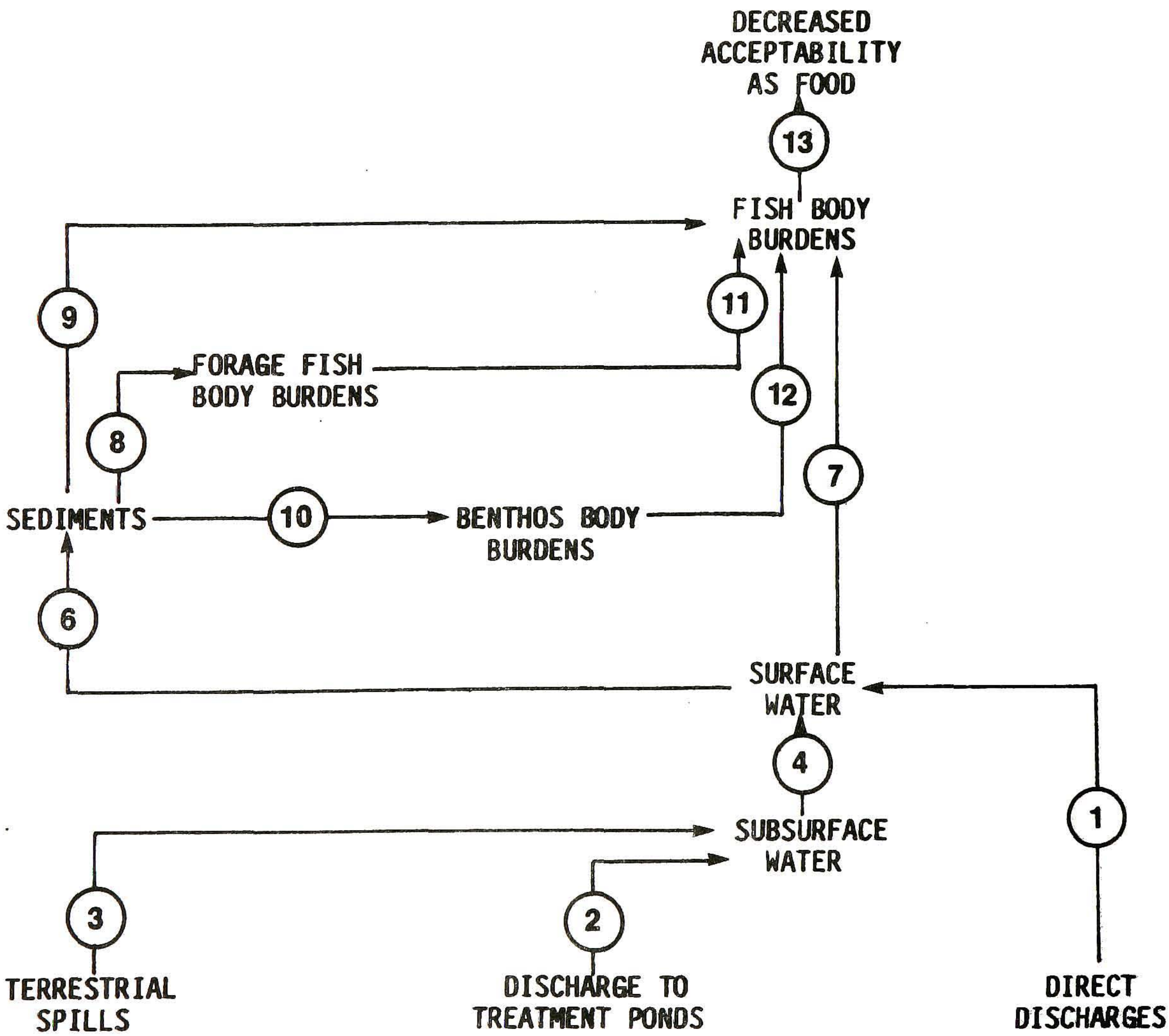
Link 4: Increased concentrations of contaminants in subsurface water will result in increased concentrations of these elements or compounds in surface water.

Link 5: Increased contaminant concentrations in surface water will lead to a decrease in the potability of water sources.

FIGURE 15-2

Waste discharge and accidental oil/chemical spills will lead to decreased acceptability of fish as a food source

HYPOTHESIS 15B



LINKAGES

Link 1: Direct discharges of contaminants into rivers, streams and lakes will increase their concentrations in water.

Link 2: Discharges of contaminants to treatment ponds will lead to increased contaminant concentrations in subsurface water.

Link 3: Terrestrial spills will lead to increased contaminant concentrations in subsurface water.

Link 4: Increased concentrations of contaminants in subsurface water will result in increased contaminant concentrations in surface water.

Link 6: Increased contaminant concentrations in surface water will result in increased contaminant concentrations in sediments.

Link 7: Increased contaminant concentrations in surface water will lead to contaminant uptake by fish.

Link 8: Increased contaminant concentrations in surface water will lead to increased contaminant body burdens in forage fish.

Link 9: Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in bottom-feeding fish.

Link 10: Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in benthic fauna.

Link 11: Increased contaminant body burdens in forage fish will lead to increased body burdens in predatory fish.

Link 12: Increased contaminant body burdens in benthos will lead to increased body burdens in bottom-feeding fish.

Link 13: Increased contaminant body burdens in fish will lead to decreased acceptability of fish as a food source by local residents.

receiving environment can, under certain conditions, result in bioaccumulation and biomagnification of some pollutants in fish. In addition, drinking water may become unpotable if the concentrations of certain contaminants exceed safe limits. The potential for hydrocarbon or heavy metal contamination and subsequent decrease in the palatability of fish and potability of water is an area of potential concern within and downstream of hydrocarbon development in the study region due to: (1) the existing and possible expanding use of fish and potable water; (2) reports of the possible deterioration of fish quality in the Mackenzie River; and (3) experiences associated with tainting elsewhere in the world. In addition, concern has been expressed that traditional sources of drinking water used by hunters could become contaminated in areas near sumps containing waste drilling mud, drill cuttings, waste lubricating oils and rig wash waters.

On the basis of the magnitude of contaminant inputs, it was expected that hydrocarbons and heavy metals will be the areas of greatest potential concern. Accordingly, they became the focus for evaluation of this hypothesis.

Exposure of fishes to hydrocarbons can result in a range of sublethal physiological, pathological and behavioural effects. Some of the pathological changes and abnormalities observed in fishes include: (1) liver necrosis (Sabo and Stegeman 1977; Dimichele and Taylor 1978; McCain et al. 1978; Woodward et al. 1983) and liver neoplasm (Malins et al. 1984); (2) gill damage (Blanton and Robinson 1973; Dimichele and Taylor 1978; Ernst et al. 1979; Englehardt et al. 1981; Woodward et al. 1983); (3) necrosis of intestinal mucosa (Dimichele and Taylor 1978; Hawkes et al. 1980); (4) pancreatic necrosis (Dimichele and Taylor 1978; Solangi and Overstreet 1982); (5) renal damage (Dimichele and Taylor 1978); (6) necrosis of olfactory and taste organs (Gardner 1975; Solangi and Overstreet 1982); (7) muscle degeneration (Dimichele and Taylor 1978); (8) changes in fin pathology (Woodward et al. 1983); and (9) fusion of gill filaments (Khan and Kiceniuk 1984). Some of these histopathological changes are unique to hydrocarbon exposure and, therefore, may be useful in monitoring programs designed to detect chronic oil pollution. However, other pathological effects appear to be caused by stress and, therefore, could be a reflection of environmental conditions unrelated to hydrocarbon exposure.

Hydrocarbons can accumulate in the tissues of fish at concentrations below those which are lethal or lead to pathological changes, and may still be of concern because they (or their degradation products) can cause tainting. Tainting is a change in the characteristic smell or flavour of fish (or any food stuff). In general, crude oil, petroleum products, refinery effluents and wastes from petrochemical complexes have all been implicated in tainting incidents involving a variety of fish, shellfish and seaweeds (Whittle 1978). The presence of a "kerosene-like" or "oily" flavour has been clearly correlated with the presence of petroleum hydrocarbons in flesh of fish collected from areas where spills of crude oil or refined petroleum products have occurred (Mackie et al. 1972; Paradis and Ackman 1975), or where there have been chronic oil discharges from ships or shore-based industrial facilities (Vale et al. 1970, Nitta 1972). However, 'petroleum' taint in fish flesh does not necessarily arise due to petroleum contamination. For example, Howgate et al. (1977) indicated that tainting of fish flesh is well known in certain fisheries and has been traced to natural dietary components. Tainting of flesh due to petroleum contamination is usually accompanied by the presence of hydrocarbons that can be traced to the contaminant source, although these hydrocarbons are not necessarily themselves responsible for the taint.

A number of compounds present in petroleum are believed to be responsible for creating an oily flavour in fish (Motohiro 1983). These are saturated and unsaturated paraffins, aromatic hydrocarbons and sulphur compounds. The intensity of the oily flavour depends, to some extent, on the type, number of carbons in, and the molecular structure of the responsible hydrocarbons. Qualitative and quantitative analyses indicate that off-flavours can be attributed to many different types of petroleum hydrocarbons. Benzothiophene, toluene, xylene and benzene may not only produce an oily flavour in fish, but they also inhibit enzyme reactions in the energy transfer system.

Exposure of fish to heavy metals can result in mortality and a range of sublethal physiological, pathological and behavioural effects that have been reviewed extensively in the literature (Rosenthal and Alderice 1976; Giesy and Wiener 1977; Reish et al. 1978; ESL 1982; Dillon 1984). Total metal concentrations in water or sediments are seldom good indicators of the potential for biological effects, because the availability of a metal for intake is largely determined by its chemical form (free ion, organically complexed, etc.) and kinetics of assimilation. Other important factors include pH, dissolved oxygen concentration, particulate matter interactions, presence of organic compounds, and the occurrence and concentrations of other metals.

During recent years, extensive and varied research has been conducted in relation to the health hazard associated with heavy metal contamination, particularly for mercury (Knauer and Martin 1972; Hardisty et al. 1974a, b; Bohn 1975; Renfro et al. 1975; Stenner and Nickless 1975; Carr et al. 1980; Liss et al. 1980; Neff 1982). It is generally believed that, with the exception of mercury and cadmium, heavy metals are not passed through food chains and, therefore, should not affect human health. On the other hand, it has been well documented that mercury bioaccumulates, is passed through food chains and is a hazard to human health (National Research Council of Canada 1980).

The following sections briefly describe the qualitative and quantitative evidence regarding the mechanism of contaminant uptake by fish and contaminant transfer between various components within the hydrologic regime, as well as recommendations of the subgroup on monitoring and research strategies that may be required to address this potential concern in the study area.

LINKAGES

Link 1: Direct discharges of contaminants to rivers, streams and lakes will increase their concentrations in water.

The working group considered this link to be generally valid, although it is also possible that a decrease in contaminant concentrations may occur if the receiving water contains a higher concentration of a particular contaminant than that present in the discharge stream.

Link 2: Discharges of contaminants to treatment ponds will lead to increased contaminant concentrations in subsurface waters.

This link is valid, but the extent to which contaminants may enter the subsurface water will depend on several factors including: the containment efficiency of the treatment ponds; the permeability of soil materials; the chemical characteristics of oil materials; and the slope of the land. At the present time, there are no data that allow quantification of the amount of contaminants that could enter subsurface waters.

Link 3: Terrestrial spills will lead to increased contaminant concentrations in subsurface water.

The extent that contaminants introduced by terrestrial spills could enter the subsurface waters would depend on the following factors:

1. soil permeability (e.g., type of material and presence or absence of permafrost or ice lenses);

2. water content of the soil;

3. type of material spilled;

4. time of year of the spill; and

5. effectiveness of subsequent clean-up operations.

Link 4: Increased concentrations of contaminants in subsurface water will result in increased contaminant concentrations in surface water.

Contaminants in subsurface waters may enter surface waters via springs or in areas of river banks, cliffs, sloughs and slumps. The concentrations of contaminants in surface waters will increase if those elements or compounds are present in higher concentrations within the groundwater.

Link 5: Increased contaminant concentrations in surface water will lead to a decrease in the potability of water sources.

Depending on the nature and concentrations of contaminants, receiving waters may or may not be affected to the extent that they are rendered unpotable, as defined by the Canadian Drinking Water Standards. In situations where the receiving waters contain contaminants in excess of acceptable standards, this situation may be rectified in one of two ways:

1. Natural dilution processes may reduce contaminant concentrations to the point where the water source is once again potable. The time required for this to occur will depend on the local mixing/dispersion regime. The Mackenzie River would probably be more effective in the natural dilution of contaminants than would be the case in smaller tributaries or lake systems.

2. If insufficient natural dilution capacity is available to restore waters to an acceptable potability, chemical or physical processes would have to be used to treat the contaminated water.

Link 6: Increased contaminant concentrations in surface water will result in increased contaminant concentrations in sediments.

Suspended sediments are an effective mechanism for trapping many dissolved contaminants (primarily hydrocarbons and heavy metals) through the process of adsorption. The degree to which suspended particles will adsorb contaminants depends on:

1. the nature of the particles (e.g., clay type, organic carbon content, surface area);

2. the concentration of the contaminant in solution; and

3. the affinity of the contaminant for particle surfaces.

The degree to which contaminant concentrations could increase in sediments will depend on how far the particles sediment out from the source of contamination, the relative concentration of contaminants in the natural sediment within this downstream area, and the mass of contaminants that are added to the system. In general, increases in contaminant levels will be easier to detect in quiet depositional areas such as lakes and river side-channels than in sediments subject to erosion (e.g., within active river channels).

Link 7: Increased contaminant concentrations in surface water will lead to contaminant uptake by fish.

Fish can quickly absorb hydrocarbons through gill epithelia, mucosa and other soft body surfaces (Malins 1977; Teal 1977; Thomson et al. 1981). An increase in available dissolved hydrocarbons usually results in increased uptake, although the rate and extent of uptake varies with the species, life-history stage and type of hydrocarbons. Absorbed petroleum hydrocarbons are usually stored in tissues with a high lipid content (e.g., liver). Following uptake, however, enzyme (MFO) mediated detoxification processes result in depuration. The rate of hydrocarbon depuration depends on a range of physiological and external factors such as competing metabolic processes, state of health and water temperature, but is usually considerably slower than uptake.

Bioaccumulation of metals by fish also occurs. Metalloenzyme systems (e.g., metallothionein) are involved in the detoxification process. Depuration efficiency depends on factors similar to those described above for hydrocarbons. The body burden of metals in fish are usually stored in the liver and kidneys.

Link 8: Increased contaminant concentrations in surface waters will lead to increased contaminant body burdens in forage fish.

Uptake of hydrocarbons and metals in forage fish will occur as described in Link 7. The degree that the body burdens of these substances increase will depend on the efficiency and rate of depuration and the duration of exposure.

Link 9: Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in bottom-feeding fish.

This is considered possible if the contaminants associated with the sediments are present in a form available to the fish and at relatively high concentrations in comparison to background levels. At anticipated levels of contaminant enrichment of sediments, it is unlikely that increases in contaminant body burdens in bottom feeding fish would be detectable.

Link 10: Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in benthic fauna.

Benthic invertebrates can accumulate both hydrocarbons and metals in their tissues. The extent of bioaccumulation is much greater when uptake occurs from the liquid phase than from the solid (sediment) phase. The rate of depuration of hydrocarbons and metals from benthic invertebrates varies from days to years depending on the exposure concentrations and the duration of exposure.

Link 11: Increased contaminant body burdens in forage fish will lead to increased body burdens in predatory fish.

Although frequently postulated, uptake and accumulation of hydrocarbons due to ingestion of contaminated prey organisms has not been shown to be a dominant pathway in the tainting of aquatic animals. Hydrocarbons may be absorbed through the gut, although they appear to be excreted quickly and do not generally enter tissues (Teal 1977; Thomson et al. 1981). In the case of metals, it is believed that only mercury and cadmium biomagnify (i.e., are passed through the food chains). These metals may become concentrated in the tissues of predatory fish following ingestion of contaminated forage fish.

Link 12: Increased contaminant body burdens in benthos will lead to increased body burdens in bottom-feeding fish.

For the reasons outlined in the discussion of Link 11, the possibility of increases in contaminant body burdens in bottom feeding fish are limited to mercury and cadmium.

Link 13: Increased contaminant body burdens in fish will lead to decreased acceptability of fish as a food source by local residents.

This link is valid to the extent that it is known that threshold values exist for the presence of petroleum hydrocarbons, organic substances and metals at which fish become undesirable because of off-flavour, smell and poor texture.

HYPOTHESIS 15A

CONCLUSION

Although the workshop subgroup concluded that all of the links of Hypothesis 15A are possible, evaluation of the likelihood of petroleum industry activities leading to unpotable water sources must consider the expected scale of activities. Using Norman Wells as an example, the primary potential sources of contaminants are currently:

1. refinery effluents;

2. discharges associated with central processing facilities;

3. drilling muds and cuttings; and

4. domestic and sanitary sewage from camps.

The Norman Wells refinery produces approximately 500 m^3 d^{-1} oil, and the waste discharge from the refinery is 45 L s^{-1}. Contaminant concentrations in this effluent are regulated by permit as follows:

Oil and grease	(max. annual average)	5	mg L^{-1}
Phenols	(max. annual average)	0.10	mg L^{-1}
Sulphide	(max. annual average)	0.10	mg L^{-1}
Ammonia Nitrogen	(max. annual average)	2.0	mg L^{-1}
pH		between 6 and 9.5	

Based on measurements reported in Envirocon (1981) an approximate estimate of the concentration of hydrocarbons in the Mackenzie River is 10 μg L^{-1} (range is 1-36 μg L^{-1}; maximum value was near an oil seep at Norman Wells). Assuming that 10 μg L^{-1} is a reasonable estimate for background hydrocarbon concentrations in the river (there is some question regarding this estimate, but it may be resolved with forthcoming data), the dilution required to reduce oil and grease effluent concentrations to background levels is 500:1. This level of dilution is likely to be achieved within a few tens of metres from the discharge point. From a mass loading perspective, the natural load of dissolved hydrocarbons in the river at Norman Wells averages 20 g s^{-1} (at a flow of 2,000 m^3 s^{-1}) as compared to 0.2 g s^{-1} from the refinery discharge (45 L s^{-1}). These calculations indicate that the potential inputs of oil and grease from refinery effluent would likely be insufficient to cause the water to become unpotable, except on a very local scale. However, it must be emphasized that local anomalies can occur, and a better estimate of natural levels of hydrocarbons in the river should be obtained.

At the present time, EPS in Yellowknife is directing a monitoring program that should provide the data necessary to determine a mass balance for hydrocarbons within the Mackenzie River in the vicinity of Norman Wells. These data will include the amount and characteristics of all contaminants present in waste streams associated with activities at Norman Wells, as well as "background" values in the river. When this study is complete and the mass balance determined, monitoring programs can be recommended and designed (if required). Considerations in designing possible monitoring programs will include the relative scales of natural and anthropogenic contributions to contaminant levels in the river, and an assessment as to whether the waste characteristics currently observed at Norman Wells are representative of those that may occur in the future at this site or at other locations along the river.

Of particular concern is the possibility that inland drinking water sources that are used by hunters travelling overland could be rendered unpotable by the presence of contaminants.

MONITORING

No monitoring of the receiving environment in the Mackenzie River is recommended until mass balance calculations are completed. However, a case study of the mobility of contaminants in the vicinity of an abandoned drilling waste sump should be initiated.

HYPOTHESIS 15B

CONCLUSION

On the basis of existing information and the current and proposed level of hydrocarbon development in the region, the subgroup concluded that it is unlikely that contaminants introduced as a result of industrial activity would lead to unpalatable fish. Nonetheless, the group recognized the importance of domestic fisheries and the fact that, although there have not yet been complaints of tainted fish in the study area, concerns have been voiced regarding abnormal (shrivelled, discoloured) burbot livers and soft, watery flesh in whitefish. Consequently, it is recommended that the on-going monitoring program that is currently directed by DFO should continue. This DFO study will provide detailed data on the composition and concentrations of hydrocarbons and heavy metals in liver and muscle tissue of fish known or suspected to have morphological abnormalities.

MONITORING

It is recommended that the time-series measurements of hydrocarbons and metals in burbot and whitefish flesh and livers continue in its current form. These studies are designed to monitor the variability in the presence of these contaminants in fish flesh, as well as to determine the relationship between the presence of specific contaminants and morphological abnormalities in fish. Possible biological causes of these abnormalities are also under investigation.

LITERATURE CITED

Blanton, W.G. and M.C. Robinson. 1973. Some acute effects of low-boiling petroleum fractions on the cellular structures of fish gills under field conditions. Pages 265-273. In: D.G. Ahearn and S.P. Meyers (eds.). The Microbial Degradation of Oil Pollutants. Louisiana State U., Centre Wetland Resources Publ. LSU-SG-73-01 Baton Rouge.

Bohn, A. 1975. Arsenic in marine organisms from West Greenland. Mar. Pollut. Bull. 6:87-89.

Carr, R.S., L.A. Reitsema and L.M. Neff. 1980. Influence of a used chrome lignosulphonate drilling mud on the survival, respiration, growth and feeding activity of the opposum shrimp Mysidorsis almyra. Pages 944 - 963. In: Symposium on research on environmental fate and effects of drilling fluids and cuttings. Courtesy Associates, Washington, D.C., U.S.A.

Dillon, T.M. 1984. Biological consequences of bioaccumulation in aquatic animals: an assessment of the current literature. Long-term effects of dredging operations program Tech. Rep. D-84-2. U.S. Army Corps of Engineers, Washington, D.C. 35 p. and tables.

Dimichele, L. and M.H. Taylor. 1978. Histopathological and physiological responses of Fundulus heteroclitus to naphthalene exposure. J. Fish. Res. Board Can. 35: 1060-1066.

Englehardt, F.R., M.P. Wong and M.E. Derey. 1981. Hydromineral balance and gill morphology in rainbow trout acclimated to fresh and sea water, as affected by petroleum exposure. Aquat. Toxicol. 1:175-186.

Envirocon Limited. 1981. A survey of fish rearing areas and hydrocarbon analysis of water samples from the Mackenzie River near Norman Wells, N.W.T. An unpublished report prepared for Esso Resources Canada Limited. Calgary, Alberta.

Ernst, V.V., J.M. Neff and J.W. Anderson. 1979. The effects of water-soluble fractions of No. 2 fuel oil on the early development of the estuarine fish, Fundulus grandis. Environ. Pollut. 14:25-35.

ESL Environmental Sciences Limited. 1982. The biological effects of hydrocarbon exploration and production related activities, disturbances and wastes on marine flora and fauna of the Beaufort Sea region. Unpubl. Rep. prepared for Dome Petroleum Limited, Calgary, Alberta. 450 p.

Gardner, G.R. 1975. Chemically-induced lesions in estuarine or marine teleosts. Pages 657-693. In: W.E. Ribelin and G. Migaki (eds.). The pathology of fishes. Wisconsin, Madison.

Giesey, J.P., Jr. and J.G. Wiener. 1977. Frequency distributions of trace metal concentrations in five freshwater fishes. Trans. Am. Fish. Soc. 106(4):393-403.

Hardisty, M.W., R.J. Huggins, S. Kartar and M. Sainsbury. 1974a. Ecological implications of heavy metal in fish from the Severn Estuary. Mar. Pollut. Bull. 5:12-15.

Hardisty, M.W., S. Kartar and M. Sainsbury. 1974b. Dietary habits and heavy metal concentrations in fish from the Severn Estuary and Bristol Channel. Mar. Pollut. Bull. 5:61-63.

Hawkes, J.W., E.H. Gruger, Jr. and O.P. Olson. 1980. Effects of petroleum hydrocarbons and chlorinated biphenyls on the morphology of the intestine of chinook salmon. Can. J. Zool. 23:149-161.

Howgate, P., P.R. Mackie, K.H. Whittle, J. Farmer, A.D. McIntyre and A. Eleftheriou. 1977. Petroleum tainting in fish. Reun. Cons. Int. Explor. Mer. 171:143-146.

Khan, R.A. and J. Kiceniuk. 1984. Histopathological effects of crude oil on Atlantic cod following chronic exposure. Can. J. Zool. 62(10): 2038-2043.

Knauer, G.A. and J.H. Martin. 1972. Mercury in a marine pelagic food chain. Limnol. Oceanogr. 17:868-876.

Liss, R.G., F. Knox, D. Wayne and T.R. Gilbert. 1980. Availability of trace elements in drilling fluids to the marine environment. Pages 691-722. In: Symposium on research on environmental fate and effects of drilling fluids and cuttings. Courtesy Associates, Washington, D.C., U.S.A.

Mackie, P.R., A.S. McGill and R. Hardy. 1972. Diesel oil contamination of brown trout. Environ. Pollut. 3:9-16.

Malins, D.C. 1977. Biotransformation of petroleum hydrocarbons in marine organisms indigenous to the Arctic and sub-Arctic. Chapter 5. Pages 47-59. In: D.A. Wolfe (ed.). Fate and effects of petroleum hydrocarbons in marine ecosystems and organisms. Permagon Press, New York. 478 p.

Malins, D.C., B.B. McCain, D.W. Brown, U. Varanassi, M.M. Krahn, M.S. Myers and S-L Chan. 1984. Sediment-associated contaminants and liver diseases in bottom-dwelling fish. Proceedings of international workshop on in-situ sediment contaminants August 20-24, 1984. Aberystwyth, Wales.

McCain, B.B., H.D. Hodgins, W.D. Gronlund, J.W. Hawkes, D.W. Brown, M.S. Myers and J.H. Vandermeulen. 1978. Bioavailability in crude oil from experimentally oiled sediments to English sole and pathological consequence. J. Fish. Res. Board Can. 35:657-664.

Motohiro, T. 1983. Tainted fish caused by petroleum compounds - a review. Pages 75-83. In: Persson, P.E., M. Yurkowski and E. Marshall (eds.). Taste and odour in waters and aquatic organisms. Water Sci. Technol. Vol. 15, No. 6-7.

National Research Council of Canada. 1980. Effects of mercury (especially methylmercury) in the Canadian environment. Exec. Rep. Pages 63-74. In: J.F. Jaworski (compiler). Exec. Rep. Effects of chromium alkali halides, arsenic, asbestos, mercury, cadmium in the Canadian environment. NRCC Assoc. Comm. on Scientific Criteria for Environmental Quality. Environ. Secretariat Publ. No. NRCC 17585. 80 p.

Neff, J.M. 1982. Fate and effect of oil well drilling fluids in the marine environment: a literature review. Prep. by Battelle New England Research Laboratory for Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Gulf Breeze, Florida, U.S.A.

Nitta, T. 1972. Marine pollution in Japan. In: M. Ruivo (ed.). Marine pollution and sea life. Fishing News (Books). 77 p.

Paradis, M. and R.G. Ackman. 1975. Differentiation between natural hydrocarbons and low level diesel contamination in cooked lobster meat. J. Fish. Res. Board Can. 32:316-320.

Reish, D.J., T.J. Kauwling, A.J. Mearns, P.S. Oshida, S.S. Rossi, F.G. Wilkes and M.J. Ray. 1978. Marine and estuarine pollution. J. Water Pollut. Contr. Fed. 50(6):1424-1469.

Renfro, W.C., S.W. Fowler, M. Heyraud and J. La Rosa. 1975. Relative importance of food and water in long-term ^{65}Zn accumulation by marine biota. J. Fish. Res. Board Can. 32:1339-1345.

Rosenthal, H. and D.F. Alderice. 1976. Sublethal effects of environmental stressors, natural and pollutional, on marine fish eggs and larvae. J. Fish. Res. Board Can. 33:2047-2065.

Sabo, D.J. and J.J. Stegeman. 1977. Some metabolic effects of petroleum hydrocarbons in marine fish. Pages 337-357. In: F.J. Vernberg, A. Calabrese, F.P. Thurberg and W.B. Vernberg (eds.). Physiological responses of marine miota to pollutants. Academic Press. New York.

Solangi, M.A. and R.M. Overstreet. 1982. Histopathological changes in two estuarine fishes, Menidia beryllina and Trinectes maculatus, exposed to crude oil and its water-soluble fractions. J. Fish. Dis. 5:13-35.

Stenner, R.D. and G. Nickless. 1975. Heavy metals in organisms of the Atlantic coast of southwest Spain and Portugal. Mar. Pollut. Bull. 6:89-92.

Teal, J.M. 1977. Food chain transfer of hydrocarbons. Chapter 7. Pages 71-77. In: D.A. Wolfe (ed.). Fate and effects of hydrocarbons in marine ecosystems and organisms. Permagon Press, New York. 478 p.

Thomson, D.H., M.A. McLaren and A.D. Sekerak. 1981. Review of effects of oil on marine flora and fauna with special reference to arctic regions. Unpubl. report by LGL Limited for Petro Canada Exploration, Calgary, Alberta. 120 p.

Vale, G.L., G.S. Sidhu, W.A. Montgomery and A.R. Johnson. 1970. Studies on a kerosene-like taint in mullet. 1. General nature of taint. J. Sci. Fd. Agric. 21:429-432.

Whittle, K.J. 1978. Tainting in marine fish and shellfish with reference to the Mediterranean Sea. Pages 89-108. In: Data Profiles for Chemicals for the Evaluation of their Hazards to the environment of the Mediterranean Sea. Vol. 2 Franklin Institute, Munich.

Woodward, D.F., R.G. Riley and C.E. Smith. 1983. Accumulation, sublethal effects and safe concentration of a refined oil as evaluated with cutthroat trout. Arch. Environ. Contain. Toxicol. 12:455-464.

HYPOTHESIS 16

THE CONSTRUCTION AND PRESENCE OF LINEAR CORRIDORS WILL AFFECT THE NUMBER, DISTRIBUTION AND QUALITY OF FISH, AND FISHING SUCCESS

PARTICIPANTS

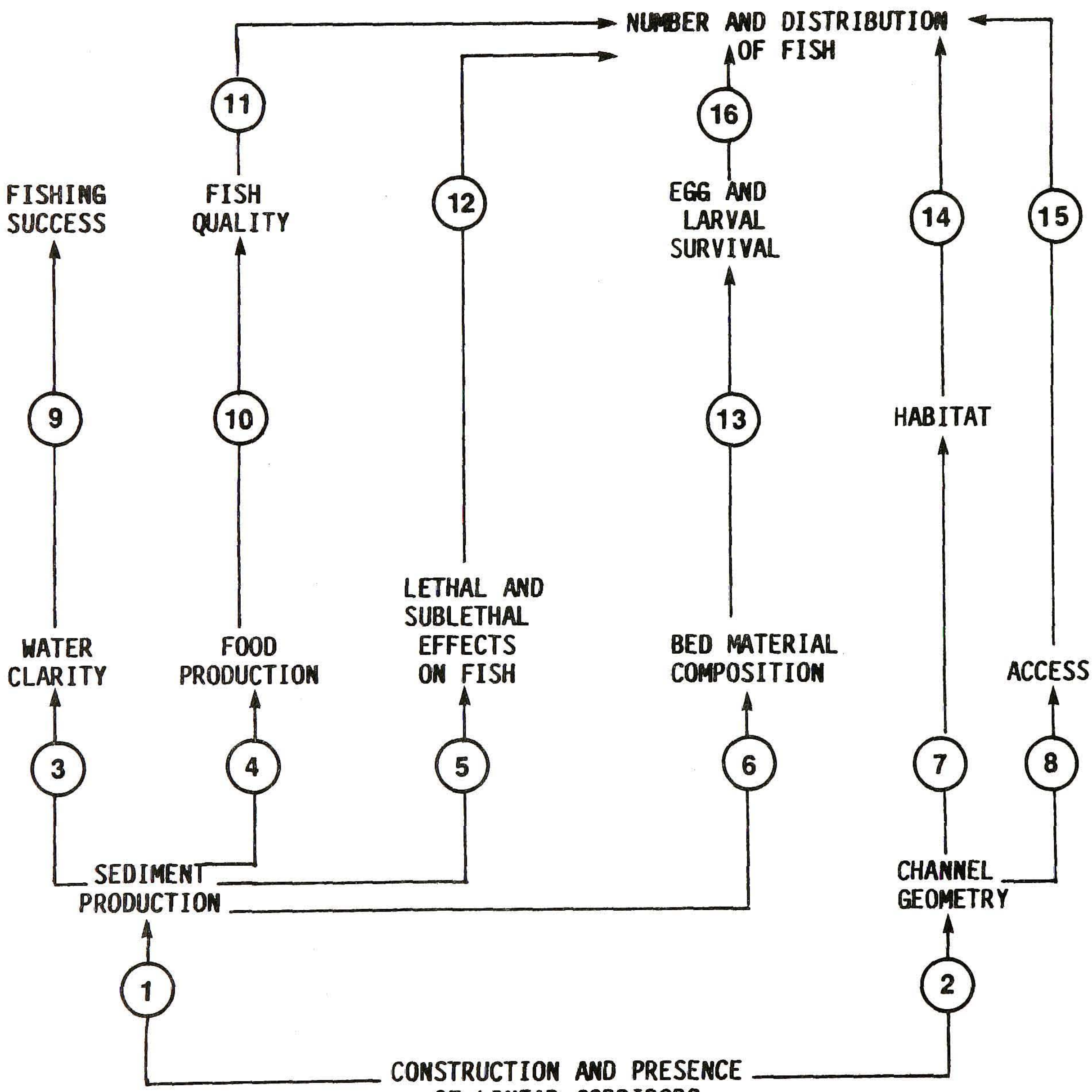
Andrew Cullen	Chris O'Brien
Mike Jones	Archie Pick
Peter McCart	Aaron Sekerak
John McDonald	Jeff Stein
Mike Miles	Dave Sutherland

INTRODUCTION

The freshwater ecosystem formed by the mainstem Mackenzie River, its major tributaries and the distributary channels and lakes of the Mackenzie Delta is the largest system that drains into arctic or boreal seas bordering North America. The region also supports unique fish resources. Some species, such as Arctic cisco, may only spawn in the Mackenzie River drainage; hence, their distribution and abundance may be governed by conditions in the freshwater environments of the Mackenzie drainage. Other species, such as broad whitefish, are more widespread, but the Mackenzie River drainage is the centre of their distribution and the location of the largest populations in Canada. Still other species, such as western Arctic char, only occur as small populations in a few rivers in the northwestern portion of the study area. These fish resources and a number of other species (e.g., inconnu, Arctic grayling, lake trout, lake whitefish) are important in the economy and lifestyle of northern residents and to a growing number of sport fishermen. As a result, the effects of linear corridors on fish are of relevance and potential concern in relation to any northern development.

FIGURE 16-1

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



LINKAGES

Link 1: Construction and operation of linear corridors will increase rates of sediment production at specific locations or over large areas.

Link 2: Construction activities will alter channel geometry at specific locations.

Link 3: Increased rates of sediment production at specific locations will decrease water clarity.

Link 4: Increased rates of sediment production at specific locations will decrease the abundance or availability of prey species.

Link 5: Increased suspended sediment concentrations and exposure durations will have lethal and sublethal effects on fish and change their behaviour patterns.

Link 6: Local changes in sediment production will affect streambed material size.

Link 7: Alterations in channel morphology will directly affect the extent or distribution of in-stream habitat at specific locations.

Link 8: Local changes in channel geometry or thermal regime will result in blockage of fish movement.

Link 9: Local decreases in water clarity will decrease angling success and increase net fishing success.

Link 10: Local decreases in the production of prey organisms will reduce the size and quality of fish.

Link 11: Local decreases in the production of prey organisms will result in fish mortality or changes in their distribution.

Link 12: Fish avoidance, attraction or migrations due to high suspended sediment concentrations will affect the number and distribution of fish.

Link 13: Increased concentrations of fine-textured materials within the river bed will reduce egg and larval fish survival.

Link 14: Local changes in the amount and quality of habitat will change the number and distribution of fish.

Link 15: Local restrictions in access will reduce spawning or rearing success and overwinter survival and, therefore, affect the number and distribution of fish.

Link 16: Local decreases in fish egg and larval survival rates will reduce numbers and alter the distribution of fish.

LINKAGES

Link 1: Construction and operation of linear corridors will increase the rates of sediment production at specific locations or over large areas.

The construction and operation of linear corridors (particularly highways, railways and pipelines) within boreal and temperate areas has resulted in temporary increases in suspended sediment concentrations and deposition of fine-textured sediments on the stream bed (e.g., Blench 1972, cited in Neill 1972; Porter et al. 1974; Landeen and Brandt 1975; Barton 1977; Kruzynski and Sekerak 1980; Cline et al. 1983). If these processes are of sufficient magnitude and persistence, they may be detrimental to fish (e.g., Saunders and Smith 1965; Bjornn et al. 1974; Phillips et al. 1975; Newcombe 1985)

The magnitude of the increase in sediment production resulting from the construction of linear corridors depends on a variety of factors including:

1. the erosional susceptibility of the materials through which the facility is constructed;

2. the project design;

3. the proximity of the corridor to a stream or river and the number of stream or river crossings;

4. the construction methods; and

5. the level of post-construction maintenance activity.

The experience of the working group participants suggests that highways are more likely than pipelines to create sediment related effects. Studies such as Fernet (1984, 1985), ESL (1983, 1985) and Kruzynski and Sekerak (1980) support the conclusion of Neill and Mollard (1980) that the sedimentation effects of river crossings in northern Canada are generally "local and temporary, and can be mitigated by proper design, construction and maintenance procedures." However in some circumstances such as where a linear corridor crosses a river many times or is located in very unstable terrain, sediment production may be more significant. Unpublished data from the Coquihalla River valley in British Columbia (R. Ptolemy, pers. comm.) provides some evidence of significantly increased rates of sediment production due to pipeline construction.

The rate of sediment production is expected to be at a maximum during construction and the period prior to revegetation. However, unusual storm events or design failure can cause large sediment loadings during the oprational phase of the project. Depending on the availability of men and equipment, significant periods of time can elapse between the detection of post-construction sediment problem and initiation of measures to curtail the introduction of sediment into a stream or river.

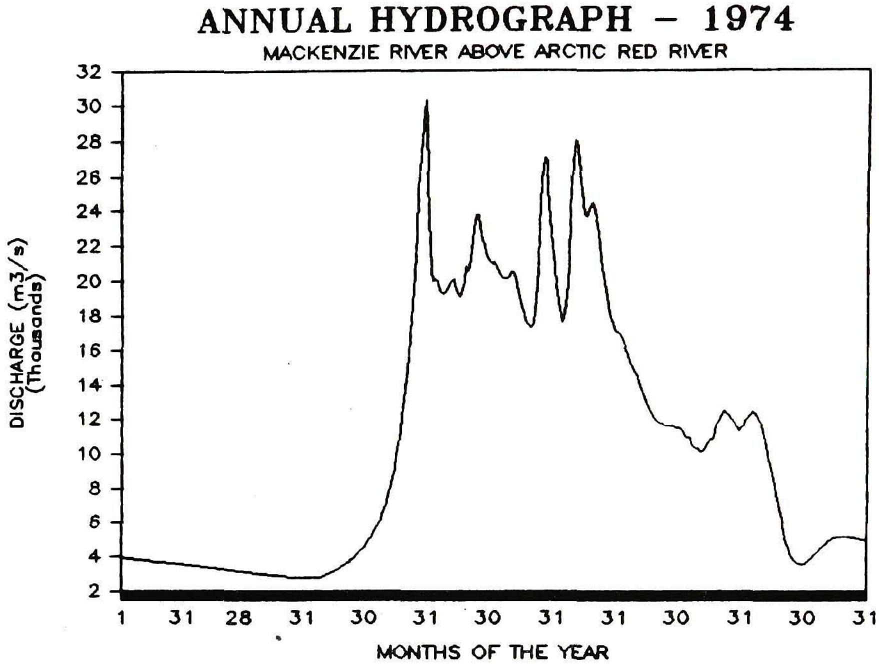
The ability to detect increases in sediment production depends in large measure on the river discharge at the time the sediment is introduced and the naturally occurring rate of sediment transport. The discharge and suspended sediment transport regimes within the study area are characterized by significant spatial and temporal variability. On the Mackenzie River the annual hydrograph is dominated by the spring freshet although summer rainstorms can also result in substantial rates of discharge as illustrated in Figure 16-2 (Inland Water Directorate 1984). Flows decrease significantly in the fall but, due to the regulation and the large size of the watershed (1,660,000 km^2) a reduced discharge continues throughout the winter months. Suspended sediment transport shows a similar seasonal variation pattern (Figure 16-2); concentrations are high throughout the spring and summer periods with maximum values of roughly 10,000 mg/L being associated with unusual mid-summer flood events.

The discharge regime of streams draining the north slope of the Yukon exhibit a more pronounced seasonal variation. As shown on Figure 16-3 for the Babbage River (basin area 4200 km^2), maximum flows are associated with spring freshet and early summer rainstorms. However, as much of the runoff of these rivers is associated with the melting of snow or ice, daily discharges during the freshet period can show a significant diurnal variation. Mid-winter flows are generally negligible and periods of zero flow may occur in all areas except those near sites of groundwater discharge (Forbes 1981). Suspended sediment concentrations show a similar seasonal pattern and maximum observed values are associated with late spring flood events. Suspended sediment concentrations are generally lower than those in the Mackenzie River; however, naturally occurring concentrations of up to 1800 mg/L have been observed.

Small watersheds, such as Boot Creek (drainage area 31 km^2) near Inuvik, have an annual discharge regime similar to that of the Babbage River but with a shorter spring freshet (two to four weeks; Figure 16-4). Data presented by Anderson and MacKay (1974) suggest that the spring snowmelt (possibly augmented by rainfall) produces the most significant runoff of the year. Systematic suspended sediment measurements are not available from small streams in the study area and, therefore, spatial and temporal variations in sediment concentrations are presently unknown.

Given the seasonal regimen described above, increased rates of sediment production are most likely to be detectable during the low flow period in winter. Due to the large temporal variations in natural sediment transport during the spring and summer, it will be difficult to detect increased sediment production in this period unless measurements are made immediately upstream and downstream of the sediment source. Even in these circumstances, detection may prove to be difficult unless the volume of sediment produced is a significant percentage of the total natural load.

On the basis of the above discussion, it was agreed that linear corridors could result in significant increases in sediment production but that it could be minimized in most circumstances through appropriate design, construction and maintenance activities.



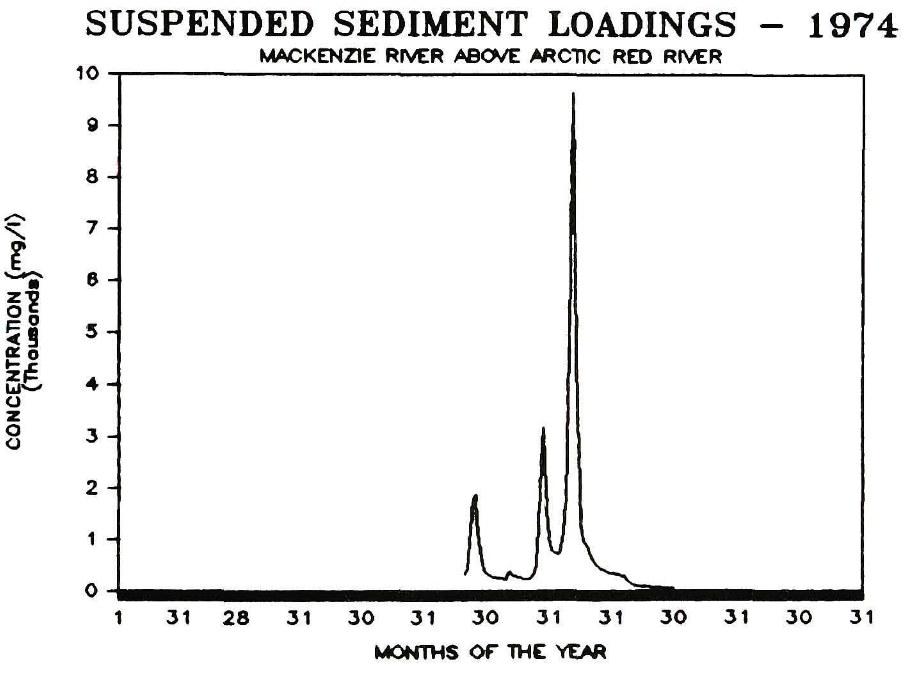
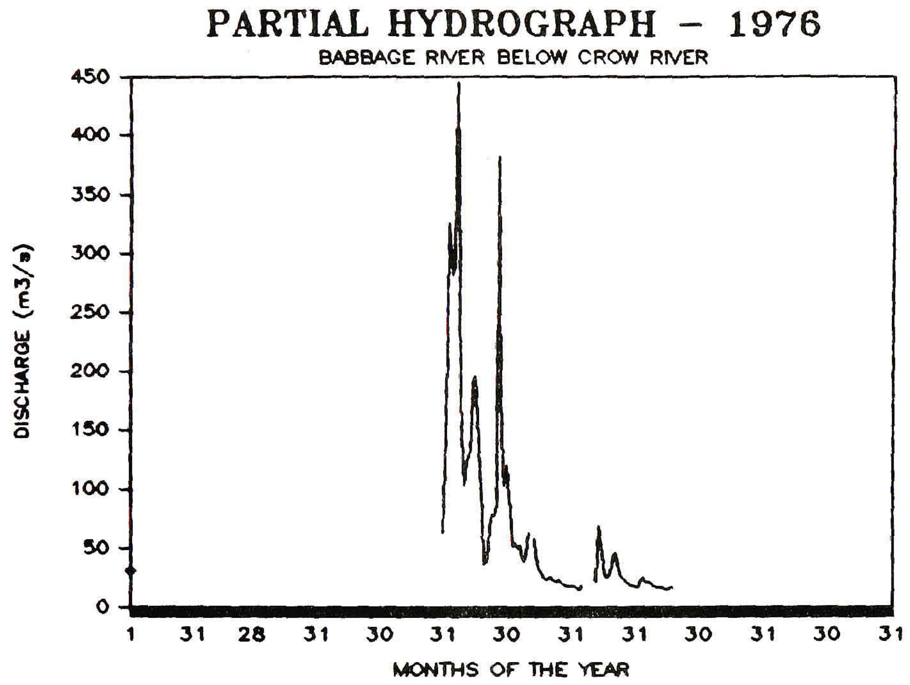


Figure 16-2. Annual discharge and suspended sediment concentrations. Mackenzie River above Arctic Red River, 1974 (data from Inland Water Directorate 1984).



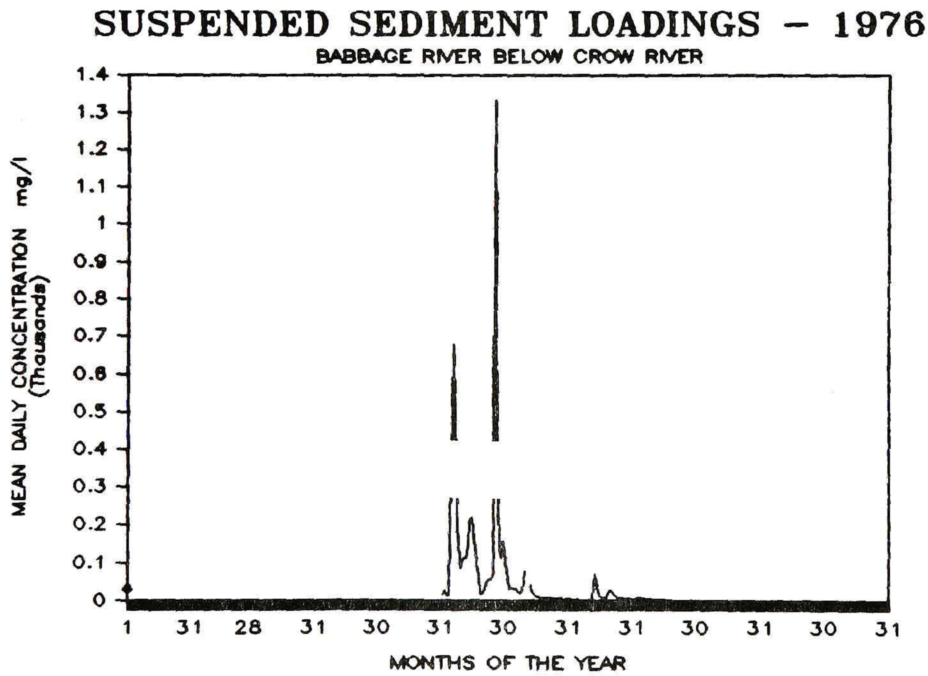


Figure 16-3. Seasonal hydrograph and suspended sediment concentrations, Babbage River below Crow River, 1976 (data from Forbes 1981).

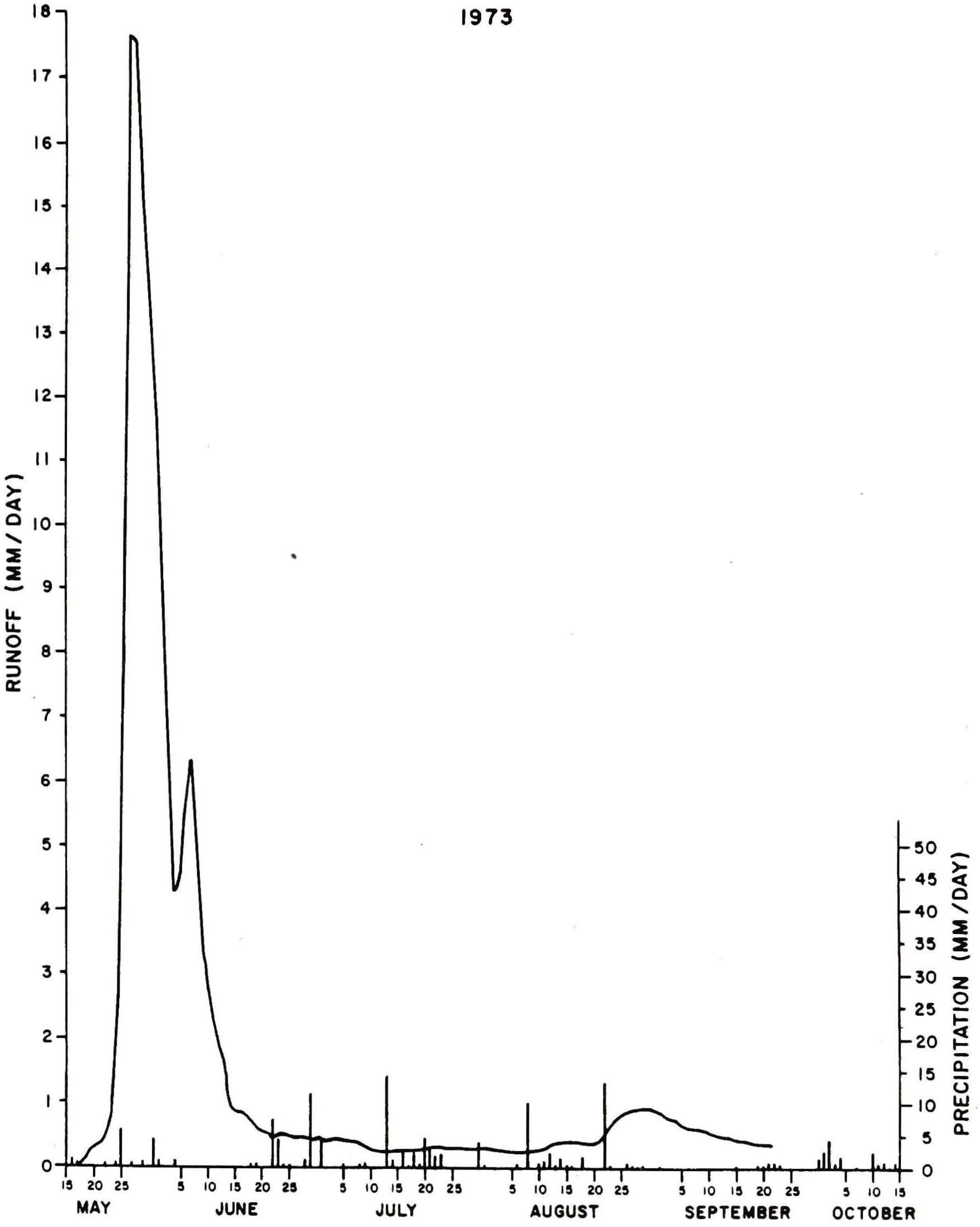


Figure 16-4. Runoff and precipitation at Boot Creek basin, 1973 (from Anderson and MacKay 1974).

Link 2: Construction and operation activities will alter channel geometry at specific locations.

Changes in stream or river channel geometry can result from:

1. in-stream construction activities such as the placement of temporary berms and the establishment of winter snow roads;

2. the removal of bed material during pipeline burial, surface gravel mining or subsurface dredging;

3. the placement of permanent culverts, bridges, berms, rip-rap, diversion channels or other river training works; and

4. construction- or operation-related changes in the thermal regime or pattern of water flow which promote icing (or aufeis) formation.

Many construction related changes in channel geometry will be of short duration. Examples would include the construction of temporary berms or diversion channels to allow instream work to be undertaken "in-the-dry". The effects of instream excavations or gravel extractions may be more persistent, particularly in those circumstances where the river cannot readily replace either the size or volume of material that was removed. The potential duration of these effects can be estimated through a variety of empirical techniques. However, long-term regional or on-site data provide a more reliable means of assessing the likely persistence of changes in channel geometry.

Permanent alterations to channel geometry are most likely to be associated with the construction of roads or above-ground pipelines. Culverts and retaining walls will likely cause the most significant change to channel morphometry and hydraulics. Buried pipelines are unlikely to result in much disturbance, especially if crossings are located perpendicular to the river.

Channel geometry may also be affected by the build-up of ice (icing) which may fill a channel during the winter and can, in some circumstances, result in significantly reduced channel conveyance capacities in the spring. The exposure of subsurface drainage and the placement of culverts are two activities that commonly result in icing formation. The burial of a cold gas pipeline within a seasonally unfrozen zone of a stream bed may also result in icing formation due to the subsequent restriction of subsurface water movement (Williams 1979).

Link 3: Increased rates of sediment production at specific locations will decrease water clarity.

The concentration of suspended sediment is a major factor determining water clarity. The effect of an increased sediment supply on water clarity depends on the texture and volume of the material entering a watercourse, pre-existing sediment concentrations and the volume and turbulent characteristics of water available to dilute or transport the incoming material.

Link 4: Increased rates of sediment production at specific locations will decrease the abundance or availability of fish foods.

According to the present development plan, most pipeline-related stream or river crossings would occur during winter when the majority of streams in the study area are frozen to the bottom. Any sediments resulting from construction will therefore be removed during the subsequent spring freshet. The subgroup expected that the effects of the incremental input of sediments on benthic organisms would be insignificant in comparison to the effects of the normal sediment loads carried by most streams at this time of year.

Summer or winter construction activities in flowing streams will decrease the abundance of benthic organisms, but such effects have generally been observed to be localized and temporary. McCart and de Graaf (1974) examined the effects of man-caused disturbance (seismic lines and winter roads) upon the benthic macro-invertebrate populations of several small sub-arctic streams near Norman Wells. It was found that there was a considerable decrease in the numbers of organisims in locations where severe and sustained erosion occurred. In other affected areas where banks have remained stable, there was no measureable change in the numbers of benthic invertebrates which could be attributed to the disturbance. Even in situations where massive amounts of sediments have been introduced, effects appear to be of relatively short duration if sediment additions are not large and continuous. Rosenberg and Snow (1975) studied a natural retrogressive-thaw flow slide on Caribou Bar Creek in northern Yukon that added an estimated 2000-2600 metric tons of sediment into the stream. Standing crop of benthic invertebrates was reduced immediately by 70% and qualitative changes in proportions of benthic-invertebrate taxa were evident. Recovery of benthic invertebrate populations occurred within a month. Although the mudslide was intermittently active during the following year, no apparent effect on the benthic invertebrate fauna resulted.

There is no evidence to indicate that increased sediment production will affect the availability of forage fish, and it is assumed that any displacement of these species due to construction activities will be minor.

Link 5: Increased sediment concentrations and exposure durations will have lethal and sublethal effects on fish and change their behaviour patterns.

Although laboratory experiments have demonstrated that fish may be killed by high concentrations of suspended sediments, such concentrations are rarely found in natural situations even during instream construction activities. For example, Wallen (1951) found that many temperate species of fish were able to tolerate suspended sediment concentrations of 100,000 mg/L for over a week and did not die until concentrations greater than 175,000 mg/L were reached. As shown in Table 16-1, recent studies on the effects of placer mining on Arctic grayling have also shown that suspended sediment concentrations must be unusually high to cause acute effects. In longer-term field experiments, McLeay et al. (1984) found grayling mortality to be unaffected over a six-week period by suspended sediments ranging in concentration from 100 to 1000 mg/L.

Table 16-1. Effects of suspended sediment exposure on Arctic grayling (from McLeay. 1983).

Acclimation temperature	Inorganic sediments (mg/L)	Organic sediments (mg/L)	Exposure Duration (days)	Effects
15°C	≦250,000	-	4	No mortality
15°C	≦ 50,000	-	16	No mortality
15°C	-	≦50,000	4	No mortality
5°C	≦10,000	-	4	No mortality
5°C	≦10,000	-	4	10-20% mortality

Sublethal effects of suspended sediments (which are considerably more common than lethal effects) are expected when relatively high sediment concentrations persist over a long period. The most commonly reported sublethal effects are reduced growth and respiratory efficiency, lowered resistance to disease and reduced spawning success and fecundity. However, the role of food chain effects or other complicating factors is not always clear. For example, Buck (1956) found that yields of largemouth bass, bluegill and red ear sunfish were highest (162 lb/acre) in clear ponds (<25 mg/L), intermediate (94 lb/acre) in somewhat turbid ponds (25-100 mg/L) and lowest (29 lb/acre) in turbid ponds (>100 mg/L). It is not known if these results were due to direct effects such as stress or reduced feeding efficiency, or due to indirect effects such as reduced food availability.

Recent studies on Arctic grayling have contributed to our knowledge of effects of sedimentation on boreal or arctic fishes. Birtwell et al. (1984) found that, in controlled circumstances, Arctic grayling from unmined (clear) tributaries in the Yukon consumed a greater diversity of prey items than did those from mined turbid streams. The condition factor for underyearling grayling from clear streams was also higher than that of grayling from turbid streams. Suspended sediment concentrations as low as 50 mg/L caused acute stress response (high and/or varied blood sugars, lowered leucocrit levels) in underyearling grayling in laboratory experiments by McLeay et al. (1983). Based on these results and those of their six-week field experiments, McLeay et al. (1983, 1984) concluded that chronic exposure of Arctic grayling to suspended sediment concentrations <1000 mg/L may not cause direct mortality of fish or impair respiratory capabilities, but suspended sediment concentrations >100 mg/L can cause a number of serious sublethal effects including impaired feeding, reduced growth rates, downstream displacement of individuals, decreased activity and decreased resistance to other environmental stresses.

The effects of suspended sediments on fish behaviour are not well documented. Most reports are of fewer fish in turbid versus clear streams (Birtwell et al. 1984) or of a decreased number of fish after clear streams become turbid or vice versa (Gammon 1970). However, fish may be attracted to turbid waters under some circumstances. Craig (1985) found that fourhorn sculpin were present in highest densities at a dredge outfall where suspended sediment levels were approximately 12,000-14,000 mg/L. In this situation, the fish may have been attracted by dead or injured prey that passed through the dredge. Sekerak et al. (1985) also reported that lake whitefish and least cisco appeared to be attracted to turbid waters caused by dredging in the Meade River, Alaska. As indicated in the subsequent discussion of Link 9, it is suspected that these whitefishes utilized the turbid waters (generally 50-100 mg/L of suspended sediments) for shelter.

The group concluded that Link 5 was valid. Although fish mortality seldom occurs in natural conditions, increased sediment concentrations induce a variety of sublethal and behavioural effects. Although most effects are considered detrimental to fish, some could be beneficial at least in the short term. Behavioural responses and sublethal effects can vary markedly among different fish species. We now have some knowledge on effect on Arctic grayling. Similar data are not available for any other species in the MEMP study area.

Link 6: Local changes in sediment production will affect streambed material size.

The fate of sediment delivered to stream channels will vary with the particle size composition and volume of material supplied, channel geometry, existing bed material size and the discharge regime of the watercourse. Material size is important since fine material may be carried in suspension for considerable distances and extremely fine sediment may not be deposited until it reaches a lake or ocean. Coarser-textured sediments may only be entrained during periods of high flow and are subject to frequent redeposition in areas with low water velocities. Channel geometry and bed material size determine how much energy is available to entrain or transport sediment. The discharge regime determines the seasonal timing of sediment transport and deposition.

The time required to flush sediments out of a system depends on the total volume of sediment entering the watercourse and the sediment transport capability of the stream. A variety of empirical techniques can be used to estimate potential bed load and suspended load transport rates. However, the results of such analyses are subject to large uncertainties and require field verification.

It may require a significant time to flush material moving as bed load out of a system. Point source inputs of large volumes of material may move gradually downstream from one depositional area to the next (Church and Jones 1982). These sediments may change the surface bed material size and the finer portions may penetrate the interstitial spaces of the underlying materials (Beschta and Jackson 1979). This is particularly likely in situations where sand or finer sediments are deposited over gravel. This process can reduce bed permeability, increase gravel compaction and reduce the flow of water and dissolved oxygen to the underlying sediments (Cooper 1965; Koski 1966; Phillips et al. 1975).

The capability of lakes to transport sediment is severely limited. Wind-generated waves and currents in lakes in the Mackenzie Delta area have a limited ability to entrain material (Mackay 1963). If a lake is seasonally connected to a sizeable river, there is a limited potential for fluvial transport of sediment. However, rates of sediment transport will generally be small or non-existent and, once deposited, sediment may not be re-entrained.

Link 7: Alterations in channel geometry will directly affect the extent or distribution of in-stream habitat at specific locations.

Construction activities, such as the placement of rip-rap, bridge abutments, and set-back dykes can reduce naturally occurring rates of channel shifting over the long term. This channel movement may be important for removing fine-textured sediments from bed materials and increasing the diversity of habitat for invertebrates and fish. Any alterations to this process may be significant when critical habitats are involved or when a linear corridor parallels or intersects a stream channel over considerable distances.

In-stream construction activities (such as excavation for a buried pipeline) or gravel extraction can alter both channel morphometry and bed material composition. These changes are likely to be relatively short-lived in streams or rivers with high bed load transport rates. More long-term effects can occur in the following situations if (1) boulders are removed from the stream and they cannot be naturally replaced by the river; and (2) the volume of excavated material is large in comparison to the rates of bed load transport. The effect of gravel mining on fish habitat along the Alyeska Pipeline route has been described by Woodward Clyde Consultants (1980a,b) and Den Beste and McCart (1984).

Increased rates of sediment production can lead to material being deposited on a stream or river bed. In severe cases this can result in changes in channel morphology and bed material size with associated effects on habitat quality and availability.

It was concluded that the potential impacts discussed above could occur. However, the likelihood of their occurrence could be minimized through appropriate engineering designs and, in cases of unavoidable impact, a variety of options are available for providing replacement habitit (e.g., Kellerhals, Miles and Seagel 1985).

Link 8: Local changes in channel geometry or thermal regime will result in blockage or restrictions of fish movements.

The subgroup noted that such changes could result from:

1. increased water velocities;

2. reduced water depth;

3. increased fall or winter water temperatures; or

4. alterations to the drainage pattern which would increase or decrease the water supply.

The effects of linear corridors on fish access is almost always a significant issue in situations where the presence of such corridors overlaps with the distribution of valued fish species. The principal cause of such concerns has been the increase in in-stream water velocities resulting from channel constriction or simplification (e.g., culvert placement, in-stream placement of bridge support structures, channelization of braided streams). For example, there is extensive evidence that poorly constructed culverts can inhibit the upstream movement of fish, especially small individuals whose burst swimming speeds are low. However, appropriate culvert design and placement and the use of bridges where necessary can usually ensure that adequate fish passage opportunities are maintained (e.g., Dane 1978a,b; Katopodis et al. 1978).

Some activities, such as gravel extraction, can result in areas of sufficiently shallow water that fish passage is inhibited, even when water velocities are relatively low. In extreme cases, changes in channel geometry or bed material size can result in localized dewatering of the stream channel. Temporary winter roads may also create physical barriers in spring, delaying or possibly even preventing fish access to spring and summer rearing areas. Again, however, appropriate engineering design can minimize these effects.

Changes in the thermal regime of streams, particularly as a result of the presence of heated pipelines, might affect fish that rely on thermal cues to stimulate downstream movements. For example, Arctic grayling move out of feeding areas into overwintering habitats when stream water temperatures drop to 4°C (Den Beste and McCart 1984). If instream temperatures are artificially elevated above 4°C, the fish may remain in habitat that is unsuitable for overwintering and ice buildup may then prevent fish from leaving. During the coldest part of winter, these warmed water areas may be extremely restricted in size. This type of impact, while possible, is likely to be very localized.

Linear corridor construction can alter small drainage courses or infill wetland areas and result in localized effects on fish habitat. However, in general, this type of impact is readily mitigated by careful route selection and the placement of appropriate drainage structures. In cases of unavoidable impact, a variety of techniques are available to provide similar or higher quality replacement habitat.

Due to their restricted distribution, Arctic char is the fish species thought to be most susceptible to physical or thermal changes in habitat. Grayling in the small tributary streams draining into the mainstem Mackenzie River from the east could also be adversely affected. In addition, the large rearing populations of anadromous whitefishes on the Tuktoyaktuk Peninsula may be susceptible to this type of impact, particularly if several streams along the Peninsula are rendered inaccessible.

Link 9: Local decreases in water clarity will decrease angling success and increase net fishing success.

Available information suggests that water clarity could have both positive and negative effects on fishing activities. Despite the apparent lack of specific studies, it was expected that sport fishing would be less effective in turbid waters, since most fishermen use spin casting methods with rapidly moving lures that fish cannot detect efficiently in turbid waters.

Sekerak et al. (1985) examined the abundance of whitefishes in the vicinity of dredging activities in the Meade River near Barrow, Alaska.

Dredging increased turbidity by about two orders of magnitude (from 11.5 mg/L to 50-200 mg/L) for tens of kilometres downstream of the dredge. Gillnet catches in turbid waters averaged 5-10 fish per hour, while catches in clear water averaged less than 2 fish per hour. This trend towards greater catches in turbid water was apparent for lake whitefish and least cisco but not for Arctic grayling. It was not thought that the likelihood of a single fish being caught increased in turbid waters, but rather that fish appeared to be more abundant in turbid waters, perhaps preferring this habitat due to the shelter it provides. Since the majority of the whitefishes were in pre-spawning condition and were not feeding in the river, food was not expected to be a factor influencing their distribution. Whatever the reason for the concentration of fish in turbid water, gillnetting success was increased.

Although the subgroup concluded that water clarity could affect fishing success in certain situations, it was not thought to be a significant area of concern in the present development plan for the following reasons:

(1) Much of the subsistence gillnet fishery takes place in the Mackenzie River or other large rivers during the open water season. During this period, the rivers are naturally turbid and any increases in turbidity due to development activities would likely be undetectable. Gillnetting in lakes could be positively influenced by increased turbidity since the fish would have more difficulty detecting the net.

(2) Sport fishing in smaller streams generally occurs when the water has cleared after the spring freshet, but pipeline crossings of these streams would be constructed in winter. Road construction generally occurs in summer and has a greater potential to increase water turbidity and interfere with sport fishing. However, even these effects are normally limited in duration.

(3) Most of the effects of road construction would occur during the active construction phase, which is a period when public access is limited. Consequently, sport fishing would not occur at the time when streams are likely to be most affected by increased water turbidity.

Link 10: Local decreases in the production of prey organisms will reduce the size and quality of fish.

Significant decreases in the growth and production of prey organisms in streams and lakes may result in reduced growth rates and the smaller adult fish. If the food shortages are localized, fish will tend to redistribute themselves among the more productive habitats if they have the opportunity.

There is no evidence to suggest that reduced availability or production of prey organisms influences the quality of fish, except in situations where size is a factor determining fish quality (e.g., in trophy fisheries).

Link 11: Local decreases in the production of prey organisms will result in fish mortality or changes in their distribution.

It is unlikely that the localized, short-term reductions in production of prey organisms that could result from the development plan under consideration will cause mortality of fish. It is considered more probable that fish would redistribute themselves to avoid heavily sedimented, unproductive habitats.

Link 12: Fish avoidance, attraction or migrations due to high suspended sediment concentrations will affect the number and distribution of fish.

Since it was concluded that Link 5 was valid, it follows that Link 12 must also be valid. However, the significance of any change in fish abundance or distribution is expected to be minor because of the short-term, site-specific nature of increases in suspended sediment concentrations.

Link 13: Increased concentrations of fine textured sediments within the river bed will reduce egg and larval fish survival.

Significant increases in the proportion of fine material within or on stream substrates will decrease the survival of eggs and larval fish as a result of:

1. reduced oxygen availability;
2. reduced rates of dissipation of metabolites; and
3. the physical inability of larvae to emerge through substrates containing a high percentage of fine sediment.

Decreased rates of oxygen and metabolite transfer would likely have the most significant effect on species, such as Arctic char, which have large eggs (and therefore low surface to volume ratios), which are fall spawners and have a long period of incubation (up to nine months). The effects of sediments in stream substrates would be least for spring spawning species, such as grayling, which have small eggs (with relatively high surface to volume ratios) and short incubation periods (often less than a month).

Link 14: Local changes in the amount and quality of habitat will change numbers and distribution of fish.

With the exception of Arctic char, most fish species are widely distributed and occur in relatively large numbers throughout much of the study area. It was therefore concluded that changes in fish distribution due to alterations in most habitats would be of minor significance. Arctic char were considered an exception as they are more likely to be affected by local disturbances for the following reasons:

1. they only occur in a few streams in the northwestern portion of the study area;

2. they overwinter and spawn in localized areas (in and immediately downstream of perennial springs); and

3. their critical overwintering and spawning habitats are spatially limited and, therefore, are susceptible to local disturbance.

Lake trout also have a restricted distribution in the study area but their habitat (large, deep lakes) is not as susceptible to local disturbance as is that of the Arctic char.

Link 15: Local restrictions in access will reduce spawning or rearing success and overwinter survival and, therefore, affect the number and distribution of fish.

Restrictions in access to spawning areas could reduce spawning success and, over the long term, affect population sizes. The severity of such events depends on a number of factors including the duration of the restriction and the availability of suitable spawning habitat below it. The primary species at risk in the MEMP study area are those such as Arctic char and grayling, which utilize small streams for spawning. The coregonids, which spawn in larger tributaries and the mainstem Mackenzie River, are less likely to encounter blockages during migration.

It is unlikely that the development of linear corridors within the study area will significantly restrict access to fish rearing habitats, except for projects which cross stream/lake systems along the Mackenzie Delta and Tuktoyaktuk Peninsula. This area is extensively used by juvenile and adult coregonids for rearing and feeding (Lawrence et al. 1984; Bond and Erickson 1985).

While most fish species in this region use deep sections of rivers, lakes or the Mackenzie itself as overwintering habitat, other species such as grayling and arctic char are found in spatially-restricted, spring-fed areas of smaller streams (McCart 1980). Flows are limited in such habitats and even minor restrictions could reduce the overwinter survival of grayling and char.

Link 16: Local decreases in fish egg and larval survival rates will reduce the number and alter the distribution of fish.

Local decreases in egg and larval survival rates could lead to decreases in the populations of certain species if the area of disturbance accounts for a large proportion of the egg production of those populations. This is most likely to occur with species such as Arctic char which have a restricted spawning distribution in the western Arctic. Populations are expected to tolerate some mortality if it is limited to only a small proportion of the total egg deposition and to one or a few year classes.

The regional distribution of the populations of some fish species could change if survival of eggs or larvae in one or more areas was substantially reduced. Nevertheless, reductions in the density or biomass of fish populations in part of the study area would not necessarily be reflected in changes in the geographic range of affected species populations.

CONCLUSIONS

Linear Corridors Will Affect Fishing Success

The subgroup considered this sub-hypothesis to be valid. However, it was concluded that any effects of hydrocarbon development in the study area on fishing success are likely to be localized and of minor significance. In addition, other factors are important in determining fishing success, and for this reason, the hypothesis would also be difficult to test.

Linear Corridors Will Affect Fish Quality

This sub-hypothesis was concluded to be valid if the size of fish was considered an index of quality. However, given the present development scenario, it appears unlikely that linear corridor developments would have a significant effect on fish size. Other factors such as the rate of fisheries exploitation and the presence or absence of disease were expected to have a greater influence on fish quality.

Linear Corridors Will Affect the Number and Distribution of Fish

The group agreed that this sub-hypothesis was valid although it was expected that the magnitude of any effects would vary with location and fish species. The types of impacts identified in this hypothesis can be minimized by careful route selection and design, development of appropriate mitigation strategies where required, routine on-site supervision during the construction period and normal post-construction monitoring and maintenance activities.

RESEARCH AND MONITORING

The subgroup discussed the need for a wide variety of investigations, including:

1. studies to improve the design of culverts such that fish passage can be ensured during icing conditions;

2. determination of the distribution, movements and critical habitats of whitefishes and grayling;

3. systematic monitoring of fish and selected indicator species;

4. expansion of the existing hydrometric network (including both discharge and sediment stations) to provide base line data for engineering and biological studies;

A consensus on the need for any particular research or monitoring program was, however, not reached within the time available. Lack of consensus appeared to be a result of a combination of:

1. research not being needed to determine the validity of the links;

2. the conclusion that mitigation strategies were generally available to deal with the potential impacts discussed in this hypotheses; and

3. while there was general agreement that the existing physical and biological data base could usefully be expanded, it was not felt that recommendations for additional baseline studies could be justified on the base of Hypothesis 16.

It was generally agreed that present knowledge would allow for development of linear facilities in the MEMP study area without large detrimental effects to fish populations if mitigative measures were applied where necessary and appropriate base line information was collected on a site-specific basis during the design phase of the project. In some cases, overdesign of facilities could compensate for a lack of knowledge of particular site-specific conditions or biota and, should unexpected effects occur, these would be detected and rectified by routine project monitoring and maintenance activities.

LITERATURE CITED

Anderson, J.C. and D.K. McKay. 1974. Progress of hydrologic studies at Boat Creek and Peter Lake watersheds, N.W.T., during 1973. Pages 203-224. In: Hydrologic aspects of northern pipeline development. Environ.-Social Comm., Task Force on Northern Oil Develop., Rep. 74-12.

Barton, B.A. 1977. Short-term effects of highway construction on the limnology of a small stream in southern Ontario. Freshwat. Biol. 7:99-108.

Beschta, R.L. and W.L. Jackson. 1979. The intrusion of fine sediments into a stable gravel bed. J. Fish. Res. Board Can. 36:204-210.

Birtwell, I.K., G.G. Hartman, B. Anderson, D.J. McLeay, and J.C. Malick. 1984. A brief investigation of Arctic grayling (Thymallus arcticus) and aquatic invertebrates in the Minto Creek drainages, May, Yukon Territory: An area subjected to placer mining. Can. Tech. Rep. Fish. Aquat. Sci. 1287: 57 p.

Bjornn, T.C., M.A. Brusven, M. Molnau, F.J. Watts and R.L. Wallace. 1974. Sediment in streams and its effects on aquatic life. Wat. Resource Res. Inst. Univ. Idaho, Project B-025-IDA. 47 p.

Bond, W.A. and R.N. Erikson. 1985. Life history studies of anadromous coregonid fishes in two freshwater lake systems on the Tuktoyaktuk Peninsula, Northwest Territories. Can. Tech. Rep. Fish. Aquat. Sci. 1336:vii + 61 p.

Buck, D.H. 1956. Effects of turbidity on fish and fishing. Trans. N. Amer. Wildl. Conf. 21:249-261.

Church, M. 1974. Hydrology and permafrost with reference to northern North America. Pages 7-20. In: Proc. Workshop Seminar Permafrost Hydrology. Environ. Can., Ottawa.

Church, M. and D. Jones. 1982. Channel bars in gravel-bed rivers. Pages 291-338. In: R.D. Hey, J.C. Bathurst and C.R. Thorne (eds.). Gravel-bed rivers, fluvial processes, engineering and management. J. Wiley Sons.

Cline, L.D., R.A. Short, J.V. Ward, C.A. Carson and H. Gary. 1983. Effects of highway construction on water quality and biota in an adjacent Colorado mountain stream. U.S.D.A. Forest Serv., Rocky Mt. Forest and Range Exp. Sta. Res. Note RM-429. 11 p.

Cooper, A.C. 1965. The effects of transported stream sediments on the survival of sockeye and pink salmon eggs and alevin. Int. Pac. Salmon Fish. Comm., Bull. XVIII. 71 p.

Craig, P. 1985. Aquatic surveys of the Kaktovik dredging operations 1913 and 1984. Unpubl. rep. by LGL Ltd. for North Slope Borough, Barrow, Alaska. 25 p.

Dane, B.G. 1978a. A review and resolution of fish passage problems of culvert sites in British Columbia. Fish. Mar. Serv. Tech. Rep. 810. 126 p.

Dane, B.G. 1978b. Culvert guidelines: Recommendations for the design and installation of culverts in British Columbia to avoid conflict with anadromous fish. Fish. Mar. Serv. Tech. Rep. 811. 57 p.

Den Beste, J. and P. McCart. 1984. Results of studies of the long-term effects of the Trans-Alaska Pipeline System on fish and aquatic habitats. A report to Alyeska Pipeline Service Co. 1972 p.

ESL Environmental Sciences Ltd. 1980. Summary report, aquatic environmental programs, southern British Columbia pipeline prebuild, September 10 to October 9, 1980. Unpubl. rep. prep. for R.C. Stutz Management Company Ltd.

Fernet, D.A. 1984. Fisheries and water quality monitoring in relation to an in-stream blast in the Mackenzie River. Unpub. rep. for IPL (NW).

Fernet, D.A. 1985. Aquatic monitoring, July 1984. Unpubl. rep. for IPL (NW).

Forbes, D.L. 1981. Babbage River delta and lagoon: hydrology and sedimentology of an arctic estuarine system. Ph.D. Thesis. Univ. British Columbia, Vancouver. 554 p.

Gammon, J.R. 1970. The effect of inorganic sediment on stream biota. Environ. Protection Agency, 18050 DWC. 141 p.

Inland Water Directorate. 1984. Unpublished computer file. Wat. Serv. Can., Yellowknife, N.W.T.

IPP Interprovincial Pipeline Ltd. (NW). 1984. Water quality monitoring in relation to pipeline construction across Bosworth Creek, N.W.T. Unpubl. rep.

Katopodis, C., P.R. Robinson and B.G. Sutherland. 1978. A study of model and prototype culvert baffling for fish passage. Fish. Mar. Serv. Tech. Rep. 828. 78 p.

Kellerhals, R., M. Miles and G.C. Segel. 1985. River channel encroachments by highways and railways. Pages 77-96. In: Proc. 7th Canadian Hydrotechnical Conf. Can. Soc. Civil Eng., Saskatoon, Sask.

Koski, K.V. 1966. The survival of coho salmon from egg deposition to emergence in three Oregon coastal streams. M.Sc. Thesis, Oregon State Univ., Corvallis. 84 p.

Kruzynski, G.M. and A.D. Sekerak. 1980. Effects of constructing a pipeline in winter across the Fort Nelson River, British Columbia. Unpub. rep. by LGL Limited for Westcoast Transmission Co. Ltd., Vancouver, B.C. 35 p.

Landeen, B.A. and C.W. Brandt. 1975. Impressions on the construction of the Painted Mountain Gas Pipeline. Fish. Mar. Serv. Pac/T-75-24. 58 p.

Lawrence, M.J., G. Lacho and S. Davies. 1984. A survey of the coastal fishes of the southeastern Beaufort Sea. Can. Tech. Rep. Fish. Aquat. Sci. 1220: x + 178 p.

Mackay, J.R. 1963. The Mackenzie Delta area, N.W.T. Can. Dep. Mines Tech. Surveys, Geograph. Branch, Memoir No. 8. 202 p.

McCart, P.J. 1980. A review of the systematics and ecology of Arctic char (*Salvelinus alpinus*) in the western Arctic. Can. Tech. Rep. Fish. Aquat. Sci. 935. 89 p.

McCart, P. and D. de Graaf. 1974. Effects of disturbance on the benthic fauna of small streams in the vicinity of Norman Wells, Northwest Territories. In: P.J. McCart (ed.), Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon and Northwest Territories. CAGSL Biological Report Series, Vol. 15, Chapt. 4, 29 pp.

McLeay, D.J., A.J. Knox, J.G. Malick, I.K. Birtwell, G. Hartman, and G.L. Ennis. 1983. Effects on Arctic grayling (*Thymallus arcticus*) of short-term exposure to Yukon placer mining sediments: Laboratory and field studies. Can. Tech. Rep. Fish. Aquat. Sci. 1171: 134 p.

McLeay, D.J., G.L. Ennis, I.K. Birtwell and G.F. Hartman. 1984. Effects on Arctic grayling (Thymallus arcticus) of prolonged exposure to Yukon placer mining sediment: a laboratory study. Can. Tech. Rep. Fish. Aquat. Sci. 1241: 95 p.

Neill, C.R. 1972. Hydrologic and hydraulic studies for northern pipelines. In: Proc. Ann. Conf. Can. Soc. Civil Eng., Edmonton, Alta. 25 p.

Neill, C.R. and J.D. Mollard. 1980. Examples of erosion and sedimentation processes along some northern Canadian rivers. Pages 565-597. In: Proc. Int. Symp. River Sedimentation, Beijing, China.

Newcombe, C.P. 1985. Fisheries and the problem of turbidity and inert sediment in water: annotations and bibliography. Unpublished report, Fisheries Branch, B.C. Ministry of Environment. 46p.

Phillips, R.W., R.L. Lantz, E.W. Claire and J.R. Moring. 1975. Some effects of gravel mixtures on emergence of coho salmon and steelhead trout fry. Trans. Am. Fish. Soc. 104:461-466.

Porter, T.R., D.M. Rosenberg and D.K. McGowan. 1974. Winter studies of the effects of a highway crossing on the fish and benthos of the Martin River, Northwest Territory. Fish. Mar. Serv. Tech. Rep. Serv. No. CEN/T-74-3. 50 p.

Richwa, P. and J.W. McDonald. 1985. 1984 benthos and water quality/hydrology monitoring program. Unpubl. rep. prep. by ESL Environmental Sciences Ltd. for Union Oil Company of Canada Ltd.

Rosenberg, D.M. and N.B. Snow. 1975. Ecological studies of aquatic organisms in the Mackenzie and Porcupine River drainages in relation to sedimentation. Fish and Mar. Serv. Tech. Rep. 547. 86 p.

Saunders, J.W. and M.W. Smith. 1965. Changes in a stream population of trout associated with increased silt. J. Fish. Res. Board Can. 22:395-404.

Sekerak, A.D., W.B. Griffiths and N. Stallard. 1985. Aquatic investigations in response to dredging in the Meade River, Alaska. Unpub. rep. by LGL Limited for North Slope Borough, Barrow, AK. 158 p. + Appendix.

Wallen, I.E. 1951. The direct effect of turbidity on fishes. Bull. Okla. Agric. Mech. Coll. 48:1-27.

Williams, P.J. 1979. Topics in applied geography. Pipelines and permafrost physical geography and development in the circumpolar north. Longman Group Ltd., New York. 98 p.

Woodward-Clyde Consultants. 1980a. Gravel removal in arctic and subarctic floodplains in Alaska. Report to U.S. Fish and Wildlife Service. FWS/OBS-80/08. 403 p.

Woodward-Clyde Consultants. 1980b. Gravel removal guidelines manual for arctic and subarctic floodplains. Report to U.S. Fish and Wildlife Service. FWS/OBS-80/09. 169 p.

HYPOTHESIS NO. 17

WOLVERINES THAT ARE ATTRACTED TO CAMPS AND GARBAGE WILL BE KILLED AS NUISANCE ANIMALS, THUS REDUCING THE POPULATION

PARTICIPANTS

Lorraine Allison	Maurice Mendo
Susan Fleck	Steve Matthews
Harvey Jessup	Nicholas Sonntag

INTRODUCTION

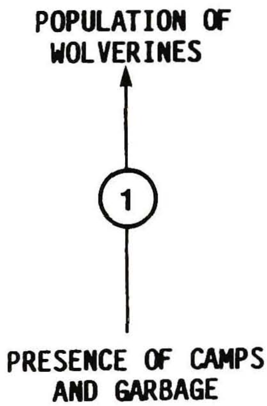
Wolverines are found throughout Canada except the Maritimes, but are most abundant in the forested mountains in the west and on the northern tundra. They are the largest member of the weasel family (Mustelidae). Wolverines display fidelity to a home range but they do not aggressively defend their territories to the exclusion of other wolverines. This is likely due to the size of their home range; 422 km^2 for males and 388 km^2 for females (Hornocker and Hash 1981). They are not restricted in their movements by major bodies of water or mountain ranges as is the case with other mustelids.

Females reach sexual maturity at two years of age. Breeding takes place from June until August and two to four young are born in April/May, following a period of delayed implantation. The young reach adult size by the fall but often accompany the female until late winter. Dispersing wolverines can travel in excess of 480 km in search of new ranges (Gardner and Jessup 1984).

Wolverines are opportunistic feeders and scavenge mainly on carrion, but they are also known predators of small mammals, birds, birds' eggs, and an occasional caribou calf or lamb. Wolf kills are also an important source of food and wolverines have been observed following caribou herds and feeding on wolf kill remains (S. Fleck, pers. comm).

FIGURE 17-1

Wolverines attracted to camps and garbage will be killed as nuisance animals, thus reducing the population



LINKAGES

Link 1: Wolverines attacted to camps and garbage will be killed as nuisance animals, thus reducing the population.

The wolverine is managed as both a game animal and a furbearer in the Yukon and the N.W.T. Although sports hunters are allowed to take one wolverine during the regular hunting season, most of the harvest is taken by trappers between November 1 and March 31. The national harvest has exceeded 900 animals with over one third of those coming from the Yukon (Statistics Canada 1984). The fur is known for its resistance to frost and is used as a northern garment trim. Up to 90% of the harvested furs are sold to natives in the north for domestic use (J. Desmond, Hudson's Bay Co., pers. comm.).

LINKAGES

Link 1: Wolverines attracted to camps and garbage. Wolverine will be killed as nuisance animals, thus reducing the population.

Wolverines tend to be reclusive and are not attracted to people unless food is also present. However, once attracted to food at a camp site, wolverines can become a nuisance although not a threat to humans in the area. There are no records of wolverines having ever attacked people, but like bears, they can destroy property. Because wolverines tend to be shy and large camps are well regulated, problems are greater at smaller seismic and drilling camps than at large pipeline construction camps. During the IPL pipeline construction, no observations of wolverine at the mainline camps were reported (S. Matthews, pers. comm.).

The arguments for the links between attraction of wolverine, killing of nuisance animals and decreased wolverine populations are identical to those put forward for grizzly bears (Hypothesis 3). Like bears, wolverines occur in low densities and have large home ranges. It is not known how many animals can be attracted by a single camp or how far wolverines will move to a source of food. During the 1982/83 trapping season a trapper in the Yukon took 15 wolverines from one wolf kill (moose) in a valley approximately two miles in width and four miles in length (H. Jessup, pers. comm.); such concentrations are extremely unusual.

The present population levels, numbers harvested and effects of the harvest on wolverine populations are unknown. The effects of small increases in the annual kill are also unknown.

CONCLUSIONS

The linkage in this hypothesis is considered unlikely based on known information on wolverine behaviour. There is no need to have development-associated killing of wolverines. This is a management and regulation problem. Because they pose no threat to people, nuisance wolverines can be removed from camp areas without killing them.

RESEARCH AND MONITORING

There is no need for monitoring programs specifically related to the effects of development on wolverines. However, trapping and hunting around camps should be limited or prevented.

LITERATURE CITED

Gardner, C. and H. Jessup. 1984. Long distance movement by an adult wolverine. In prep.

Hornocker, M.G. and S. Hash. 1981. Ecology of the wolverine in Northwestern Montana.

Statistics Canada. 1984.

PART 2: RESOURCE HARVESTING HYPOTHESES

INTRODUCTION

The terms of reference for MEMP were expanded to include consideration of the effects of development on the socio-economic process of resource harvesting by Native people in the region, as well as its effects on biophysical processes.

Resource harvesting is a complex system involving biological, economic, and social variables. These include the abundance, distribution, and quality of the biological resources themselves; direct socio-economic considerations such as costs and benefits of harvesting, alternative opportunities and constraints; and indirect effects of the more general process of socio-cultural change and the perception of social well-being. The effects of industrial development upon harvesting can thus be conceptualized as following three separate but related causal paths, as illustrated in Figure 1.

It was decided at the first MEMP workshops to restrict the consideration of resource harvesting impacts to the middle set of variables (Hypotheses 18-25). The variables on the right hand side of Figure 1 are the subject of Hypotheses 1-17. The variables on the left hand side were considered to be beyond MEMP's terms of reference, except insofar as they could be shown to affect directly those in the middle column.

Harvesting can be conceived of as a Valued Ecosystem Component (VEC) in two ways. First, harvesting refers simply to a physical output; a quantity of produce resulting from measurable inputs. Changes in input will result in different levels of output. Secondly, harvesting refers to a way of life which, when altered, may have effects on social and cultural well-being. Hypotheses 18-25 attempt to address both.

The first usage may be defined in terms of precise, quantifiable

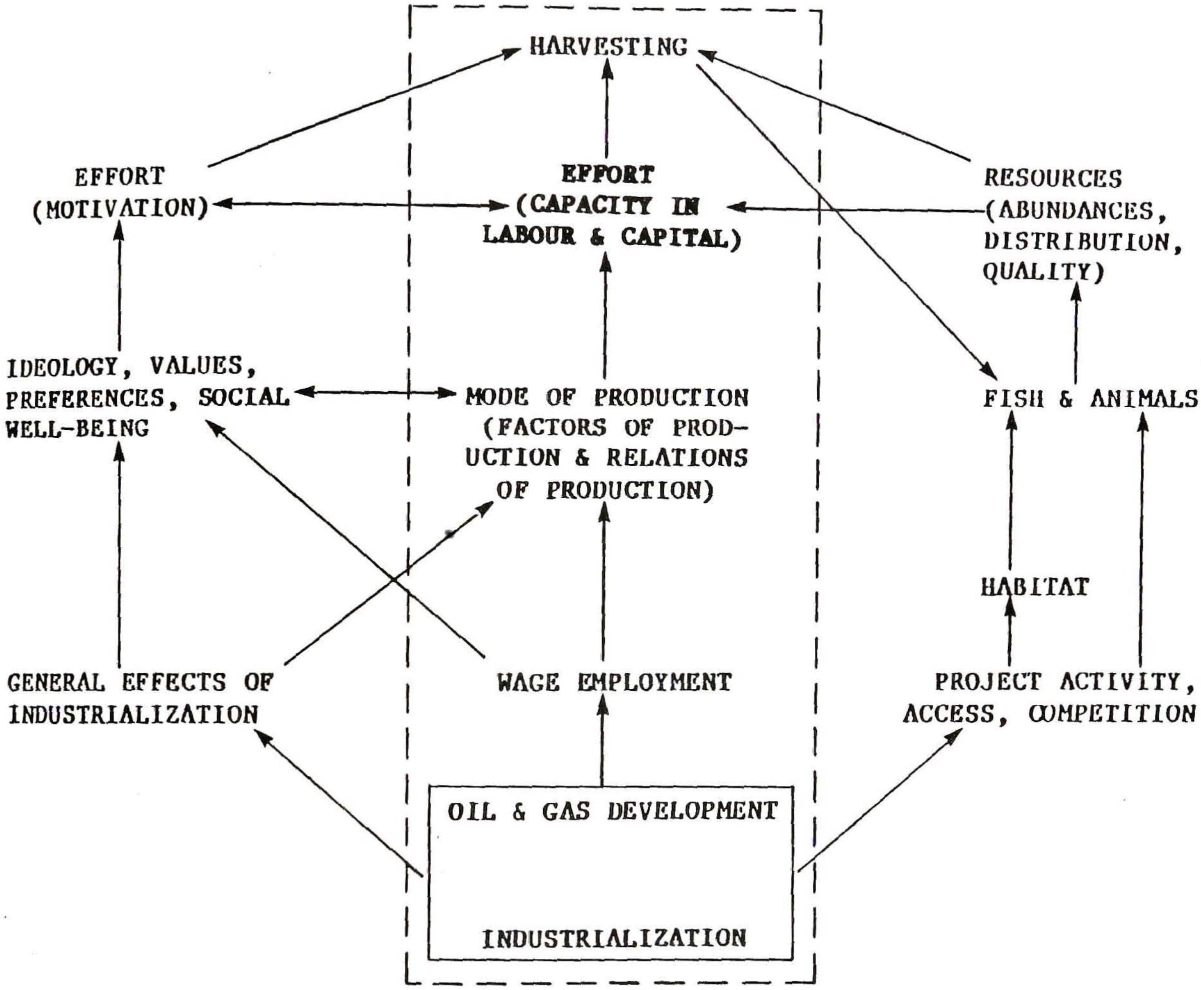


Figure 1. Model of the impact of industrial development on Native resource harvesting. (Terms used in this diagram are explained in Concepts and Terminology).

parameters, for example:

> The maintenance of community harvests at per capita levels and at catch per unit effort levels within their recent range of natural variability (see Factors of Production and Effort, and Harvest).

The second usage takes account of the several distinct but overlapping elements of harvesting that Native people value; that is, how harvesting as an **activity** is a VEC. These include:

1. a socio-economic system of food production;

2. a set of dietary standards, which may be expressed in cultural as well as quantitative nutritional terms;

3. a viable economic option for some portion of the Native population; and

4. a social and cultural way of life based on harvesting.

The first usage emphasizes short-term cost/benefit calculations as the stimulus to harvesting effort. It is essentially an economic model that explains behaviour in terms of individual preference and utility. The second emphasizes long-term considerations of social system maintenance and their effects on effort. It is an anthropological model that explains behaviour in terms of interdependent preferences (in effect, culture). Although the first is easier to model, quantify, and monitor, the two are closely related and the resource harvesting hypotheses consider the second as well. Non-Native harvesting (i.e., recreational hunting and fishing) was excluded from the terms of reference for this project.

Some of the hypotheses, at their current state of development, lack supporting scientific documentation. None have been formally tested in the study area; some have not even been stated before. Instead they are derived from two sources: the knowledge and experience of local people along with some social scientists who have done related research in the study area, and from relevant research results from similar study areas. Due to the continuously evolving nature of any local resource harvesting system, however, analogues from other times and places can never have more than qualified application. Consequently the contributions of local harvesters themselves at the workshops were especially important in formulating the resource harvesting hypotheses.

Consideration of industrial impact on resource harvesting has moved BEMP and MEMP from the natural sciences to the social sciences. It is therefore appropriate to provide readers with an outline of the concepts and terminology that are used in these hypotheses.

Concepts and Terminology

Key variables are enumerated according to the following general categories: The social unit, the resource base, the factors of effort, harvests, and the agents of change. Much of the material in this section has appeared in similar form in DeLancey & Usher (1986), a report prepared for the Government of the N.W.T. in relation to MEMP.

Unit of Production

The basic unit of production (also referred to in the hypotheses as "production unit" or "producing unit") in the study region consists of several individuals normally resident under the same roof (and also normally family-related). Their economic functions (see below) are determined largely according to sex, age, and experience. The unit of production consists of all those members of a household who in some way contribute economically to the harvesting, processing, marketing and distribution of animals and fish as well as other domestically used renewable resources. Almost invariably this includes all members of the household. This unit endures for many years, with membership fluctuating chiefly on the basis of birth, death, and marriage, but also incorporating other social means of entry and exit.

For at least the last 20-30 years in the study region, the household has been the most readily observable unit of both production and consumption. This is in contrast to most models of economic activity, which differentiate between the firm (maximizing profit) as the unit of production, and the individual (maximizing utility) as the unit of consumption. To analyse the units of production in harvesting, it is essential to consider both the functional roles and interrelations of the individual members.

Although harvesting is organized on a household basis, the typical household is also engaged in other economic activities which it combines with harvesting for its optimum maintenance. For example, household income may be derived from any or all of the following sources:

1. wages and salaries;

2. transfer payments (e.g., family allowance, child tax credit);

3. sale of commodities (e.g., furs, handicrafts); and

4. domestic production (e.g., meat, fish, wood).

Members of the household, as a unit of production, may thus perform one or more of the following roles:

1. harvesters (those actually engaged in hunting, fishing, and trapping);

2. processors (those who skin and clean pelts, butcher meat, split fish, prepare food, etc.);

3. servicers (those who make clothing and gear, clean and maintain them, repair equipment, etc.); and

4. supporters (those who contribute cash obtained from sources other than harvesting to the purchase of gear and supplies).

For a household to be a producing unit, it must have harvesters among its members. It is an advantage to have processors and servicers among its members, although if necessary these functions can be obtained by arrangement with other households, or even commercially. Unless a substantial amount of income from harvesting is in the form of cash, the household must have supporters. Cash support may be obtained by harvesters themselves taking on wage employment, or by other household members contributing employment or other income to the harvesting endeavour.

Harvesting Group

Any particular harvesting task may be performed by an individual or a group. Harvesting group composition may vary from one form of harvesting to another and even from one occasion to the next. Examples include trapping partnerships, whaling crews, and hunting parties. These groups may consist entirely of members of a single unit of production, or they may consist of members of two or more such units, who temporarily or habitually ally themselves (generally on the basis of kinship), for the specific tasks in question.

While the foregoing definitions are generally applicable in the study region, the specific principles of household and harvesting group formation are somewhat fluid, and vary in detail over time and space. Consequently they should be empirically verified at the outset of any particular research and monitoring program, and periodically confirmed thereafter. However, it is these basic social units of production, rather than individuals *per se*, that are the appropriate units of observation and analysis in a resource harvesting monitoring program.

Mode of Production

Mode of production is a descriptive term that categorizes socio-economic systems according to their factors of production (land, labour, and capital, see Factors of Production and Effort), and their relations of production (see below). The basic units described above are themselves part of a larger social unit: traditionally the co-residential hunting group or the band, more recently the community or some socially integrated section of it, or some regional entity. The key properties (relations of production) of these larger units are:

1. a communal interest in defined harvesting territories;

2. a system of property relations (i.e., rules governing who has what rights over the factors of production, for example the land tenure system, rights of ownership and use with respect to equipment, and rights to command labour);

3. a system of resource management based on rules of allocation and harvesting;

4. a system for recruiting, training, and organizing productive labour; and

5. a system of mutual aid and sharing that ensures flexibility among units of production with respect to both the factors of production and the product itself, so that the basic needs of all households are taken care of.

There is substantial literature documenting the evidence and mechanics of these systems, both in the study area and for hunting and fishing societies generally. It is therefore a basic assumption in each of the resource harvesting hypotheses that all of these systems are presently in force in the study area. That assumption should be considered valid until it can be demonstrated otherwise.

The Resource Base

The resource base consists of the harvested species of animals, birds, and fish, each of which is considered in terms of the following attributes:

1. abundance (i.e., population as indicated by total number and/or density);

2. distribution (i.e., geographic variation in numbers and density, especially seasonally and from year to year); and

3. quality (i.e., suitability of flesh for human consumption, or saleability of pelts or other byproducts).

Other renewable resources are also significant in some areas, such as berries and other edible plants, and wood for fuel and tools. No attempt has been made in MEMP, however, to develop criteria for harvest monitoring with any special reference to those resources.

Factors of Production and Effort

The factors of production are conventionally considered to consist of land (resources), labour, and capital. The first has been considered in the previous section. The other two, in the context of fish and wildlife harvesting, may be more precisely defined as effort. Effort consists of the following attributes of labour, in combination with operating equipment (capital):

1. Time. With respect to harvesting, time can be defined in two ways:

   a) time actually spent harvesting, including preparation, travel, search, kill, retrieval, transport, processing, marketing; and

   b) amount and distribution of time in which the opportunity to harvest occurs.

   The first definition is relevant to a consideration of effort as further defined below, the second to household decision-making.

2. Skills. The physical and mental skills necessary for harvesting, as well as accumulated knowledge of habitat and environment, and especially of the abundance, distribution, behaviour, and natural history of species.

3. Information. Current information on environmental conditions and resource abundance, distribution and quality.

4. Equipment. Productive equipment, such as boats, engines, snowmobiles, rifles, fishnets, as well as gas, lubricants, parts, and ammunition required for their operation and maintenance, may be measured in terms of its value (quantity x purchase value x depreciation rate) and its effectiveness (productivity as measured by rate of gain, or output over input, in units of energy or currency).

5. Effort. Effort is thus the product of equipment, time, skills, and information. Since only the first two are easily quantifiable, the measurement of effort is commonly reduced to a product of equipment (gear) and time. Specific parameters of the unit of effort varies by type of harvesting. Some common ones include (in approximate order of their intrinsic precision and their correlation with harvesting success):

   a) fishing - (length and depth of net x days set);

   b) trapping - trap checks (traps x trapline trips), trap days (traps x day set); and

   c) hunting - hunter days (hunters x days out).

Harvest

Harvest is discussed in terms of volume (numbers struck and retrieved), value and numbers struck and lost. Volume, the numbers of animals struck and retrieved, is normally expressed as the quantity taken over a specified time and in a specified area. (This is the number normally reported by harvesters when surveyed) Harvest (i.e., success) can also be expressed relative to effort, specifically, catch per unit of effort (CPUE).

Two other definitions are possible:

1. Total number of animals removed from a population by virtue of harvesting activities (i.e., retrieved + struck and lost + stress-induced mortality). This quantity, higher than struck-and-retrieved, is of primary interest to wildlife managers, and may be expressed as the number of animals or as their total live weight (biomass).

2. Total number of animals used by the harvesting group (i.e., struck and retrieved less numbers lost in transport, storage, and preparation, less numbers judged inedible or unsaleable). This quantity, lower than struck-and-retrieved, is the basis of the economic value of the harvest. It may be expressed as the number of carcasses or pelts, or in units of edible weight.

Based on the above, harvest may be expressed as a value, either precisely in terms of dollar income, weight of produce, or quantity of key nutritional elements; somewhat arbitrarily on the basis of imputed values or shadow prices; or as a rank order based on cultural or personal preference. It is the evaluation of the harvest in these or other relevant terms by the harvesting groups themselves, not the absolute kill level, which governs the amount and allocation of harvesting effort.

Struck-and-lost refers to the numbers of animals actually killed or mortally wounded by direct encounters with gear (ammunition, traps, fishnets), but which are not subsequently retrieved by harvesters. This number is significant because it may vary, as a proportion of retrieved harvest, with the skills and equipment of harvesters, and may induce changes in the state regulatory regime in response. Struck-and-lost may be expressed as an absolute quantity or as a rate, relative to the quantity retrieved.

Agents of Change

Five types of changes entrained by or related to hydrocarbon development have been identified as having significant impacts on the harvesting system.

Industrialization

The general process of socio-economic change associated with industrialized societies (as opposed to the more popular usage, i.e., factories and blue-collar work). Some key features are:

1. the predominant unit of production is the firm, whether publicly or privately owned;

2. the factors of production are conceptually and practically separate, and each is a commodity that can be bought and sold by private individuals or firms;

3. in particular, labour is a commodity that is paid for primarily by means of wages or salaries, and firms buy labour itself rather than its products. (A corollary is that labour is mobile, and hence people, as the embodiment of labour, must be separable from their ties to land, kin and community.) Employment is thus equated not with gainful activity as such, but the sale of labour by individuals to firms for a wage or salary;

4. in particular, land and resources are commodities that are bought and sold in the market, and are commonly the private property of individuals or firms;

5. there is commonly a separation between the conception and execution of tasks within the unit of production (i.e., of functions between managerial and technical personnel on the one hand, and manual and clerical personnel on the other); and

6. there is a hierarchial organization of labour within the productive unit, with owners and/or managers having the predominant right to determine the objectives, organization, and techniques of production.

The above is an indicative rather than exhaustive list. However, it will be seen that industrialization as defined above applies to all of the basic economic institutions of non-Native society - government, financial, and business, as well as to what is normally considered as "industry". It is in this sense that the oil and gas industry itself is only a representative part of the overall mode of economic organization.

Industrialization as a general process occurs independently of any particular oil and gas project or activity, and results in certain gradual changes in the harvesting system (in particular, with respect chiefly to the relations of production outlined above), detectable only as long-term trends rather than in direct response to particular activities. It is nonetheless important to recognize where and how these changes are occurring so as to enable valid interpretation of shorter-run changes detected through a monitoring program.

Wage Employment

The features of wage employment that affect harvesting include:

1. wage rates;
2. duration of employment;
3. conditions of employment;
4. location of employment;
5. hiring policies; and
6. training policies.

All employment, regardless of employer or industry, may be expected to have an impact on the harvesting system. Employment which is directly or indirectly created by the oil and gas industry is significant to the extent that it:

1. differs from other types of employment in any or all of the above respects, and

2. constitutes a major change in the quality of employment opportunities available to harvesters.

The most significant short-run effects of employment upon harvesting are on the one hand to reduce the time available for harvesting and on the other to provide extra cash which enables the purchase of better harvesting equipment. Wage rates, a measure of time and income, provide a key indication of purchasing power and hence the likelihood of wage employment actually contributing to harvesting success. By the same token, measures of harvesting costs are also required.

Project Activity

Specific aspects of oil and gas development such as traffic, construction, seismic operations, and drilling may physically affect harvesting when they occur (e.g., through damage to productive equipment and caches, vandalism, interference, etc.).

Access (for local Native harvesters)

Physical installations or changes as a result of project or project related activities may affect the harvester's access to resources. These include seismic lines which increase or redirect access to trapping areas (at least when relatively new); roads which increase or redirect access to hunting to trapping areas (at least when relatively new); roads which increase or redirect access to hunting areas; and winter ship traffic creating open water lanes which cannot be crossed by terrestrial vehicles.

Competition

Increased numbers of non-local harvesters active in the area may create competition. This may occur through:

1. increased non-Native settlement or Native inmigration from other areas in response to project or project-related employment opportunities;

2. temporary presence of non-local harvesters, Native or non-native, due to project employment (e.g., rotational or fly-in situations); and

3. increased road access from outside the region, which allows non-local harvesters (Native or non-Native), easier and less readily controlled entry for hunting and fishing.

It should be noted that project activity, increased access and competition may also have direct effects on fish and wildlife or their habitat, resulting in changes in the abundance, distribution or quality of harvestable resources. These direct biophysical effects are considered in PART 1: Biological Hypotheses (1-17).

Concerns of Native Harvesters

Native people from northern communities had considerable influence on the direction taken by the project with respect to resource harvesting and the development of all of the impact hypotheses, but especially those on resource harvesting. Native representatives stressed two points at all workshops and meetings. One is that the communities themselves wish to be involved in the design and implementation of any monitoring system. The other is that they are concerned as much about relatively small-scale regional and site-specific impacts as they are about impacts on populations or habitat types, because community harvesting areas are not necessarily coincident with population ranges or natural habitat boundaries. What a natural scientist might thus view as an incidental impact on a particular population or habitat might be considered a major impact by local harvesters, or vice-versa. This underlines the necessity of a community-based monitoring system.

Literature Cited

DeLancey, D. and P.J. Usher. 1986. Identification of impact indicators for renewable resource harvesting. Rep. prep. for Environmental Planning and Assessment, Dep. Renewable Resources, Government of the N.W.T.

HYPOTHESIS NO. 18

WAGE EMPLOYMENT WILL CHANGE THE HARVEST OF WHITE WHALES

PARTICIPANTS

Alex Aviugana	Pamela Norton
Albert Elias	Cal Sikstrom
Rick Hurst	Tom Strong
Peter McNamee	John Ward

INTRODUCTION

White whale harvesting has historically been important to residents of the Mackenzie Delta communities (Tuktoyaktuk, Aklavik and more recently, Inuvik). As many as 200-300 people used to congregate at traditional summer camps, such as East Whitefish Station, for the harvest and processing of white whales. These traditional whaling sites are still used, but by fewer people and fewer family groups. Historical data indicate that the number of white whales harvested annually has declined over the years (Fraker 1977). This is most likely due to the fact that native dependence on the white whale as a source of food is not as important as it was in past years. Many native residents are employed in the wage economy and supplement their diet with food from commercial outlets. In recent years, the white whale harvest has been relatively stable.

During the BEMP workshop in 1985, the participants addressed the hypothesis that various facilities and activities associated with offshore hydrocarbon development will affect the white whale harvest by changing whale distribution and abundance. Vessel traffic could affect the time available to hunt and, therefore, affect the harvest; this is addressed in Hypothesis 19. The proximity of oil industry base operations to white whale concentrations (particularly at Tuktoyaktuk), could lead to the harvesting of whales by hunters from elsewhere in the region during periods when they are not actively engaged in wage employment. The participation of less-experienced hunters

FIGURE 18-1

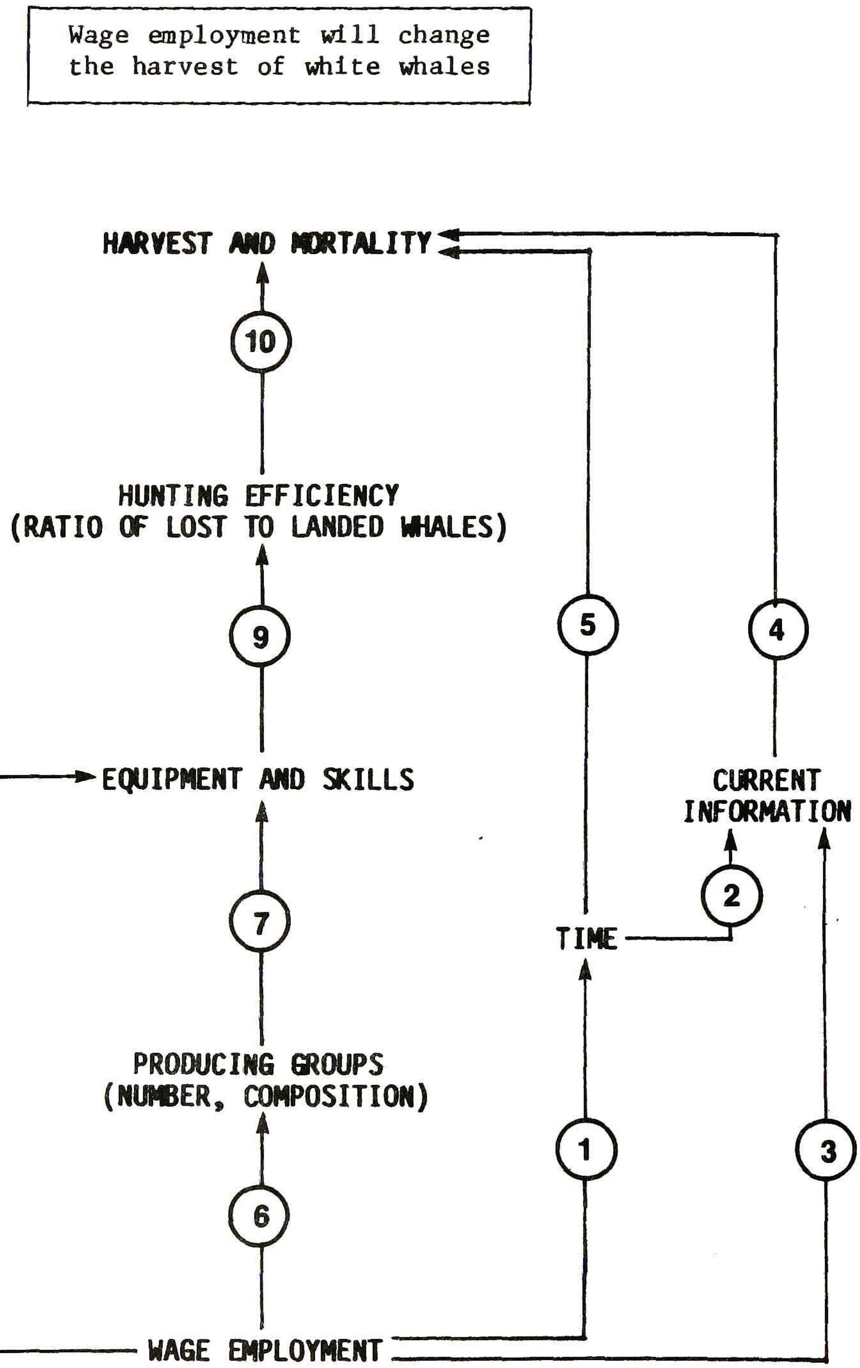


Figure caption to read: Effects of wage employment on the white whale harvest

LINKAGES

Link 1: Wage employment of Mackenzie Delta residents will result in less time available for hunting and thereby reduce native hunting effort.

Link 2: Reduced hunting effort will decrease the amount of new information obtained each year concerning the distribution and availability of white whales.

Link 3: Wage employment will affect the current level of information by changing the travelling routes and living areas of natives.

Link 4: A change in the current level of information will affect the harvest.

Link 5: Reduced hunting effort will decrease the number of whales taken and/or change the age/sex composition of the harvest.

Link 6: Wage employment will alter the number and/or the composition of harvesting groups.

Link 7: A change in the number and/or the composition of harvesting groups will decrease the general level of skills and change the quality of equipment used by hunters.

Link 8: Wage employment will change the quality of the equipment used by hunters.

Link 9: Less skillful hunters and a change in the quality of equipment used will reduce hunter efficiency (i.e., increase the ratio of lost to landed whales).

Link 10: An increase in the ratio of lost to landed whales will increase white whale mortality.

could affect the overall efficiency and size of the white whale harvest. This area of concern is addressed in detail in Hypothesis 20.

This hypothesis focuses on the potential that wage employment of local residents in the Mackenzie Delta area will alter the time and/or resources available to hunters and, therefore, change the resource harvesting intensity and patterns. For example, a greater number of inexperienced local hunters were involved in the Alaskan bowhead whale hunt following land claim settlements, and this resulted in an increase in the number of whales that were struck-and-lost. On the other hand Kruse (1982) reported that employment of Alaskan Inuit by the oil industry did not result in a significant decrease in the time spent or interest in the traditional hunting activities throughout the year.

LINKAGES

Link 1: Wage employment of Mackenzie Delta residents will result in less time available for hunting and thereby reduce native hunting effort.

Whaling camps serve a variety of social and economic functions other than the harvest of white whales. The transfer of traditional skills and knowledge to other hunters is particularly important (A. Aviugana, A. Elias, T. Strong, pers. comms.). The subgroup agreed that wage employment may not prevent hunters from participating in the annual white whale harvest (because they value the experience and use holidays and other time off to hunt) but it may affect the level of effort. Weekend or short-term hunters spend a greater proportion of their available time travelling. Although the actual time spent hunting is not necessarily reduced, the opportunity to become involved in other activities at whaling camps may be lost (i.e., processing effort is reduced). The hunter may not have time to process the whale, and instead the muktuk is used fresh or taken back to the settlement to be frozen. In such cases, the whale meat is often left for use by people remaining in the camp, or in rare cases, abandoned.

Link 2: Reduced hunting effort will decrease the amount of new information obtained each year concerning the distribution and availability of white whales.

The subgroup concluded that this link is invalid. Information on the current distribution and availability of whales is easily obtained by hunters. For example, most hunters from Aklavik and Inuvik stop at a whaling camp to talk with other hunters before engaging in the harvest and current information on whale location is freely shared. During the annual harvest, the entire community of Tuktoyaktuk is similar to a whaling camp with respect to the exchange of information. The only conceivable change that might affect the free sharing of information is the establishment of a quota at a level that would cause competition among hunters for a limited number of white whales.

Link 3: Wage employment will affect the current level of information by changing the travelling routes and living areas of natives.

Link 4: A change in the current level of information will affect the harvest.

Links 3 and 4 were considered invalid. As stated in the previous discussion (Link 2), knowledge on the distribution and availability of white whales is not gained solely through hunter experience, but also through consultation with other members of the community that actively participate inthe harvest. In addition, the Mackenzie stock of white whales tends to congregate in the same general areas at the same time each year. The location of traditional whaling camps depends on the site fidelity demonstrated by this stock. For these reasons, the subgroup concluded that even if most hunters were employed in the wage economy, this would not affect the current level of information regarding the white whale stock or the harvesting of this stock.

Link 5: Reduced hunting effort will decrease the number of whales taken and/or change the age/sex composition of the harvest.

It was agreed that reduced effort because of wage employment would not necessarily reduce the white whale harvest but the subgroup considered the effects of wage employment on hunter selectivity to be worth addressing. It was agreed that wage employment will reduce the quality of hunting time available to weekend hunters (due to adverse weather and unpredicted patterns in whale distribution), which may cause hunter selectivity (i.e., the desire for large, older male animals) to be compromised. This may lead to harvesting of the first available whale (large or small, male or female) rather than the preferred whale, and also encourage hunting in less than optimal conditions. This could ultimately lead to reduced hunting efficiency and a change in the age and sex of the harvest. (The taking of more females could have a negative impact on the white whale population if the maximum sustainable yield is approached, but this was considered unlikely both at the present time and in the near future.)

Link 6: Wage employment will alter the number and/or the composition of harvesting groups.

The group considered this link to be valid. Experience in the Mackenzie Delta has shown that although sharing of the harvest still occurs among some hunters, there are presently fewer large family harvesting groups. Natives employed in the wage economy may choose to hunt by themselves rather than as part of a large family unit and fewer young people that are employed may consistently participate in the white whale harvest.

Link 7: A change in the number and/or the composition of harvesting groups will decrease the general level of skills and change the quality of equipment used by hunters.

The subgroup considered this link to be valid. The harvesting of white whales requires specific skills and appropriate equipment. It was noted that camp experience is very important for acquiring the necessary skills, including the techniques required for effective hunting and processing. Equipment selection, care and handling is also learned from experienced hunters. The ability to predict and deal with weather conditions is considered particularly important for the hunter and difficult to obtain independently.

Link 8: Wage employment will change the quality of equipment used by hunters.

The group concluded that the quality of equipment used and the decision to allot funds to upgrade equipment were determined on an individual basis. Wage earners may be in a better position to purchase higher quality equipment which could lead to increased hunter efficiency. However, at the same time wage employment could reduce the experience of the hunter, which could lead to inappropriate equipment being used for the hunt. Some experienced hunters may occasionally use poor quality equipment, but they rely less on their equipment than the inexperienced hunter, so hunting efficiency will not be affected.

Link 9: Less skillful hunters and a change in the quality of equipment used will reduce hunter efficiency (i.e., increase the ratio of lost to landed whales).

The group concluded that community pressure and education have prevented a decrease in and may have, in fact, improved hunting efficiency to date. Regulations (imposed from within or outside of the community) are expected to control the number of white whales that are struck-and-lost.

This link is addressed in greater detail in relation to Link 4 of Hypothesis 20.

Link 10: An increase in the ratio of lost to landed whales will increase white whale mortality.

This link is considered self-evident and valid. Hunters usually have a production target, so if a whale is struck-and-lost, they continue to hunt until a whale is successfully taken.

CONCLUSIONS

The group concluded that wage employment may reduce the time available for hunting, which may affect hunter selectivity, thus changing the composition of the harvest. However, wage employment was not expected to affect the level of the harvest. Although employment may change the number and/or the composition of the harvesting group, as well as reduce the level of skill of the hunter and overall quality of equipment, regulations imposed from within or outside of the community are expected to offset these changes. Wage employment is unlikely to change the level of information regarding the distribution and availability of white whales.

RESEARCH AND MONITORING

The subgroup supported the continuation of the monitoring program that is presently being conducted by the Department of Fisheries and Oceans. The program provides valuable information regarding the age structure of the harvest, current status and trends of the Mackenzie white whale population and aids in identification of potential conflicts with industry operations that could affect the annual hunt. The following information is obtained:

- number of whales landed
- number of whales struck-and-lost
- names, home settlements and hunting area of hunters
- sex of harvested whales
- total length of harvested whales
- age of harvested whales (teeth, jaw, colour)
- reproductive information
- method of hunting (calibre of rifle, number of shots fired, number of shots to hit the whales, use of harpoon before or after shooting)

To evaluate whether wage employment directly influences the white whale harvest, it was suggested that the program be expanded to include information concerning the employment status of the hunters. However, due to the personal nature of this information, it was realized that it could be difficult to obtain such information, especially on a consistent basis.

LITERATURE CITED

Fraker, M.A. 1977. The 1977 whale monitoring program, Mackenzie Estuary, N.W.T. Unpubl. rep. by F.F. Slaney and Co. Ltd. for Imperial Oil Ltd., Calgary. 53 p.

Kruse, J.A. 1982. Subsistence and the North Slope Inuipiat: the effects of energy development. Man and the Arctic Program, Monograph No. 4. Institute of Socio-economic Research, University of Alaska, Anchorage.

HYPOTHESIS NO. 19

VESSEL TRAFFIC WILL DECREASE THE WHITE WHALE HARVEST

PARTICIPANTS

Alex Avuigana	Pamela Norton
Albert Elias	Tom Strong
Rick Hurst	John Ward
Peter McNamee	

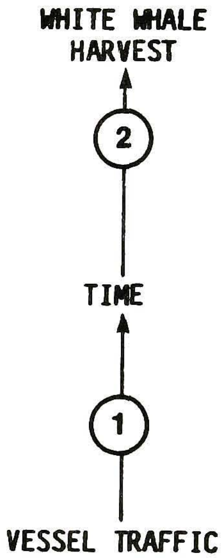
INTRODUCTION

Vessels currently operate throughout Kugmallit Bay, which is frequented by white whales. Vessel traffic was formerly present in Shallow Bay and Niakunak Bay, which are also areas used by white whales. Although vessel traffic has been present in Kugmallit Bay for more than 15 years, white whales continue to occur in the area during their period of summer residence in the southeast Beaufort Sea.

Estimates of the number of white whales occurring in the Beaufort Sea have varied from 2000 in 1972 (Slaney 1973) to about 11,500 in 1981 (Davis and Evans 1982). Results of the 1984 offshore surveys suggest that the true population estimate is probably close to 11,500 whales and may even be greater (Norton and Harwood 1985). White whales are hunted by Inuvialuit from Aklavik, Inuvik and Tuktoyaktuk in areas of the Mackenzie Estuary where the whales concentrate during July and early August each year. The reported annual harvest has ranged from 208 in 1954 to 68 in 1965. An average of 121 whales have been landed annually, with a probable total mortality associated with the harvest of fewer than 200 (based on 23 years of data between 1954 and 1984; Strong and Weaver, in prep.). In any given year, approximately 30% of the harvest is from Niakunak Bay on the west side of the Estuary, and 70% from Kugmallit Bay on the east side of the Estuary (Strong and Weaver, in prep.). Hunting practices differ slightly between the two areas because of different water depths and coastal topography.

FIGURE 19-1

Vessel traffic will decrease the harvest of white whales



LINKAGES

Link 1: Vessel traffic will reduce the time available for hunting by directly interfering with hunting activities.

Link 2: Less time available for hunting will result in a decrease in the harvest of white whales.

LINKAGES

Link 1: Vessel traffic will reduce the time available for hunting by directly interfering with hunting activities.

This link was considered valid, although the disturbances resulting from vessel traffic are of a temporary nature. The oil and gas companies operating in this region are committed to continuing the mitigation of potential conflicts with the white whale harvest by scheduling vessel movements so that they do not coincide with the timing of the annual hunt.

Link 2: Less time available for hunting will result in a decrease in the harvest of white whales.

Current levels of vessel traffic have not had a measurable effect on the white whale harvest (DFO unpublished catch statistics; Strong and Weaver in prep.). However, the effects of a large-scale increase in vessel traffic on the white whale harvest, which may result from increased industry activity (e.g., a port on the Yukon North Slope or oil/gas shipment from offshore wells) is unknown. Such an increase would most likely affect the whale harvest in Niakunak Bay because of the greater difficulty in harvesting whales in deeper water. A substantial increase in the level of vessel traffic may result in changes in the distribution and movements of white whales in the Mackenzie Estuary, although evidence from other summering areas such as the St. Lawrence River suggest that white whales habituate to areas of repeated vessel traffic (Sargeant and Hoek 1973). The potential effect of ship traffic disturbance on the distribution of white whales was examined during the BEMP workshops in 1984 and 1985 (INAC and Department of Environment 1985).

Given the current levels of vessel traffic, the group concluded that Link 2 is invalid. The average annual harvest has remained relatively consistent for more than 15 years (Strong and Weaver, in prep.). Presently, the major factor that influences success is weather conditions (A. Aviugana, pers. comm.).

CONCLUSIONS

The hypothesis is considered possible, but unlikely in view of the present levels of vessel traffic and associated mitigative practices for the scheduling of vessel traffic.

RESEARCH AND MONITORING

Current monitoring practices are sufficient at the present time, but if development plans change and the potential for interference with the white whale harvest increases, the scope of monitoring programs should be re-evaluated.

LITERATURE CITED

Davis, R.A. and C.R. Evans. 1981. Offshore distribution and numbers of white whales in the eastern Beaufort Sea and Amundsen Gulf, 1981. Unpub. rep. by LGL Limited, Toronto, for Dome Petroleum Limited, Calgary, and Sohio Alaska Petroleum Company, Anchorage. 135 p.

INAC (Indian and Northern Affairs Canada) and Department of Environment. 1985. Beaufort Environmental Monitoring Project 1984-1984. Final Report. Unpubl. rep. by ESL Environmental Sciences Limited, LGL Limited, ESSA Limited, Arctic Laboratories Limited and Arctic Sciences Limited. 162 p.

Norton, P. and L.A. Harwood. 1985. White whale use of the southeastern Beaufort Sea, July-September 1984. Can. Tech. Rep. Fish. Aquat. Sci. No. 1401. v + 46 p.

Sargeant, D.E. and W. Hoek. 1973. Whale-watching. Nature Canada 2(4):27-30.

Slaney, F.F. and Company Limited. 1973. White whale study. Herschel Island - Cape Dalhousie coastal region of the Beaufort Sea. Unpubl. rep. for Imperial Oil Limited, Calgary. 29 p.

HYPOTHESIS NO. 20

COMPETITION BY NON-LOCALS WILL CHANGE THE NUMBER OF WHITE WHALES LANDED AND INCREASE MORTALITY IN THE POPULATION

PARTICIPANTS

Alex Aviugana	Pamela Norton
Albert Elias	Tom Strong
Rick Hurst	John Ward
Peter McNamee	

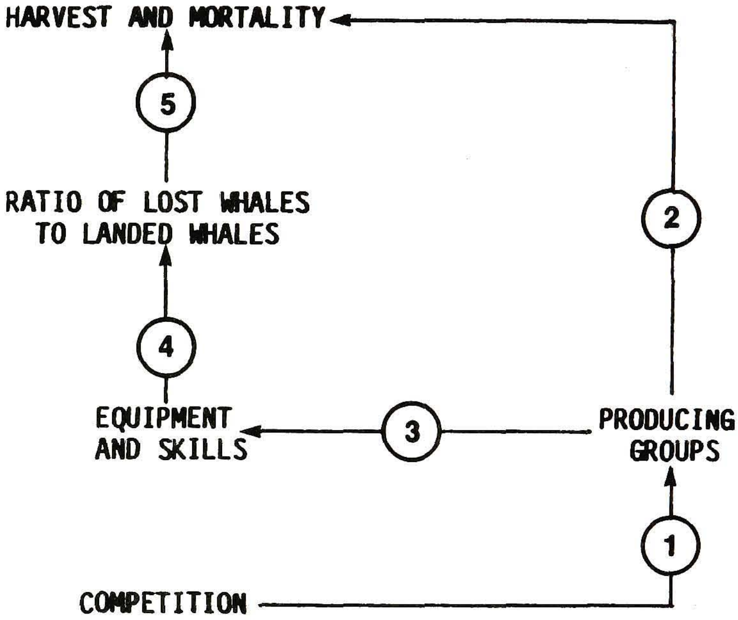
INTRODUCTION

White whales in the Mackenzie Estuary are harvested almost exclusively by residents of Aklavik, Inuvik and Tuktoyaktuk. Two or more hunters and often at least one whale processor typically comprise each producing group; the number of groups is relatively consistent from year to year. The whaling camps are occupied for a period ranging from several days to weeks. Occasionally hunters from another community will participate in the harvest, usually accompanying a local hunter in his boat. For example, in 1981 families from Holman Island participated in the harvest and took 13-15 white whales, with the assistance of residents of Aklavik (Norton Fraker and Fraker 1982).

White whales are hunted in areas of the Mackenzie Estuary where they congregate during the months of July and August. Major hunting areas (Shallow Bay/ Niakunak Bay, East Mackenzie Bay and Kugmallit Bay) are easily accessible by boat from the oil and gas industry bases at Inuvik and Tuktoyaktuk. Non-local Inuvialuit employed by the industry work on a 'time-on, time-off' basis at these bases. This hypothesis addresses the potential concern associated with participation of non-local employees in the white whale harvest between work shifts.

FIGURE 20-1

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



LINKAGES

Link 1: Competition will increase the number of, and alter the composition of the harvesting groups if both local and non-local hunters are involved in the harvest.

Link 2: An increase in the number of harvesting groups will increase the harvest and mortality of white whales.

Link 3: Inexperienced, non-local hunters will have less skill than local hunters, as well as incomplete or inappropriate equipment.

Link 4: Less skillful and effective hunters, in conjunction with incomplete or inappropriate equipment, will increase the ratio of lost to landed whales.

Link 5: An increase in the ratio of lost to landed whales will cause an increase in white whale mortality.

LINKAGES

Link 1: Competition will increase the number of, and alter the composition of the harvesting groups if both local and non-local hunters are involved in the harvest.

It was considered extremely unlikely that non-local wage earners would remain in the area to hunt white whales between work shifts. Available information suggests that, because of family ties and other obligations, non-local employees of the petroleum industry return to their home communities when not working. There is no reason to suspect this will change in the future.

In the event that some non-local individuals remain in the area to hunt white whales, the number of harvesting groups is unlikely to change. An increase in the number of harvesting groups would involve the moving of entire families to local communities within the Mackenzie Delta area or the whaling camps. Due to practical considerations (e.g., shortage of housing), this was also considered extremely unlikely.

Link 2: An increase in the number of harvesting groups will increase the harvest and mortality of white whales.

This link was considered self-evident and valid. Data collected during the white whale monitoring programs conducted in the Mackenzie Estuary (Fraker and Fraker 1979; Fraker and Fraker 1981) indicate that there is a high degree of correlation between landed catch and the number of hunters in camps.

Link 3: Inexperienced, non-local hunters will have less skill than local hunters, as well as incomplete or inappropriate equipment.

The skills and knowledge required to harvest any resource are acquired through experience and communication with experienced hunters. The sub-group agreed that harvesting of white whales in particular, requires extensive training and experience. Consequently, hunters from communities without a traditional whaling history will have less skill in the harvest of white whales. The group suggested that even hunters originally from the Mackenzie Delta region, who now live outside the area, will have lost some of the necessary skills due to the lack of recent experience.

There is no evidence to suggest that non-local hunters use their own equipment (i.e., boat and motor, harpoon, floats, hooks) to hunt white whales. This is probably due to the fact that it is impractical to transfer equipment to the Mackenzie Estuary and then transport the equipment and whale products back to the home communities. In addition, much of the equipment used for hunting white whales is specific to the harvest of this species, and the acquisition of the appropriate equipment would not only require knowledge of the hunting techniques, but also a sizeable investment.

An inexperienced non-local hunter may occasionally share equipment with an established local harvester. However, an experienced hunter is unlikely to lend all his gear to a novice hunter, because this would seriously interfere with his own hunting success.

The subgroup concluded that this link was valid.

Link 4: **Less skillful and effective hunters, in conjunction with incomplete or inappropriate equipment, will increase the ratio of lost to landed whales.**

In the Mackenzie Estuary struck whales are most often lost because (1) an inappropriate rifle calibre is used; (2) the whale is not harpooned before being shot (Fraker 1980); or (3) the whale sinks and the hunter has inappropriate equipment to retrieve the animal. On the basis of direct and indirect experience gained by several workshop participants, the subgroup suggested that the ratio of lost to landed whales is much lower when hunters are skilled and use the most appropriate equipment.

In recent years, over 80% of the white whales struck in the Mackenzie Estuary were successfully landed (Strong and Weaver, in prep.). In 1983-1984, the percentage of animals struck-and-lost was as low as 14% in some whaling camps (Strong and Weaver, in prep.). This ratio may have been as high as 50% in the past (Fraker 1980). Workshop participants attributed the recent improvement in hunting efficiency to increased hunter awareness, communication and education. With the involvement of the Department of Fisheries and Oceans, local hunters have attempted to improve the efficiency of the white whale harvest.

During the workshop, much of the discussion in relation to Link 4 focused on possible mitigative measures which could be undertaken to maintain the present harvest level (i.e., number of landed whales) and, at the same time, reduce the ratio of lost to landed animals. The subgroup suggested the following:

1. use of the most appropriate and effective equipment (properly maintained boat and motor, harpoons, hooks, floats and sinkers, and the proper calibre rifle);

2. securing of the whale by harpoon before it is shot, if and when practical; and

3. securing of one whale before another is pursued.

Implementing these measures requires the support and involvement of the hunting communities.

The establishment of a quota on the numbers of white whale harvested could only be envisaged if the maximum sustainable yield is achieved or exceeded. Existing evidence suggests that this is unlikely. In the past, the average number of whales landed in the Mackenzie Estuary was 121/year and the maximum number of whales harvested was 208 (Strong and Weaver in prep.). Population estimates for the Mackenzie stock of white whales have ranged from 2000 (Slaney 1973) to 11,500 (David and Evans 1982). Results of the 1984 offshore survey suggest that the population size is probably closer to 11,500 whales, and may even be as high as 17,500 (Norton and Harwood 1985). Using Sergeant's (1981) figure of 5% for the maximum sustainable yield for toothed whales and assuming a population size of 12,000 white whales, the Mackenzie population could sustain a harvest rate of approximately 600 animals/year. The present white whale harvest is substantially less than this. The group emphasized that the validity of this calculation is dependent on a reliable estimate of the population size and that the population size could change because of several factors unrelated to harvesting (e.g., industry activities or severe ice conditions; INAC and Environment Canada 1984, 1985).

Link 5: An increase in the ratio of lost to landed whales will cause an increase in white whale mortality

This link is considered valid and self-evident.

CONCLUSION

The working group concluded that it was unlikely that competition by non-local hunters will 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.

LITERATURE CITED

Davis, R.A. and C.R. Evans. 1982. Offshore distribution and numbers of white whales in the eastern Beaufort Sea and Amundsen Gulf, 1981. Unpubl. rept. by LGL Limited, Toronto, for Dome Petroleum Limited, Calgary, and Sohio Alaska Petroleum Company, Anchorage. 135 p.

Fraker, M.A. 1980. Status and harvest of the Mackenzie stock of white whales (Delphinapterus leucas). Rep. int. Whal. Comm. 30:451-458.

Fraker, M.A. and P.N. Fraker. 1979. The 1979 whale monitoring program, Mackenzie Estuary. Unpubl. rep. by LGL Limited, Sidney, B.C., for Esso Resources Canada Limited, Calgary. 51 p.

Fraker, P.N. and M.A. Fraker. 1981. The 1980 whale monitoring program, Mackenzie Estuary. Unpubl. rep. by LGL Limited, Sidney, B.C., for Esso Resources Canada Limited, Calgary. 98 p.

INAC (Indian and Northern Affairs Canada) and Environment Canada. 1984. Beaufort Environmental Monitoring Project 1983-1984 Final Report. Unpubl. rep. by LGL Limited, ESL Environmental Sciences Limited and ESSA Limited. 292 p.

INAC (Indian and Northern Affairs Canada) and Environment Canada. 1985. Beaufort Environmental Monitoring Project 1984-1985 Final Report. Unpubl. rep. by ESL Environmental Sciences Limited, LGL Limited, ESSA Limited, Arctic Laboratories Limited and Arctic Sciences Limited. 162 p.

Norton, P.N. and L.A. Harwood. 1985. White whale use of the southeastern Beaufort Sea, July - September 1984. Can. Tech. Rep. Fish. Aquat. Sci. No. 1401: v + 45 p.

Norton Fraker, P. and M.A. Fraker. 1982. The 1981 white whale monitoring program, Mackenzie Estuary. Unpubl. rep. by LGL Limited, Sidney, B.C., for Esso Resources Canada Limited, Dome Petroleum Limited and Gulf Canada Resources Inc., Calgary. 74 p.

Sergeant, D.E. 1981. On permissible exploitation rates of Monodontidae. Rep. int. Whal. Commn. 31: 583-588.

Slaney, F.F. and Company Ltd. 1973. White whale study. Herschel Island-Cape Dalhousie coastal region of the Beaufort Sea. Unpubl. rep. for Imperial Oil Limited, Calgary. 29 p.

HYPOTHESIS NO. 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

PARTICIPANTS

Tom Barry	Glen Sutherland
David Krutko	David Thomas
Peter McLaren	John Ward
Chris O'Brien	

INTRODUCTION

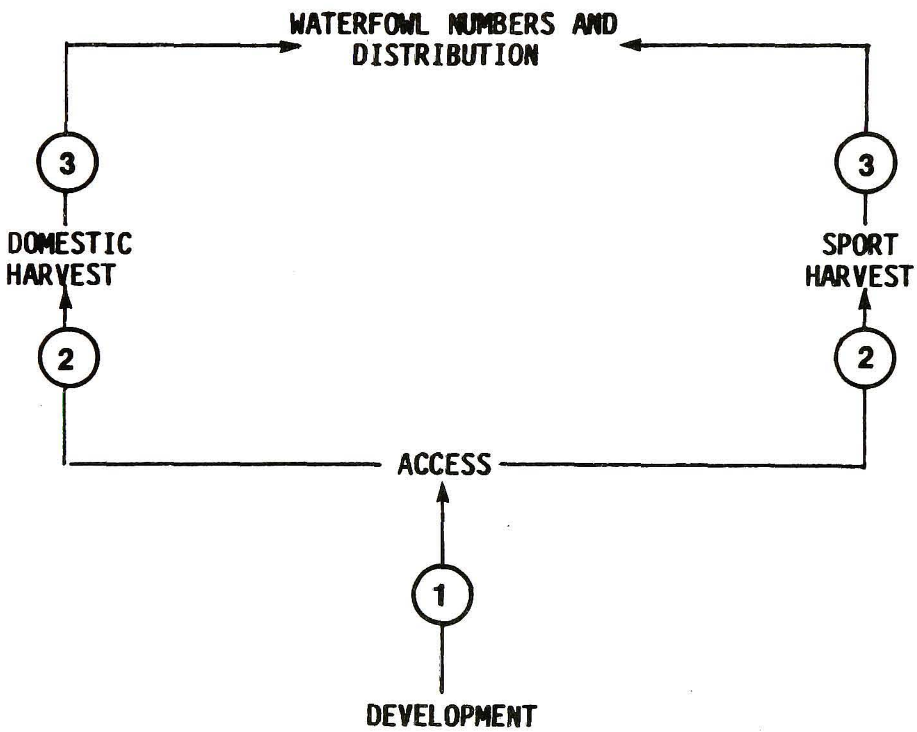
Waterfowl are an important source of food for the residents of communities within the MEMP study area. Geese and ducks are hunted in the spring when birds are moving north en route to their summering areas, and in the late summer and fall when birds are staging and gathering prior to southward migration. The species and number of waterfowl harvested depend on the location of communities. For example, residents of communities in the outer Mackenzie Delta region hunt primarily geese that congregate in the area, while residents of communities along the Mackenzie River hunt mostly ducks, especially in the fall, because geese usually fly directly to northern Alberta without stopping along the Mackenzie River.

At present, hunters travel to hunting areas primarily by snowmobiles, canoes, or power boats. All-terrain vehicles are also used regularly in some areas, and are becoming more popular (D. Krutko, T. Barry, pers. comms.). Currently, there are few roads in the region, and consequently, they do not constitute an important means of access for hunters.

The overall number of waterfowl harvested annually in the study area by domestic hunters is not known. However, it is believed to be only a small proportion of the total continental harvest and is not expected to have an impact on regional waterfowl production (T. Barry, pers. comm.). Available

FIGURE 21-1

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



LINKAGES

Link 1: Hydrocarbon development will result in increased or improved access to areas supporting waterfowl populations.

Link 2: Increased or improved access will increase the harvest of waterfowl.

Link 3: Increased harvest will lead to reductions in local populations of waterfowl.

data suggest that the annual harvest of waterfowl is relatively constant; it has not changed appreciably in the past 20 years (T. Barry, pers. comm.). Ongoing surveys of waterfowl production and breeding areas, conducted by the U.S. Fish and Wildlife Survey and the Canadian Wildlife Service in the Mackenzie Delta, have not shown a significant decline in the number of waterfowl over the past 30 years (Alliston 1984).

Concerns related to the potential effects of hydrocarbon development on waterfowl populations are that linear corridors (e.g., roads, seismic lines or aircraft landing sites) will improve or increase access to important waterfowl areas, which will result in an increase in harvest levels and a concomitant decrease in waterfowl populations. The hypothesis and the associated linkages are illustrated in Figure 21-1 and described in the following sections.

LINKAGES

Link 1: Hydrocarbon development will result in increased or improved access to areas supporting waterfowl populations.

The hydrocarbon development and production plan (Appendix A) indicates that several new right-of-ways will be constructed in the MEMP study area. Specifically, permanent access roads from wharves to production facilities and a right-of-way along a pipeline in the Mackenzie Valley are proposed. In addition, other major roads that may be established either by, or in response to development in the region include: an all-weather road from Inuvik to Tuktoyaktuk; a link between the Dempster Highway and the Yukon North Slope; and a road from a shore facility on the Yukon coast to an inland rock quarry (Dome et al. 1982). At the same time, seismic lines are presently being, and will continue to be constructed in areas of hydrocarbon exploration. Seismic lines may provide improved access to remote areas, at least in their first few years of existence when the vegetation has not yet regenerated. They may also provide limited and temporary waterfowl habitat as a result of ponding due to disturbance and subsequent melting of permafrost during clearing of seismic lines.

The presence of linear corridors such as roads and seismic lines is expected to increase access to previously remote areas. However, such areas do not necessary include important waterfowl habitat. Important waterfowl areas are typically low-lying areas where both adequate water and suitable food supplies are available. These areas have been traditionally, and are most easily reached by boat or snowmobile. Permanent all-season roads will likely be built in higher and drier sites, which are not extensively used by waterfowl. A highway between Inuvik and Tuktoyaktuk would pass through some swan and duck nesting habitat. These birds are widely dispersed nesters and, consequently, only a small portion of the population would be affected by this new access. However, this road would also pass through the Eskimo Lakes-Parsons Lake region, which is an area where large numbers of snow geese occur during spring and fall migration (A. Aviugana, pers. comm.). This road would thus provide greatly improved access to both snow geese and other waterfowl species in that area. Access to geese staging areas on the Yukon North Slope may be enhanced by an all-season road that would link this area to the Dempster Highway.

Roads that connect one form of industry development to another (e.g., wharves to production systems) would be privately operated and used primarily by industry personnel and, therefore, would be subject to company policy regarding use (J. Ward, pers. comm.). Helipads and airstrips constructed during development will also increase access to waterfowl areas. However, as with industry-built roads, such sites would be privately owned and generally off-limits to non-industry personnel. Moreover, because of the high cost of aircraft charter, it is probably not a desired form of transportation of most hunters.

The subgroup concluded that this link was valid. There will likely be an increase or improvement in access to remote areas as a result of hydrocarbon development, and this will increase exposure of waterfowl to hunters in those areas.

Link 2: Improved or increased access will increase the harvest of waterfowl.

As stated earlier, the domestic hunt occurs during both the spring and the late summer-fall when birds are healthy and fat and, therefore, are a desirable food source. At this time, most waterfowl occur in low-lying areas that provide an abundant food supply. These areas are accessible primarily by boat or snowmobile. New roads built in conjunction with hydrocarbon development are unlikely to be sited in these areas and, consequently, are not expected to result in an increase in access to the areas or in waterfowl harvest levels.

There was considerable discussion regarding the potential impact of two proposed roads. A road from Inuvik to Tuktoyaktuk would provide immediate access to an area of nesting waterfowl; however, nesting waterfowl are not a preferred food at this time of year due to their poor physical condition (T. Barry, pers. comm.) The group concluded that, even assuming a worst-case situation whereby nesting waterfowl are eliminated along the entire highway, only a relatively small number of nesting swans and ducks is likely to be harvested, due to the dispersed nature of these populations.

Of greater concern is the potential effect of the proposed Inuvik-Tuktoyaktuk road on the harvest of snow geese. Large numbers of geese are present in the proposed road corridor in the spring, constantly moving between areas around the Eskimo Lakes and the Mackenzie Delta. Similarly, large numbers of snow geese pass through the Eskimo Lakes-Parsons Lake area in late summer en route to staging areas in and west of the Mackenzie Delta (A. Aviugana, pers. comm.). This region is relatively inaccessible to hunters; however, the presence of an all-weather road would probably result in an increased harvest of geese from the area. Such an increase would most likely be in addition to the harvest in present hunting areas.

A road on the Yukon North Slope may provide increased access to snow geese that stage in this area prior to fall migration. However, there is considerable variation in both the timing and distribution of geese on the North Slope at this time of year (Koski 1975, 1977a,b). Their distribution is influenced by several factors including weather conditions, snow cover, and the quality and abundance of the food supply (Patterson 1974; Koski 1977a,b). Because of the high degree of mobility of geese and the often large temporal and spatial variation in their distribution, geese may or may not be present near such a road at a particular time. It was also considered unlikely that any domestic hunters would abandon traditional and dependable hunting areas near their homes for a more distant, unreliable hunting area. Moreover, hunting for waterfowl is often done in conjunction with other resource harvesting activities, such as muskrat trapping or char fishing. A hunting excursion to the North Slope would not provide the opportunity for such combined harvest activities.

The effect of increased access of sport hunters to waterfowl was also considered by the subgroup. Sport hunting in the Mackenzie Delta and Valley region occurs only in the late summer and autumn when most waterfowl are staging prior to their fall migration. Sport hunting presently constitutes only a small proportion of the total harvest from the study area (D. Krutko, T. Barry, pers. comms.). There are few facilities in the region that support or cater to recreational hunting (e.g., lodges, fly-in camps) although it is possible that such facilities will be established as development in the area proceeds. However, whether increased access resulting from hydrocarbon development will accelerate or initiate sport hunting is unknown.

The subgroup concluded that this link was theoretically valid. The most probable significant increase in harvest levels will be as a result of increased access by the proposed Inuvik-Tuktoyaktuk road. However, the present development plan (Appendix A) provides no indication that this road will be constructed by industry, and no commitment has been made by the government for such a project. Hence, on the basis of the present development plan, the subgroup concluded that significant increased harvest of waterfowl was unlikely to occur as a result of increased access.

Link 3: Increased harvest will lead to reductions in local populations of waterfowl.

Since an increase in waterfowl harvest levels was considered unlikely to occur as a result of hydrocarbon development, reductions in local waterfowl populations are not anticipated. However, it must be noted that future development plans change to include a road between Inuvik and Tuktoyaktuk, this hypothesis should be re-evaluated.

CONCLUSION

The subgroup concluded that although the hypothesis was valid, it was unlikely to occur given the present development plan. Moreover, it was suggested that if an increase in harvest levels of waterfowl was to occur, it would be difficult to detect or quantify, since long-term data on the number and species of waterfowl harvested for domestic use do not exist. Domestic harvesting presently accounts for the majority of birds harvested. Methods of access and the use of traditional hunting areas suggest that improved access to waterfowl areas as a result of industry development would only marginally increase the opportunity for improved harvests; such an increase in harvest levels would not likely be significant to local populations of waterfowl.

RESEARCH AND MONITORING

No monitoring or research programs were recommended. However, it is apparent that without quantitative baseline information concerning the numbers and species of birds presently harvested in the study area, any future changes cannot be documented. However, the majority of the subgroup agreed that a program to obtain such information is unjustified at the present time, since current harvest levels are not considered a major concern in relation to the number and distribution of waterfowl and since they are not expected to change significantly in response to hydrocarbon development.

LITERATURE CITED

Alliston, W.G. 1984. A monitoring study of the species, numbers, habitat use and productivity of waterfowl populations on two study areas in the wooded Mackenzie Delta, summer 1983. Rep. by LGL Limited, King City, Ontario, for B.C. Hydro, Vancouver, British Columbia.

Dome Petroleum Ltd., Esso Resources Ltd. and Gulf Canada Resources Ltd. 1982. Beaufort Sea-Mackenzie Delta environmental impact statement. 7 Vols. Calgary.

Koski, W.R. 1975. Study of the distribution and movement of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slope and Alaskan North Slope in August and September, 1974, including a comparison with similar data from 1973. Arctic Gas Biol. Rep. Ser. 30(1). 58 p.

Koski, W.R. 1977a. A study of the distribution and movements of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slope, and Alaskan North Slope in August and September, 1975. Arctic Gas Biol. Rep. Ser. 35(2). 54 p.

Koski, W.R. 1977b. A study of the distribution and movements of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slope and eastern Alaskan North Slope in August and September 1976. Rep. by LGL Ltd., Toronto, for Canadian Arctic Gas Study Ltd., Calgary, Alberta. 69 p.

Patterson, L.A. 1974. An assessment of the energetics of the North Slope to staging snow geese (*Chen caerulescens hyperborea*). Arctic Gas Biol. Rep. Ser. 27(4):1-67.

HYPOTHESIS NO. 22

INCREASED LEVELS OF WAGE EMPLOYMENT WILL CHANGE THE TOTAL ANNUAL HARVESTS OF RESOURCES BY COMMUNITIES IN THE REGION

PARTICIPANTS

Albert Adams	Ron Graf
Jim Allard	Maurice Mendo
Alex Aviugana	Heather Myers
Doug Bruchet	Jim Pierrot
Debbie DeLancey	Peter Usher
Albert Elias	Bob Wolfe
Bob Everitt	

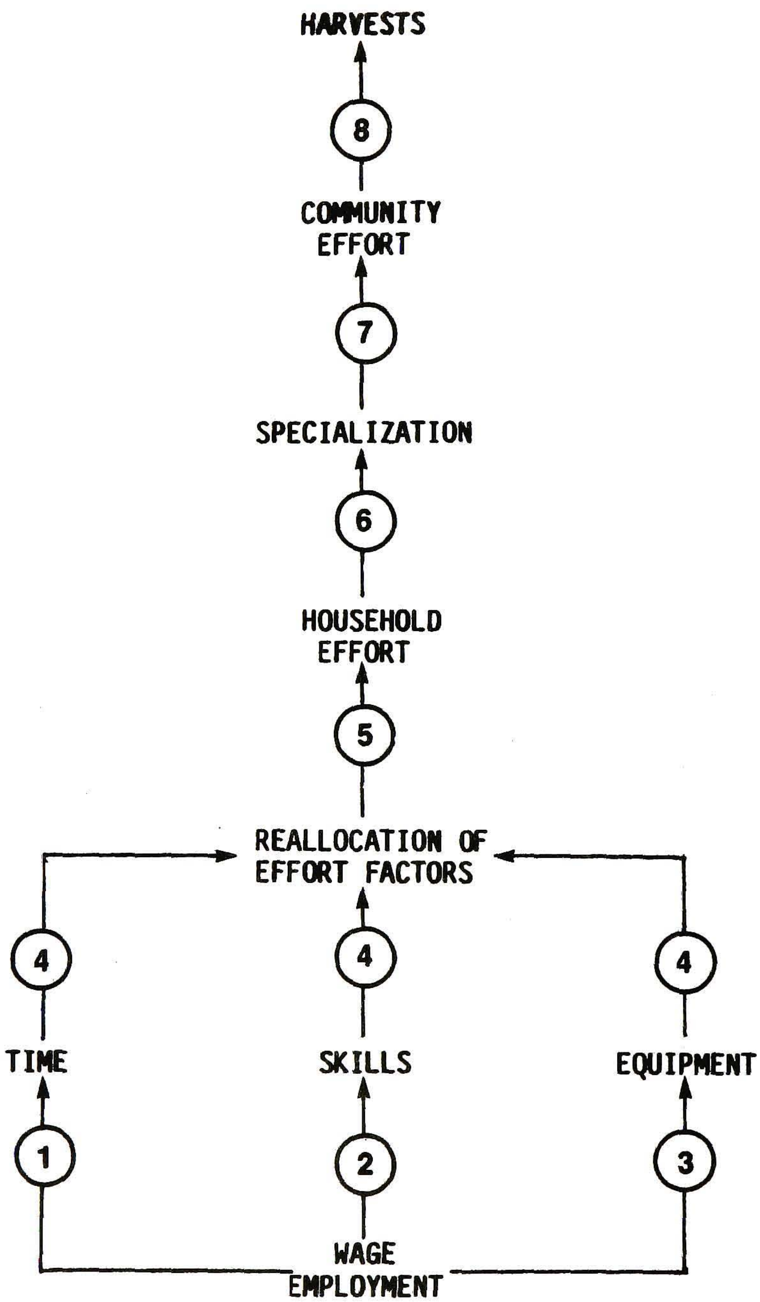
INTRODUCTION

Planned and proposed oil and gas developments in the study area will result in increased wage employment in the region. It is likely that the construction phase of major projects, such as pipelines or processing facilities, will result in short-term or seasonal employment of thousands of workers over a few years, while the operation and maintenance of these facilities, along with continued exploration, field development, and associated multiplier effects will result in seasonal and steady employment for hundreds of people over many years. Assuming no change in the prevailing government and industry policies of training and employing local residents, their opportunities for wage employment will increase significantly. Specific opportunities will range from seasonal, blue-collar work requiring little formal education to permanent, white-collar work requiring more extended formal education.

Although neither wage employment in general, nor oil and gas employment in particular, are new phenomena in the Canadian Beaufort Sea region, the following changes are expected as a consequence of the development plan under

FIGURE 22-1

Increased levels of wage employment will change the total annual harvests of resources by communities in the region



LINKAGES

Link 1: Wage employment reduces the time available for harvesting.

Link 2: Wage employment decreases or delays opportunities to learn harvesting skills.

Link 3: Income from wage employment enables expansion and improvement of the supply of harvesting equipment.

Link 4: The allocation of effort employed by both individual units of production and related sets of units will change.

Link 5: Total effort on the part of individual and/or related sets of producing units will change.

Link 6: Substitution and reallocation of effort factors will affect both the numbers of producing units in a community and their degree of specialization.

Link 7: Specialization among producing units results in a reallocation of effort and a change in the total community harvesting effort.

Link 8: The level of effort is positively related to the volume of harvest.

consideration:

1. an increase in the number of wage employment opportunities open to native residents at any particular time;

2. an increase in the duration of these opportunities in general (i.e., the maintenance of a steady employment rate as opposed to earlier boom-bust employment events);

3. an increase in the duration and a shift in the conditions of individual employment opportunities (i.e. from seasonal intermittent, blue-collar employment to permanent blue- or white-collar employment, partly as a consequence of the transition from exploration and construction to operations and maintenance); and

4. an increase in the time, training and commitment required of individuals in order to obtain employment, as a consequence of (3).

It is assumed here that a significant proportion of native people will continue to enter the higher paid semi-skilled and skilled occupations in the oil and gas industry itself, rather than the lower paid service sector jobs.

The effects of wage employment may be considered in two ways. When opportunities for wage employment are abundant and sustained over a long period of time, there may be a long-term transition from a social and economic system based primarily on harvesting, to one based on wage employment. In that case, wage employment may be seen as simply an aspect of a more comprehensive shift to an industrialized society. On the other hand, wage employment can be viewed as having more immediate and short-term effects on individual and household decision-making. This discussion focuses on the latter situation and concentrates on the implications of incorporating wage employment into households and communities which continue to be committed to harvesting.

Significant research on the effects of wage employment and rising cash income on harvesting has been reported by Kleinfeld (1981), Kruse et al.

Association (1979), Hobart, Walsh and Assoc. (1980), Hobart (1981, 1982), Wenzel (1983) (for Coppermine and North Baffin). Key findings are that, in the short-term at least, rising wage employment and income are associated with rising harvest levels, and that participation in wage employment is not inversely associated with participation in harvesting. These results are generally attributed to the fact that wage income is a critical source of cash for improving the stock of equipment available for harvesting.

LINKAGES

Link 1: Wage employment reduces the time available for harvesting.

The reduction of time available for harvesting does not necessarily mean that people actually spend less time harvesting, because there is substantial 'spare' time. In other words, the time required for harvesting is not so great that every day spent in wage employment represents an equivalent day lost to harvesting (Usher 1971, 1972, Sahlins 1972).

Time-saving technological changes in the harvesting process (see below) and the recent growth and diversification of the communities themselves have reduced the overall harvest-related time demands on household producing groups. The availability of a wider array of imported products and commercial, financial, municipal and other services has substantially reduced the time required for general livelihood and harvesting support activities, such as trading trips, provision of heat, light and shelter, sewing and equipment manufacture and repair (D. DeLancey, pers. comm.). For example the shift to snowmobiles as the basis of transport has eliminated the time required to feed and care for dog teams, except in bush communities where they have been retained (A. Adams, J. Allard, pers. comms.).

The time allocation problem is thus not one of ensuring that a minimum number of days per year is available for harvesting, but of ensuring that the right time (in the sense of the most productive time) is available for harvesting. In many cases these times are predictable (e.g., for whaling, goose hunting, fish runs, etc.).

For the above reasons, the subgroup concluded that this link was not valid.

Link 2: Wage employment decreases or delays opportunities to learn harvesting skills.

Skills are changing as technology develops so that, as certain traditional skills are lost, the new ones required for contemporary hunting methods are gained. The criterion for determining if the required skills are being learned is whether people are able to harvest what they need. As a rule, people do get an adequate harvest, although sometimes novices are less efficient and take more time, use more gas and ammunition, are harder on equipment and fail to retrieve a greater proportion of their kills than experienced harvesters. This is considered to be part of a normal learning process and it is expected that these novices will become more efficient over time. The transmission of skills to young people is a problem at times but one which can usually be solved at the community level using traditional methods (J. Pierrot, pers. comm.). The loss of other aspects of native culture, such as language, can be viewed as an indication that the transmission of skills in the community is not entirely successful. Certain disruptive effects of the wage employment of young males on the household unit (Asch 1977; Usher 1982), though real, may be only temporary and without lasting direct consequences for the majority of households. This does not, however, preclude long-term, cumulative effects on the social system as a whole, associated with the general impact of development.

There may be some sex differences in the impact of development on traditional skills. Current rates of male recruitment in communities in the Mackenzie Valley and Beaufort region appear to be adequate to sustain harvesting. There is some concern, however, that there is already a noticeable loss of female skills. The decline in the ability and inclination to tan moosehides is an example and is clearly illustrated by the rising price of home-tanned moosehide despite the continued abundance of raw moosehide. There has been no documentation of variation in employment trends by sex within the MEMP region, however the trends documented recently in Alaska (Kleinfeld 1981; Kleinfeld et al. 1983) should apply.

Where more experienced harvesters within the household are otherwise employed and cannot teach younger members how to harvest, qualified harvesters from other households will teach them. This situation is no different from earlier times when young men lost their primary instructor through death, separation, or other changes in household composition. Those who wish to learn will generally do so, although possibly later in life (due to school requirements more than wage employment) than formerly.

Link 3: Income from wage employment enables expansion and improvement of the supply of harvesting equipment.

Cash income from harvesting activities is normally insufficient to cover the costs of harvesting. Income from other sources, such as wage employment, is therefore essential to permit even a minimum level of participation in harvesting. Beyond this minimum, the harvester (or household producing group) has the discretion of investing in better equipment (producer goods) vis a vis consumer goods.

Investment in new forms of capital and operating equipment will occur if either of two advantages are gained:

1. greater speed or hauling capability during travel or search time; or

2. greater effectiveness in killing and retrieval (increased catch per unit of effort).

In fact, most recent innovations (e.g., snowmobiles, larger boats and motors) have had the first effect rather than the second, and the bulk of current harvesting expenditures are now directed to maintaining and operating the stock of those innovations.

Assuming the self-limiting nature of the harvest (see conclusions), people have used speed to reach the most productive harvesting areas, harvest what they need, and return quickly, rather than increasing production. The effect of these innovations has been to reduce the time required for harvesting and to enlarge the geographic extent of community harvesting areas, mainly by enabling traditional harvesting territories to be exploited effectively from one community base instead of from numerous scattered and semi-permanent encampments (Freeman 1976). The preference for saving time over increasing production has been shown to be true even with commercial resources such as furs (Usher 1972).

Speed and capacity have advantages for purposes other than harvesting, however, such as intercommunity travel. Consequently investment in larger vehicles and engines cannot be entirely attributed as a cost of harvesting. For example, snowmobiles are of limited use for trapping and hunting in soft snow in the bush. Nonetheless people buy snowmobiles for travelling on established trails between communities, and may use them incidentally for harvesting (A. Adams, J. Allard, pers. comms.). This suggests that the accurate measurement of harvesting effort is a complex problem requiring further refinement (INAC 1985).

Link 4: The allocation of effort factors employed by both individual units of production and related sets of units will change.

Harvesting as an economic activity is organized primarily on a household basis. The basic unit of production thus consists of several persons (normally related) whose functions are determined largely according to sex, age, and experience. These functions include the harvesting, processing, marketing and distribution of animals and fish and other domestically used renewable resources, as well as providing cash or other services in aid of those functions. The household endures for many years, with membership fluctuating chiefly on the basis of birth, death, and marriage, as well as other social means of entry and exit.

Any particular harvesting task may be performed by an individual or a group. The harvesting group composition may vary from one type of harvesting activity to another and even from one occasion to the next. Examples include trapping partnerships, whaling crews, hunting parties. These groups may consist entirely of members of a single producing unit, or they may consist of members of two or more such groups, who temporarily or habitually ally themselves (generally on the basis of kinship) for the specific tasks in question.

The amount of labour that the various members of a producing group (or household) can devote to harvesting and processing will vary depending on who assumes wage employment, under what conditions, and for how long. This link refers specifically to short-term changes in composition (i.e., from month to month or season to season) in response to alternative activity.

Link 5: Total effort on the part of individual and/or related sets of producing units will change because of substitution and reallocation.

While wage employment may alter one or more of the factors of effort, the most prevalent response to wage employment is the reallocation of harvesting time and equipment to ensure that the household puts in the desired level of effort. This is accomplished by:

1. The selection of types of employment that allow adequate time for harvesting, such as seasonal blue-collar work (Kruse et al. 1981, 1982), rotational employment (Hobart 1981, 1982) or steady jobs within the home community.

2. The substitution of capital for labour, by purchasing capital equipment and operating supplies that make harvesting more efficient. The gain is a reduction of the time required for a given amount of harvesting effort.

3. The assumption of the former role of the wage earner by other family members, specifically in hunting for certain key food species such as caribou or moose.

4. Entering into arrangements with members of other households (often kin-related) to harvest on specific occasions. An example would be where one individual provides gas and ammunition to another, on the assumption that the harvest will be shared.

The conclusion of the subgroup was therefore that this link was not valid.

Link 6: Substitution and reallocation of effort will affect both the numbers of producing units in a community and their degree of specialization.

Flexibility in allocating factors of production among and within producing units suggests that, in any community, there is likely to be significant temporal variation (from season to season and year to year), in which the number of producing units actually engaged in harvesting may fluctuate. Alternative opportunities for generating income and increasing productivity of individual producing units mean that it is no longer necessary for all households in a community to participate fully in harvesting.

One of the effects of increasing wage employment is to reduce the harvesting effort of some households in any community tomarginal rates. This occurs in those households where all potential harvesters participate in wage employment to such an extent, whether by choice or necessity, that they no longer have time to engage in harvesting on other than the most casual basis (e.g., an annual goose hunt). There are other more general effects of industrial development that reduce harvesting participation on the part of some households. These include:

1. the formation of new households in which the male head has no desire or ability to harvest (this does not preclude the possibility that he might subsequently develop both);

2. the increasing incidence of households headed by females with young children, who even if capable of harvesting cannot afford the time and equipment; and

3. the impoverishment of some households through periodic down-turns in employment and income, with the result that they cannot sustain a cash-dependent mode of harvesting. [This is a consequence not of wage employment itself, but of the loss of wage employment once dependent on it. For some effects of impoverishment on harvesting, see Wolfe et al. (1984).] Over-capitalization and the inability to repay debt may aggravate this situation (INAC 1985).

It is also possible, however, for increasing wage employment to increase the number of producing units in any community. This is especially so for those forms of harvesting requiring significant capital investment. The effects of wage employment, especially where wage rates are high, is to enable a producing group to capitalize itself earlier in its cycle of development, so that the total number of units capable of participation at any one time is increased (R.J. Wolfe, pers. comm.).

The factors leading to a reduction in the number of harvesting households in the study region are thought to outweigh those leading to an increase. One indication of this would be an increasing variation in household production levels, not only by species (which is not a new phenomenon - D. DeLancey, pers. comm.), but also by total volume of food production. It is suspected that this is the case, although there are insufficient harvest survey results in he region to confirm it. There is some evidence, however, that this trend is emerging in the N.W.T. generally (Usher et al. 1985).

Link 7: Specialization among producing units results in a reallocation of effort and changes the total community harvesting effort.

Fluidity in the formation and composition of producing units and flexiblity in the allocation of factors of production suggest that a reduction in the number of producing or harvesting groups does not necessarily imply a reduction in the total community harvesting effort. Although not supported by adequate data or formal testing in the study region, it appears that:

1. Specialization to date has been largely a matter of personal or household choice and the outcome of processes generally viewed as acceptable at the community level;

2. Total community levels of harvesting effort have not been significantly altered by these developments; and

3. The traditional ethic of sharing and mutual aid ensures a reasonable distribution of country food to all households, so that there is not a significant class of people in the community whose welfare is decreased by the trend toward specialization.

If all of the above are true, then a reduction in participation rates due to specialization is not of itself a matter of concern. Harvesting is not jeopardized since neither the volume of community harvests nor the value of the harvesting activity to the community is affected. Link seven is therefore considered not valid.

Link 8: The level of effort is positively related to the volume of harvest.

This link was considered self-evident although some features of it require explanation. First, harvest refers to the numbers of animals retrieved.Consequently, the same amount of measurable physical effort (time x gear) expended with less skill may result in a lower harvest due to lower retrieval rates. This is especially significant in marine mammal hunting, but is also applicable in principle to most other species. Second, if effort can be reduced to a common measure for all types of harvesting, some types may be intrinsically more efficient than others. Thus by changing the mix of species harvested, increased harvest volumes could result without any corresponding change in effort. In principle, however, if all effort factors including skills could be objectively and consistently enumerated, Link 8 is valid as stated.

CONCLUSIONS

The hypothesis is not considered valid as long as the following conditions pertain:

1. Wage employment is flexible, especially with respect to timing, location and duration;

2. Income is sufficient to enable appropriate levels of capitalization for harvesting. In principle, this income need not come exclusively from wage employment in industry, although recently that has been its primary source. In the case of wage employment, however, this means that wage rates must be high enough to enable capitalization without the necessity of prolonged absence from the home community or of excessive overtime;

3. The system of mutual aid and sharing within each community continues to ensure effective substitution of labour and capital within and among units of production; and

4. Adequate levels and distributions of the appropriate skills are maintained within the general pool of labour and are reasonably accessible to the number of producing units that need them.

Several additional assumptions and factors which are essential to the validity of the hypothesis are discussed below.

1. For those producing units that continue to harvest at more than casual levels, there is a primary orientation to harvesting. Cash income from wage labour (among other things) is treated as a means to an end, the end being the maintenance of harvesting. The hypothesis is therefore invalid for communities in which harvesting continues to be a dominant social and economic activity.

   Since trapping is a cash-producing activity, in contrast to hunting and fishing, it is more likely to be discontinued than non cash-producing activities such as hunting and fishing when immediate wage employment opportunities are more advantageous. Nonetheless, certain limited forms of trapping may continue to be compatible with wage employment, such as running shorter day or weekend lines, or concentrating effort during the peak periods of late fall and early winter, instead of spreading it out over the entire season. Hunting and fishing for domestic needs, however, was generally considered insensitive to wage employment, at least in the short term. People will hunt for what they need regardless of the local employment situation, so long as the flexibility already described continues to function.

2. There are two factors regarding the question of 'needs' and the extent to which the domestic harvest is self-limiting. First, there are long-standing rules and traditions that, in effect, limit effort. People do not harvest everything in sight simply because

they are technically capable of doing so. Second, hunters do not restrict the concept of needs to their immediate family or household, especially for meat, but include community requirements as a whole. If they are aware that other people in their camp, extended family or community need meat, they will continue to hunt, up to their ability to retrieve the harvest. The self-limiting factor is thus based on community rather than individual requirements, and hence presupposes the availability of reliable information on what those collective needs are.

It is unclear whether people would harvest more meat and fish if they were more abundant or accessible. This likely depends in part on current levels of harvest. In some communities, people already harvest very high per capita levels and might not be able to use much more. In others, there may be a greater reliance on groceries due to shortages of country food. Annual per capita harvests in the N.W.T. have ranged from about 160 to 320 kg in recent years (and even higher in some Inuit communities relying primarily on marine mammals), substantially above the national average consumption rate of meat and fish. However, in some Alaskan communities, especially those whose harvesting areas are heavily used by non-residents, per capita harvests are much lower (Wolfe 1985). Harvest levels in most (but not all) communities in the study area are considered adequate (Dome Petroleum et al. 1982; INAC 1985).

RESEARCH AND MONITORING

The key indicators were identified as wage employment, effort, harvests, and mutual aid. The specific requirements for each are outlined below.

Wage employment

Data are needed on labour force participation rates by age, sex, occupation, industry, hours per week, duration of employment, flexibility of work time, location of employment, and wage rates (as an indication of purchasing power and hence effort) (BRIA 1979; Kruse et al. 1981; Kleinfeld et al. 1983). An appropriate data base would require the use and possibly modification of existing record keeping systems, as well as the compilation of periodic survey data. Compilation and interpretation of literature and existing data sources are required to establish a baseline. Development of standard parameters is recommended.

Effort

Effort should be monitored on a case study basis. Periodic gear censuses and cost surveys (Usher 1971, 1972, 1982; Muller-Wille 1978) should be combined with occasional, more detailed analyses of labour inputs and skills levels. Some refinement and standardization of basic methods developed by Usher (1971, 1973), Muller-Wille (1978), Resolute Bay HTA and Arctic Pilot Project (1983), and Bone and Green (1985) is required.

Harvests

Harvests should be monitored by species and by community. Annual community totals are sufficient for testing this hypothesis. Harvest surveys similar to the type under way in the eastern and central Arctic would provide an adequate data base. For historical depth and to establish a baseline of natural variability, harvest data should be reconstructed from existing data bases in a form amenable to linking with future survey data, covering at a minimum the ten-year period prior to the start up of regional comprehensive surveys (Usher et al. 1985).

Mutual aid, cooperation and sharing

Monitoring should focus on the viability and strength of family, household, kinship and alliance systems within communities though which mutual aid, sharing of equipment, distribution of produce and transmission of knowledge, skills and values are effected. This requires periodic case studies based on anthropological research methods (participant observation, informal extended interviews). Some baseline research is essential since no current literature exists for the region. Wolfe et al. (1984) provide a sound example of research design and execution.

LITERATURE CITED

Asch, M. 1977. The Dene economy. Pages 47-61. In: M. Watkins (ed.). Dene Nation - the colony within. University of Toronto Press, Toronto.

BRIA. 1979. Socio-Economic impacts of the Nanisivik Mine on North Baffin Region communities. Rep. prep. by Baffin Region Inuit Association for Nanisivik Mines Ltd., Govt. of N.W.T. and Govt. of Canada.

Bone, M. and D. Green. 1985. Analysis of responses to the questionnaire on economic and social behaviour of hunters. Rep. prep. by Signe Research Associates Ltd. for the Northern Economic Planning Directorate, Dep. Indian Affairs & Northern Development.

Dome Petroleum Ltd., Esso Resources Canada Ltd., and Gulf Canada Resources Inc. 1982. Environmental impact statement for hydrocarbon development in the Beaufort Sea-Mackenzie Delta region. Vol. 5 - Socio-economic effects.

Freeman, M.M.R. (ed.). 1976. Inuit land use and occupancy project. 3 vols. Dep. Indian Affairs & Northern Development, Ottawa.

Hobart, C.W. 1981. Impacts of industrial employment on hunting and trapping among Canadian Inuit. Pages 202-218. In: M.M.R. Freeman (ed.). Proc. 1st Int. Symp. Renewable Resources and the Economy of the North. Ass. Can. Univ. Northern Studies, Ottawa.

Hobart, C.W. 1982. Industrial employment of rural indigenes: The case of Canada. Human Organization 41: 54-63.

Hobart, Walsh and Associates. 1980. Rotational employment of Coppermine Inuit men: effects and community perspectives. Environ.-Social Prog. Dep. Indian Affairs and Northern Development, Ottawa. Rep. A1-36.

INAC. 1985. Northern consumers, socio-economic change, and access to traditional food resources. Canada Dep. Indian Affairs and Northern Development, Economic Strategy Division. Ottawa.

Kleinfeld, J. 1981. Different paths of Inupiat men and women in the wage economy. Alaska Review of Social and Economic Conditions 18: 1-28.

Kleinfeld, J., J. Kruse and R. Travis. 1983. Inupiat participation in the wage economy: effects of culturally adapted jobs. Arctic Anthropology 20: 1-21.

Kruse, J.A. 1982. Subsistence and the North Slope Inupiat: the effects of energy development. Man in the Arctic Program, Monograph No. 4. Institute of Social and Economic Research, Univ. Alaska, Anchorage.

Kruse, J.A., J. Kleinfeld and R. Travis. 1982. Energy development on Alaska's North Slope: effects on the Inupiat population. Human Organization 41: 97-106.

Kruse, J.A., J. Kleinfeld, R. Travis and L. Leask. 1981. Energy development and the North Slope Inupiat: a quantitative analysis of social and economic change. Institute of Social and Economic Research, Univ. Alaska, Fairbanks.

Kupfer, G. and C.W. Hobart. 1978. Impact of oil exploration work on an Inuit community. Arctic Anthropology 15: 58-67.

Muller-Wille, L. 1978. Cost analysis of modern hunting among the Inuit of the Canadian Central Arctic. Polar Geography 2: 100-114.

Resolute Bay HTA (Hunters and Trappers Association) and Arctic Pilot Project. 1983. Resolute Bay resource harvest study. 1981.

Sahlins, M. 1972. Stone age economics. Aldine, Chicago.

Usher, P.J. 1971. The Bankslanders: economy and ecology of a frontier trapping community. Vol. 2 - economy and ecology. Northern Sci. Res. Group, Dep. Indian Affairs and Northern Development, Ottawa. NSRG-71-2.

Usher, P.J. 1972. The use of snowmobiles for trapping on Banks Island. Arctic 25: 171-181.

Usher, P.J. 1973. Preliminary report on the apparent impact of seismic exploration on arctic fox trapping on Banks Island, N.W.T. Unpubl. rep., Northern Sci. Res. Group. Dep. Indian Affairs and Northern Development, Ottawa.

Usher, P.J. 1982. Assessing the impact of industry in the Beaufort Sea Region. Rep. prep. for the Beaufort Sea Alliance. Ottawa.

Usher, P.J., D. DeLancey, G. Wenzel, M. Smith and P. White. 1985. An evaluation of native harvest survey methodologies in northern Canada. Environmental Studies Revolving Funds, Rep. No. 004.

Wenzel, G. 1983. The integration of remote site labor into the Inuit economy of Clyde River, N.W.T. Arctic Anthropology 20: 79-92.

Wolfe, R.J. 1985. Impacts of economic development on subsistence productivity: western region and Copper Basin cases. Paper prep. for Alaska Anthropological Association Meetings, Anchorage, Alaska.

Wolfe, R.J., J.J. Gross, S.J. Langdon et al. 1984. Subsistence-based economies in coastal communities of southwest Alaska. Division of Subsistence, Alaska Dep. Fish & Game, Juneau, Tech. Pap. No. 89.

HYPOTHESIS NO. 23

CHANGES IN ACCESS WILL AFFECT THE HARVEST OF BIRDS, FISH AND MAMMALS

PARTICIPANTS

Albert Adams	Ron Graf
Jim Allard	Maurice Mendo
Lorraine Allison	Heather Myers
Alex Aviugana	Jim Pierrot
Robert Everitt	Aaron Sekerak

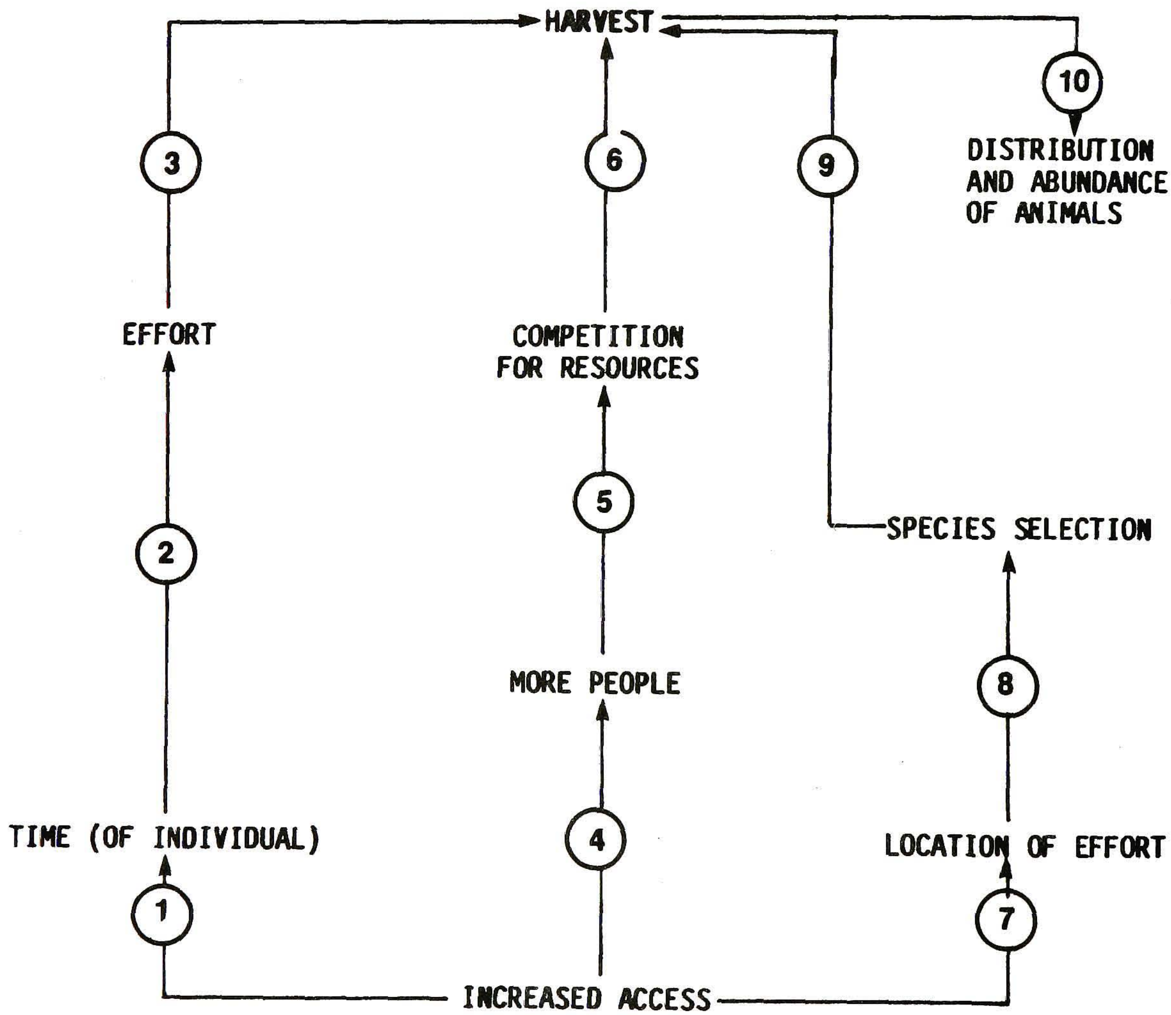
INTRODUCTION

Several oil industry activities result in increased on-land access that can be used by people travelling to hunting, fishing, and trapping areas. Seismic operations in forested areas increase access to an area during or, more usually, after the construction year. Such access is useful only for snow-machine or dog-team travel during winter months. Winter roads provide access for pickup trucks during a similar period of the year. All-weather roads provide access year long, and are usable only by trucks and cars. Ditches along roads are unsuitable for travel by snow machine (A. Aviugana, pers. comm.). Effects of development on the use of boats and aircraft for travel was mentioned but not considered by the group. The possibility of industrial activities disrupting or decreasing access to areas used for renewable resource harvesting was not discussed since it forms part of Hypothesis 23.

The influence of increased access on harvest of big game animals in southern regions is well documented. New road access into an area generally results in increased harvest effort, increased numbers of animals killed, and possibly reduced game populations (Phelps et al. 1983). The situation in the north is not the same because of the high proportion of harvests taken by native hunters and the relatively small recreational harvest.

FIGURE 23-1

Changes in access will affect the harvest of birds, fish and mammals



LINKAGES

Link 1: Changes in access will decrease the time spent in harvesting activities by an individual harvester.

Link 2: Decreases in travel time will affect the level of effort or catch per unit of effort.

Link 3: Changes in the level of effort will change harvests.

Link 4: Increased access to an area results in increased use of the area.

Link 5: An increase in the number of people using an area for hunting and trapping will result in competition among them for limited resources.

Link 6: Competition for resources will affect harvests.

Link 7: Increased access changes the locations at which harvesting effort is applied.

Link 8: Changes in the location of effort may result in changes in the species harvested.

Link 9: Changes in species selection will influence harvests.

Link 10: Harvest changes as a result of increased access may affect the distribution and abundance of animals locally or regionally.

It was suggested that the prevailing interest of the group members in large game, specifically caribou, resulted in an undue emphasis being placed on that species. Other species such as fish, migratory birds and furbearers were considered to be less affected than the large game animals by the anticipated change in conditions. However, lack of time prevented several species or groups of species from being fully considered.

LINKAGES

Link 1: Changes in access will decrease the time spent in harvesting activities by an individual harvester.

Discussion of travel time and access centred around big game hunting and trapping. Responses of hunters and trappers to improvements in access are dependent upon that access being near areas in which hunted or trapped species are found. Hunting effort will be directed at areas where the chances of success are considered highest, and the most effective means will be used for reaching the area. Roads will be used for travel if they result in a decrease in time or distance travelled or an increase in ease of travel. For instance, if it is faster or easier to reach a desired location on a seismic line, it will be used in preference to alternative trails that are more direct. Use of roads can result in less time spent travelling per trip, but community members of the subgroup did not considered time savings of up to half a day to be important enough to influence major hunting and trapping decisions.

Travel on winter and permanent roads for non-harvesting purposes, such as community visits, will be used for opportunistic hunting and effectively increase the amount of time spent in harvesting activities.

Link 2: Decreases in travel time will affect the level of effort or catch per unit of effort.

For hunts of fixed duration, if less time is spent travelling, then more time will be available for hunting. If length of time is not a factor in the hunt, then decreases in travel time may have no effect on level of effort. If the harvest is based on a target number of animals related to need of the individual or the community, decreased travel time may not affect the level of effort.

Having more time to spend at the designated location is more important for part-time hunters than it is for full-time harvesters. Improved access may enable part-time hunters and trappers to travel to harvesting areas further from their home communities than they otherwise would.

Travel time does not appear to have a major effect on the level of effort for hunting, trapping, or other harvesting activities. It could become important if success rates were improved to the extent that the harvesters' requirements could be fulfilled by fewer trips of longer distance.

Link 3: Changes in the level of effort will change harvests.

The level of effort obviously affects harvests; however, it was thought that the influence of decreased travel time resulting from improved access (Link 1) would be limited and not significant for the following reasons:

1. the amount of travel time saved (and thus change in the level of effort) because of improved access would be relatively small in most cases; and

2. many hunts end when the target harvest level is reached.

Hunters who have jobs and must hunt in their time off may find their ability to harvest improved with increased access. Whether that will change the overall community harvest or not is unknown.

Trapping, waterfowl hunting, and fishing were not specifically discussed in relation to travel time, level of effort and harvest. Links 1, 2 and 3 were not thought to be significant for those harvests.

Link 4: Increased access to an area results in increased use of the area.

Improved ease of travel to distant areas will result in an increase in the number of people using the area for renewable resource harvesting activities. This may be due to either an internal shift in areas used by a community within its normal harvesting region or an addition of people from outside the community (see Hypothesis 25).

In some parts of the Northwest Territories it is possible to reach wintering herds of caribou by driving along winter roads such as the Colville Lake Road and the Gordon Lake Road (R. Graf, J. Allard, pers. comms.) or along permanent roads such as the Dempster Highway. In such cases, caribou may be taken by native hunters from distant communities including those who would not normally use the area or hunt that particular herd.

People will travel long distances for the chance to hunt barren-ground caribou. However, travel cost and distance will be factors in each individual's decision whether to hunt a given area (A. Aviugana, pers. comm.). Costs will also be weighed against the need for caribou and the availability of alternative food sources closer to home.

Improvements in access within a community's normal harvesting area will allow people to travel to more distant resources. This may result in people moving to new hunting areas as they become more accessible or using the new areas in addition to their normal ones.

Shifts in harvesting locations may or may not be permanent. In the long term, local distributions of hunted species may change as animals learn to avoid well-travelled roads, particularly permanent roads. Opportunistic hunting along roads will prevent the distributions of hunted species from returning to pre-access conditions.

Link 5: An increase in the number of people using an area for hunting and trapping will result in competition among them for limited resources.

Wildlife populations are a limited resource. If too many people try to use that resource in any one area, competition will occur either within the community or between the community and other users. If the kill exceeds the substaitial harvest, the population will decline. Until then, the effects of such competition will be felt mainly by the harvester.

One type of competition involves the 'trespass' upon a full-time trapper's area by other people who are also trapping or shooting fur species. Traplines are protected by custom rather than by law. The knowledge that a newly accessible area is a productive trapline can lead to trespass and result in a trapper's management plans for the area being subverted. For example, it is a common management practice among trappers to use an area for one or two years then rest it to allow the animal populations to recover. In locations that are too readily accessible, someone else may move in during the 'rest' years (A. Adam, pers. comm.).

Caribou hunting is a special situation in which regional changes can occur from year to year without inducing competition within or between communities. The movements of caribou as they near a hunting area are monitored by local people. The hunt focuses on the most accessible animals and the location of the hunt will change from year to year in response to movement of the caribou on the winter range. Large shifts in hunting locations will have small effects on caribou populations, providing that the total number of animals taken remains manageable. Recognition of the special nature of the caribou populations seems to be implicit in arrangements within and among communities for caribou harvests. If caribou fail to reach a community that normally harvests the herd, arrangements are usually made, without conflict, for the community to receive part of the harvest from other communities. It is now known whether road access to wintering caribou results in an increase in the number of caribou harvested. However, it seems probable that increased road access to winter ranges will result in a larger harvest, because pickup trucks are cheaper to run than aircraft and faster than snow machines.

Species other than caribou are distributed in a less concentrated manner, and are usually accessible to the native harvester over a longer period of time. However, although not specifically access related, competition between native harvesters and sports fishermen is considered to be a cause of problems with the native fishery in Fort Franklin (J. Allard, pers. comm.).

Community representatives did not consider either the potential overlap of native communities harvesting areas or conflicts with immigrants over wildlife resources to be insurmountable problems. It is believed that they will be dealt with in constitutional agreements for splitting the territories or in land claims settlements. Other solutions were proposed in Hypothesis 24. Informal arrangements now exist in some communities for dealing with small numbers of immigrants. It is possible that conflict with immigrants could become a problem in the future when larger numbers of people are involved.

Link 6: Competition for resources will affect harvests.

If there is an increase in the number of people harvesting a resource from a specific area, one of the following situations will occur:

1. there may be no change in the total harvest removed from the area because each person takes a smaller share;

2. there may be an increase in the total harvest without conflict among harvesters because the population is now under-harvested; and

3. the harvest may increase with resulting conflict among resource users because the resource is in short supply.

There are few situations in which competition will result in a decreased harvest.

Link 7: Increased access changes the locations at which harvesting effort is applied.

New roads will be used by hunters and trappers for travel, but will not alter the full-time harvester's use of preferred areas in the long term, as long as those areas are not invaded by other people using new roads. Harvesters will go where the animals are; if roads make animals easier to hunt, they will be used. Noise caused by traffic on roads and new seismic lines will displace game; therefore, harvesters usually hunt away from the major travel routes.

Part-time harvesters may use roads to travel to more distant areas, and may shift their effort to areas more readily reached by road. Heavy snow can force animals to travel along plowed roads or snowmobile tracks, and therefore increase the potential harvest. Although both hunting and angling occur in locations away from travel routes (Dimintrov and Weinstein 1984), they are concentrated in roadside locations. Increased recreational harvesting has occurred along roads outside of the MEMP area including the Gordon Lake Road (R. Graf, pers. comm.) the Colville Lake Road (J. Allard, pers. comm.), the fishing access at Mosquito Creek, and at various other roadside muskrat and duck hunting locations (H. Myers, R. Graf, pers. comms.). People from as far away as Fort Smith travel to the Gordon Lake road to harvest caribou.

Seismic lines make travel easier (except in deep snow years) and will be used for travel even if the distance traversed is considerably longer than the direct route. Seismic lines one year old or more are used for tracking of game animals; older lines will be used for trapping when they traverse appropriate habitat.

Limited studies have been conducted on the extent to which new access shifts the land use of an individual or a community (Dimitrov and Weinstein 1984). The extent to which locations of harvests are shifted is not known.

Link 8: Changes in the location of effort may result in changes in the species harvested.

This link suggests that, if access affects the relative ease of harvesting a particular kind of animal, or if a shift in harvesting areas affects the species available (for example a move from moose habitat to caribou habitat), a shift in species taken may occur. When caribou were near the town of Fort Good Hope, a heavy harvest of caribou was taken and moose were hunted only lightly. In a year when moose were plentiful and easily harvested, relatively large numbers of them were taken (J. Pierrot, J. Allard, pers. comms.). Although moose and bison are the normal staple sources of meat for residents of the Fort Smith area, fewer moose may be taken if a large harvest of caribou can be obtained on the Gordon Lake Road. In each of these cases, even if the same amount of meat came into town in each year, the species mix would be quite different. It should be noted this pattern will not be true for harvest of furbearers.

There are no data available to suggest whether improved access to known herds of animals results in an increase in amounts of meat consumed in the community, or if compensation of the type suggested above will occur. There are also no data to suggest whether an increase in supply of one species results in a decreased take of an alternative species, although it seems possible. Since community representatives suggested that community desires normally exceed supply, it is expected that the degree of compensation would be limited.

Link 9: Changes in species selection will influence harvests.

When a shift in the species taken occurs, harvests will be affected. The harvests of one species will be larger than normal, while the harvest of the other will be smaller. Factors such as personal preference for certain kinds of meat and the quantity of meat obtained per animal for each species will make the situation more complex.

It might be expected that an average community harvest could be calculated for each species over a long period of time. However, if access continues to increase in the study area, and the permanent road network is expanded, this average may be difficult to determine.

Link 10: Harvest changes as a result of increased access may affect the distribution and abundance of animals locally or regionally.

The above discussions indicate that increased access could result in local changes in the distribution and abundance of harvested species. Whether the total community harvest or wildlife populations will also change is unknown. Local reductions in populations, particularly of fur-bearing and big game animals, could occur from an increased harvesting pressure due to improved access. Fish populations could also be reduced in areas where summer access is improved.

Many factors other than changes in access complicate the situation; the need to feed an expanding local population is one example. An important factor in a changing social situation will be the harvest on a community basis. Changes in community harvests may be in the form of changes in the distribution of the harvest or a change in the total take. Even if the total number of hunters decreases, the community harvest may be maintained. If overall increases in harvests occur, populations of species could be affected. If access to a given area improves and it focuses the location of harvesting effort, then it is expected that there will be more pressure on available wildlife in that area (at least in the short term). This can affect local wildlife distributions or populations: moose, fish and furbearers have disappeared from around towns and certain other accessible areas. Areas along roadways, particularly permanent roads, will become barren of game in the same way.

The effects of harvesting on the distribution and abundance of animals can be local and not influence the entire animal population, or they can be regional and thus affect animal populations. Significantly larger community harvests are more likely to affect animal populations than are harvests which remain at the same level but move to new locations.

CONCLUSIONS

The group concluded that changes in access may affect the harvest of mammals and fish, but probably not migratory birds. The effects would generally occur as a result of the increased ease with which harvesting could take place, usually because of a saving of time or a capability to travel farther, but possibly also because of a saving of money or a change in the location of effort.

The harvesting of large game will be affected by all-weather roads, winter roads and seismic lines. Furbearer harvests will be similar, but perhaps less affected by roads than by seismic lines. Fish harvest will be affected by increased access on all-weather roads, particularly if the roads cross the creeks used by harvested fish for migration. Increased pressure on fisheries is primarily related to increases in angling rather than netting. The harvest of migratory birds could only be influenced by access from all-weather roads. The likely effect on birds was considered to be insufficient to warrant research or monitoring unless a road was being built close to a colonial nesting site or a major staging area.

RESEARCH AND MONITORING

Many factors other than changes in access (such as fur prices, normal changes in wildlife distribution and events discussed in other hypotheses) will influence harvests in conflicting or additive ways. Such factors must be isolated from the influence of access if the actual effects of any one of them on the harvest is to be determined.

To determine the effects of increased access on harvests, it is necessary to know the size of the community harvest and individual harvests, any trends in changing composition of the harvest and the locations at which animals are taken. Data must be collected for periods preceding and following the change in access. It must also be assumed that harvest changes in an area to which access was increased are a result of the improved access.

An ongoing harvest study is required to provide the baseline information for the testing of the hypothesis. The location and quantity of each hunter's harvest would be recorded on a regular basis. Detailed information on changes in access in the community's harvesting area over the years of the study would be compiled, as would wildlife distribution data. Data on furbearers may only be required for a small area since the opportunity to trap is usually restricted by custom. However, improved access in some areas can result in conflicts within the community's hunters and trappers (A. Adam, pers. comm.). In view of the detail of information required, the access study would probably have to be an addition to a regular harvest study that was being carried out only in certain communities.

Similar data may be required for testing other harvest-related hypotheses and a certain amount of common data collection may be possible. In addition, rather than collecting information from all the hunters and trappers in the region, data would likely have to be collected on an area or community basis by subsampling specific groups of people and monitoring the effects of changing access on their harvest of specific wildlife species.

LITERATURE CITED

Dimintrov, P. and M. Weinstein. 1984. So that the future will be ours. Rep. prep. for the Ross River Indian Band, Ross River, Yukon.

Freeman, M.M.R. (ed.). 1976. Inuit land use and occupancy project. 3 vols. Dep. Indian Affairs and Northern Development, Ottawa.

Phelps, D.E., R. Jamison and R.A. Demarche. 1983. The history of mountain goat management in the Kootenay region of British Columbia. British Columbia Fish and Wildlife Bulletin B-20. 37 p.

HYPOTHESIS NO. 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

Albert Adams	Maurice Mendo
Jim Allard	Heather Myers
Lorraine Allison	Jim Pierrot
Bob Everitt	Jeff Stein
Rick Josephson	Peter Usher
Steve Matthews	

INTRODUCTION

Industrial activities associated with the exploration phase of hydrocarbon development occur primarily during the winter months (e.g., seismic operations on land and oil well drilling). Construction activities, such as pipeline building, are also done in winter. Resupply and operations activities and any site-specific tasks, such as gravel mining and facility construction, will occur all year long. The following material examines the potential of these activities to conflict with harvesting.

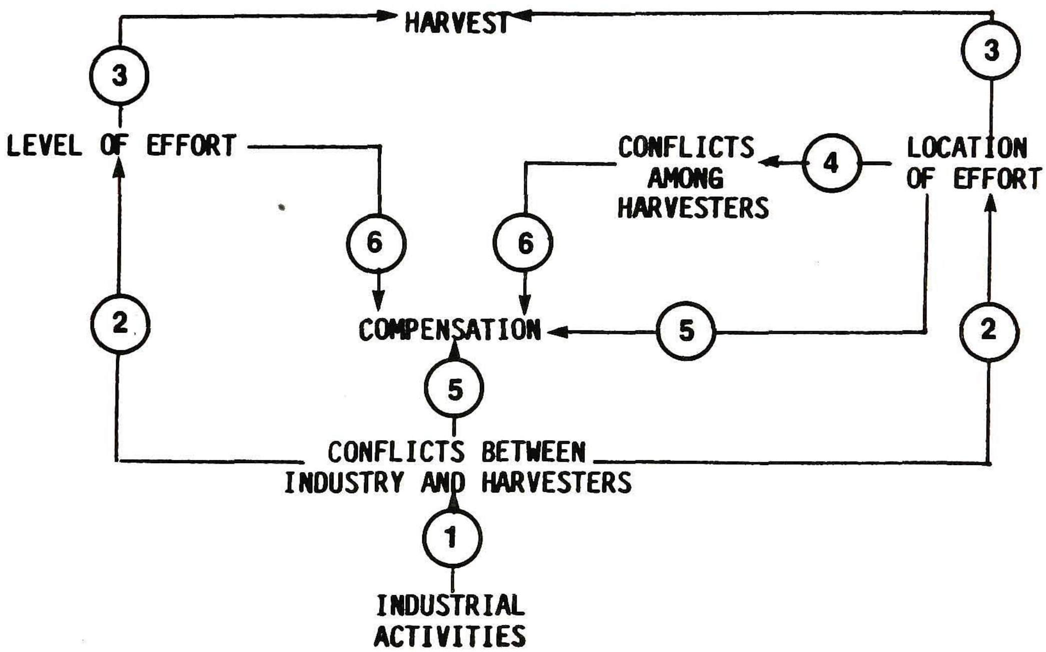
LINKAGES

Link 1: Industrial activities will result in conflicts between industry and harvesters.

It is difficult for two different endeavours such as renewable resource harvesting and non-renewable resource extraction to be carried out on the same land surface at the same time. Potential conflicts between the renewable resource harvester and the developer occur in three ways:

FIGURE 24-1

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



LINKAGES

Link 1: Industrial activities will result in conflicts between industry and harvesters.

Link 2: Conflicts between industry and harvesters will result in the alienation of land from resource harvesting on a temporary or permanent basis.

Link 3: Changes in location and level of effort of some harvesters will reduce both individual and community harvests.

Link 4: Harvesters will move into someone else's harvesting area and come into conflict and compete with harvesters who are already using the area.

Links 5 and 6: All levels of conflict resulting from the exclusion of harvesting from specified areas will be compensated.

1. Destruction of property. Although efforts are made to prevent it, development companies or their employees do, on occasion, destroy property: traps are buried during clearing operations, furbearers may be released from traps and cabins and equipment may be damaged (M. Mendo, pers. comm.). In addition, equipment such as snow machines may be damaged by collisions with old cable and other debris left in an area (e.g., wire on the ground on the CN transmission line; M. Mendo, J. Allard, pers. comms.).

2. Damage to the habitat. Conflict will occur when renewable resource harvesters observe damage to lakes used for fishing or muskrat harvesting, or observe the chronic spills that result from fuel sleds being left on lakes.

3. Restrictions on the use of a land area by harvesters for a short or a long term.

Link 2: Conflicts between industry and harvesters will result in the alienation of land from resource harvesting on a temporary or permanent basis.

Formal alienation of land for industrial development, or loss of access will result in temporary or permanent cessation of resource harvesting activities in an area. The reason for alienation will be either the physical presence of an installation such as a drilling rig or construction site or human safety considerations.

The result of alienation will be the relocation of harvesting activities. Hunting is somewhat flexible in its location and will be displaced to another area. Trapping, which is a less flexible activity and involves a developmental cost when moving into an area, may be completely displaced either temporarily or permanently. If relocation is not necessary, it may be possible for the development companies to reduce the trappers' travel problems by providing trails or breaks at appropriate points across pipelines, roads and new seismic lines.

The land around each community in the study area is formally or informally recognized as part of that community's harvesting area. Informal arrangements dictate the allocation of trapping areas among the local members of the Hunters and Trappers Association. Few areas are unused, except as part of a rotational scheme developed by the trapper. Any presently vacant trapping areas will be distant from the community or known to be of poor quality. The relocation of one trapper may also displace another to some extent. Although techniques are available within the community to accommodate this type of change, it may mean that both parties suffer a loss.

The relocation of a trapper will likely result in an increase in effort as measured by increased travel time and cost to get to the new area. It will definitely involve a change in the location of the effort. Costs will also be incurred to develop the new area; new travelling trails and cabins will be required and it will take time for the trapper to learn the area.

Link 3: Changes in location and level of effort of some harvesters will reduce both individual and community harvests.

This linkage seems to be more valid for some species and areas than for others. The effect will be greatest for the trapper who may be forced to relocate. If fishing and hunting activities are displaced by local disturbances, the individual will still fish or hunt somewhere and will probably harvest the same population. Depending on the degree and type of displacement, the effect may be felt most strongly by the part-time harvester.

It is theoretically possible for the harvest to decrease, to stay the same, or to increase. However, increases are considered unlikely.

Link 4: Harvesters will move into someone else's harvesting area and come into conflict and compete with harvesters who are already using the area.

The need for either temporary or permanent relocation of harvesters will increase as development in the study area increases. Although current technology allows the harvester greater access to remote locations than ever before, community representatives indicated that there is little or no land that is not now being used by someone for harvesting.

Trappers in the Inuvik and Fort Good Hope regions are already experiencing conflicts and competition among harvesters. Government incentive programs are perhaps contributing to the problem by encouraging more people to trap on a full-time basis. At the same time, residents involved in the wage economy are becoming recreational or part-time trappers.

When expansion into new harvesting areas is not possible, other solutions are required. Within a particular community, accommodations may be reached that involve the sharing of areas (A. Adam, pers. comm.). However, such an arrangement may lead to reduced harvests for one or both parties.

Links 5 and 6: Renewable resource users will be compensated for the effects of conflicts over land use.

Past experience with trapper compensations suggest that industry will be required to compensate harvesters (both individuals and organizations) when conflicts occur between development and existing renewable resource harvesting.

Recent compensation claims have been filed by individuals for damage to property (such as traps) and loss of income related to that damage. Examples of recent claims related to the building of the IPL pipeline and seismic work are:

1. A Fort Norman trapper received compensation when a seismic crew damaged some of his traps, resulting in low catch; and

2. A Fort Simpson family filed a compensation claim when they were prevented from reaching their trapping area during pipeline testing.

In each case, cash settlements of less than five thousand dollars were negotiated (S. Matthews, pers. comm.). Companies have never admitted legal liability in these cases to avoid setting a precedent.

Other concerns regarding compensation and development include the fact that company access may be used by non-company people. Resulting damage, usually vandalism, will not be compensated by the company.

The re-institution of individual registered traplines may improve the ability of harvesters to prove a right to the land and the resources on it by increasing the authority of the individual in arguing his case. Settlements to date are small in size and cover a narrow range of damages. Although recent progress in the area of compensation is recognized by industry and community representatives, the compensation question still requires development and change.

Where conflicts arise because of the relocation of a harvester, industry should be required to compensate all affected parties. The consequences of increasing the number of trappers in one area were discussed in Link 4.

CONCLUSIONS

Industrial development and land use conflicts may result in reduced harvests, particularly for trappers. Given the outlined probable scenario, this type of conflict has minor to moderate implications for the harvest. The impacts would be felt primarily on an individual and local level. It was concluded that impacts are possible and that study is required to determine whether they occur and how serious they might be.

RESEARCH AND MONITORING

If reduced harvests occur as a result of conflicts between harvesters and industrial development, compensation will be required or at least requested. It will be useful (and perhaps necessary) to have both harvest and land use information to support compensation claims. That information could be gathered by community-based organizations.

Three parts of the present and anticipated future process for dealing with land use conflicts were identified:

1. negotiation - before the development to identify potential conflicts and to avoid them if possible.

2. mitigation - before, during and after the development, to resolve or ameliorate conflicts that cannot be or have not been avoided.

3. compensation - for damage to harvests and harvesting opportunities resulting from the development.

Data which may be used during this process should be collected. Although confidential information on individual harvests may be required for compensation claims, community-scale data may be sufficient for planning purposes and for the identification of conflicts. However, individual level impacts may not be identified by using community level data.

There are three kinds of information required:

1. The location of proposed and probable industrial developments and a knowledge of the existing land use by native harvesters will be needed for the design of effective mitigative measures;

2. A technique for determining the actual effects of the conflict on harvests will be needed as a background for compensation claims and will have to be collected by community people; and

3. The effectiveness of existing negotiation, mitigation and compensation mechanisms should be assessed on a continuing basis. To some extent the number of compensation claims may be useful indicators of the effectiveness of negotiation and mitigation, providing compensation proceedings are seen to be useful and fair.

The central concern is the harvest: Are individual and community harvests affected by the activities of industry either directly or by its effects on the resource base? It will be important to know if or how the harvesters level of effort is affected (e.g., do trappers and hunters have to go much further or spend more time to get an adequate harvest?). If problems appear with certain species, geographic areas, habitat types or harvesting activities it should be possible to identify the problem and the potential sources; industry and the communities can then work together to mitigate the problem. Research is required to find effective ways to measure effort on an individual or community basis.

To negotiate and plan effectively to minimize conflicts, it will be necessary to know both where harvesting activities occur and where industry activities are planned. These data are presently collected verbally and informally on an as-needed basis and the information is not collated. Regional organizations, such as the DIZ societies which are already funded and are concerned with this type of problem, might be appropriate parties to compile and maintain such data. The DIZ groups either have or can gather information on the land use of native harvesters; they also meet regularly with industry to discuss plans for the current season. Maps could be prepared and posted for widespread use and the information would need to be reviewed annually.

Community members are currently employed by industry to monitor certain industrial activities such as seismic exploration. A few refinements to this program are suggested:

1. The monitors should be hired by and be responsible to the community, rather than the company, to enable them to report impartially;

2. Monitors should be trained. They should understand the activities of the industry and any restrictions of their permit. They should know what mitigation techniques are to be applied and the details of the compensation system. The monitor should be familiar with the harvesting techniques and the land use of the community in the area;

3. The monitor should report regularly (e.g., monthly) to the community, the companies (principals and subcontractors) and the appropriate government agencies, and should keep records of land use, conflict and compensation.

HYPOTHESIS NO. 25

INCREASES IN HUNTING BY NON-LOCALS WILL RESTRICT HARVESTS BY LOCAL NATIVES

PARTICIPANTS

Albert Adams
Jim Allard
Lorraine Allison
Terry Antoniuk
Bob Everitt
Fred McFarland
Rick Josephson
Steve Matthews
Maurice Mendo
Heather Myers
Jim Pierrot
Jeff Stein
Peter Usher

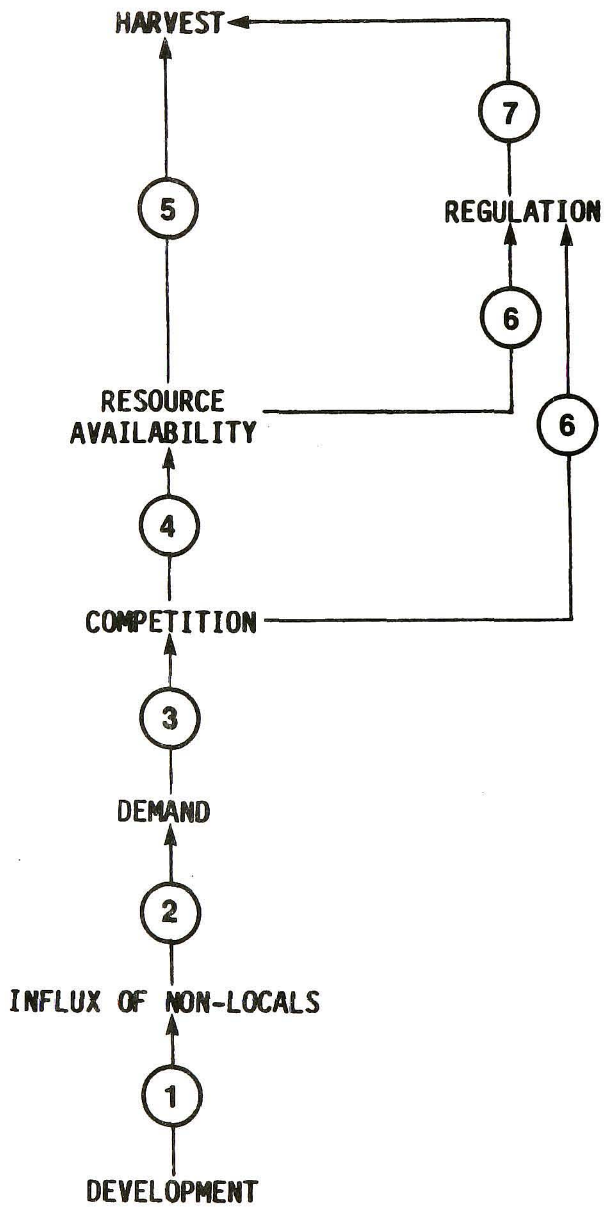
INTRODUCTION

Of the total renewable resource harvest in the study area, natives currently harvest 100% of the marine mammals, nearly 100% of the furbearers, 90% of the big game and similarly high proportions of fish and waterfowl. Native harvesters have priority access to these resources, by virtue of their aboriginal rights (the specific contents of which are currently being negotiated and tested in the context of native claims settlements), the N.W.T. Wildlife Act, particularly the General Hunting Licence provisions (which can be changed by legislation), and their numerical significance in the regional population (which could change through influx of non-locals).

Each community in the region has its own traditional harvesting area, recognized at least informally by the other communities, and in some cases also recognized under the Wildlife Regulations as Registered Group Trapping Areas. While there is some variation in the intensity and frequency of native use of these areas, there are virtually no unused areas within the study area (Freeman 1976; Dene Mapping Project). Nor, with the exception of some fishes of some inland lakes, are there any unharvested fish or animal populations within the region. The non-native recreational harvest occurs within this context since it does not occur in otherwise unused areas or affect otherwise unharvested populations.

FIGURE 25-1

Increases in hunting by non-locals will restrict harvests by local natives



LINKAGES

Link 1: Development will result in influx of non-locals.

Link 2: Influx of non-locals will result in increased demand for fish and wildlife.

Link 3: Increased demand will result in increased effort and competition among harvesters.

Link 4: Increased competition will result in decreased local resource abundance.

Link 5: Increased harvesting effort by non-locals and/or decreased local resource availability will result in reduced local native harvests and/or reduced catch per unit effort.

Link 6: Increased competition and/or decreased resource availability will lead to restrictions on local native harvests.

Link 7: Regulation of harvest will restrict native harvests.

This hypothesis examines the effects of the influx of non-locals on demand and competition for fur, fish and game resources. It is recognized that demand for these resources may increase for other reasons (e.g., local population growth), but they are not considered in this hypothesis.

LINKAGES

Link 1: Development will result in influx of non-locals.

According to the development plan, two types of influx of people are expected:

1. large-scale and short-term (i.e., thousands of people for months) during the construction phase of large projects; and

2. smaller-scale and long-term, during the operation and maintenance of oil and gas fields and transport facilities (i.e., hundreds of people for years).

In both cases, the incoming population may consist not only of non-natives but also of native people from other parts of the N.W.T., or from other communities within the region. Although the native component will be small, it may have a significant impact on resource harvesting.

Link 2: Influx of non-locals will result in increased demand for fish and wildlife.

Effects of non-native immigrants.

A large-scale short-term influx of non-natives is not expected to increase demand significantly for many reasons:

1. these workers cannot meet residence requirements for licensing;

2. in many cases they have little time available for recreation;

3. they are not in the right places to engage in recreational harvesting or poaching; and

4. firearm restrictions are normally imposed at work sites.

A smaller-scale, long-term influx of non-natives is expected to result in more significant increases in demand because:

1. operations staff and other newcomers attracted by increased economic opportunity will be able to obtain hunting licences and will have the time to use them; and

2. they will constitute a political pressure group that could agitate for increased quotas and other rights for non-native hunters.

Effects of native immigrants.

Native migrants, whether short-term or long-term, may create different demands on resources. Where the number of native immigrants is small and they are incorporated into the community by traditional social methods, their effect on demand is insignificant and qualitatively no different from normal population growth. Where the number of native immigrants is substantial and/or not easily incorporated into the local community, the resulting increment in demand may be significant.

Link 3: Increased demand will result in increased effort and competition among harvesters.

Increased demand from both non-native and native immigrants is expected to affect mostly big game (caribou, moose, and sheep), waterfowl and game fish species. Wolf and wolverine are classified as both big game and furbearers, and are thus open to Resident Hunting Licence (RHL) holders as well as to native harvesters.

Furbearers are restricted to native harvesters and access is controlled by the local Hunters and Trappers Associations (HTAs). Non-local General Hunting

Licence (GHL) holders cannot trap without permission. Consequently this link does not apply to furbearers. The link may also be inapplicable to species such as polar bear and muskoxen, the harvest of which is controlled by tags issued by the local HTA.

The influx of non-natives is expected to have a greater effect on demand for resources than that of natives. Greater numbers of non-natives are expected and the informal controls by local native harvesters may be less effective on non-natives than on natives. In all cases, the effects of immigration are anticipated to be community-specific.

Link 4: Increased competition will result in decreased local resource abundance.

Substantial declines in local resource harvest levels have been recorded in Alaska where legislation and accessibility have enabled significant non-local hunting pressure (Fall 1985; Wolfe 1985). The significant declines in per capita native harvest are attributed to three factors: road access from major centres, high local proportions of non-native residents and a lack of preferential harvesting rights for native people. These factors are not expected to be as significant in the N.W.T., due to the Western Arctic Claims Agreement already in place, and the proposed terms of the Dene/Metis Wildlife Agreement. The latter, however, is not yet in force, and may not completely control increased harvesting pressure from immigrants. In any event, this link would only be valid if previous harvest levels were at or near substainable yields.

Link 5: Increased harvesting effort by non-locals and/or decreased local resource availability will result in reduced local harvests and/or reduced catch per unit effort.

The presence of non-local hunters has been shown to have a discouraging effect on effort and harvests by Indians in northeastern British Columbia (Brody 1981). Where effort is not discouraged by competition or decreased availability, increased local effort may be required to obtain the same level of harvest. This would result in higher costs due to reduced catch per unit effort, with possible implications to the harvested populations.

Link 6: Increased competition and/or decreased resource availability will lead to restrictions on local native harvests.

The problem associated with competition will be greatly reduced if effective controls are developed in advance. Negotiation and implementation of native claims settlements and their provisions for preferential harvesting rights and minimum quotas are a part of this process. If harvesting restrictions on non-natives are in place in advance of their arrival, there will be less resistance than if they are implemented afterwards when hunting privileges will be perceived as having been lost. If competition is not controlled from the outset, restrictions on native harvests are more likely to result.

Link 7: Regulation of harvest will restrict native harvests.

Native harvests will not be reduced if the above-noted controls are in place in advance of significant immigration. However, there may still be problems with allocation of possible increased harvesting entitlements, either for domestic or commercial purposes; it is in this area of growth that native harvests may be restricted. The larger the number of non-native licence holders and commercial interests, the less likely it will be that native harvesters can increase their quota.

CONCLUSIONS

The hypothesis is considered valid in the absence of compensating legislation or regulatory action in place prior to significant new immigration. Such action is, however, envisaged in claims settlements already in place or currently under negotiation. Depending on the outcome, some additional controls may still be necessary.

RESEARCH AND MONITORING

Monitoring should be restricted, in the first instance, to documentation of the current baseline. Records of the number of non-local harvesters, their level and location of effort and their harvests should be maintained. Wherever these numbers rise significantly, further monitoring of the species and harvesting areas of concern should be undertaken including the collection of data from native harvesters. Where there is a concern that harvests may be approaching or exceeding sustainable levels, research may be required on the population status of the various wildlife species. The species considered to be the likely focuses of competition are caribou, moose, sheep, bear, wolf, wolverine, waterfowl and game fish.

LITERATURE CITED

Brody, H. 1981. Maps and dreams. Douglas & McIntyre, Vancouver.

Dene Mapping Project. Unpubl. computer data on file at the University of Alberta.

Fall, J.A. 1985. Historical changes in hunting and fishing patterns in the Copper River Basin, Alaska. Paper presented to 84th Annu. Meeting American Anthropological Association, Washington, D.C.

Freeman, M.M.R. (ed.). 1976. Inuit land use and occupancy project. 3 vols. Can. Dep. Indian Affairs & Northern Development, Ottawa.

Wolfe, R.J. 1985. Impacts of economic development on subsistence productivity: western region and Copper Basin cases. Paper presented to Alaska Anthropological Association Meeting, Anchorage, Alaska.

APPENDIX A

HYDROCARBON DEVELOPMENT
SUMMARY AND SCENARIO
FOR A
MACKENZIE ENVIRONMENTAL MONITORING PROGRAM

prepared by

R.A. OWENS ENVIRONMENTAL SERVICES LTD.

in co-operation with

LGL Limited

October, 1985

ACKNOWLEDGEMENTS

A great many persons kindly gave of their time and knowledge to assist the author in drawing together the information included here. Their help and in many cases their patience is appreciated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

1.0 INTRODUCTION

This brief summary of past hydrocarbon development in the lower Mackenzie River Valley region, together with a scenario of possible future development, has been prepared as background information for participants in the Mackenzie Environmental Monitoring Program (MEMP). Information dealing with past hydrocarbon development has been drawn primarily from statistics published by the Northern Oil and Gas Operations Division of Indian Affairs and Northern Development (1984) and by the Canada Oil and Gas Lands Administration (Annual Reports of 1982, 1983 and 1984). Description of present levels of activity and of activity anticipated in the near future is based upon information and commentary supplied by industry representives. Scenario components are based in part upon past events, in part upon the opinions and present plans of industry and in part upon arbitrary assumptions inserted by the author.

The primary purpose of the document is to assist participants in MEMP:

1. by outlining the scope and nature of past and present hydrocarbon development within the MEMP study region;

2. by presenting in an organized manner the likely direction and nature of future hydrocarbon development; and

3. by presenting hydrocarbon development variables in a way that allows consideration of possible environmental impacts in one or more future "scenarios".

Summaries describing hydrocarbon facilities and activities are included as a source of technical information concerning development. These are based on a large body of documentation prepared by firms proposing development in the region over the last fifteen years and upon "rules of thumb" kindly supplied to the author by knowledgeable industry personnel. MEMP participants will no doubt wish to consult directly these information sources as well as others dictated by their technical specialities and workshop responsibilities. To assist in this process a partial listing of available technical information regarding proposed development in the region is included as Part 7.0.

2.0 HYDROCARBON DEVELOPMENT

The term "development" is used in this document in its broadest sense, referring to the entire scope of activity involved in the realization of hydrocarbon resource potential. This usage differs from that common in the oil and gas industries where "development" is an activity occurring after resource discovery and delineation but before movement of resources to market.

When carried to completion, the development of hydrocarbon resources within any region consists of several sequential steps beginning with a decision to undertake, encourage or allow exploration and ending with delivery of hydrocarbons to market. Those steps include:

1. decision to allow/encourage exploration,
2. exploration (seismic surveys, exploratory drilling),
3. discovery and measurement of reserves,
4. plan/construct transport system(s),
5. produce and process reserves, and
6. transport and market reserves.

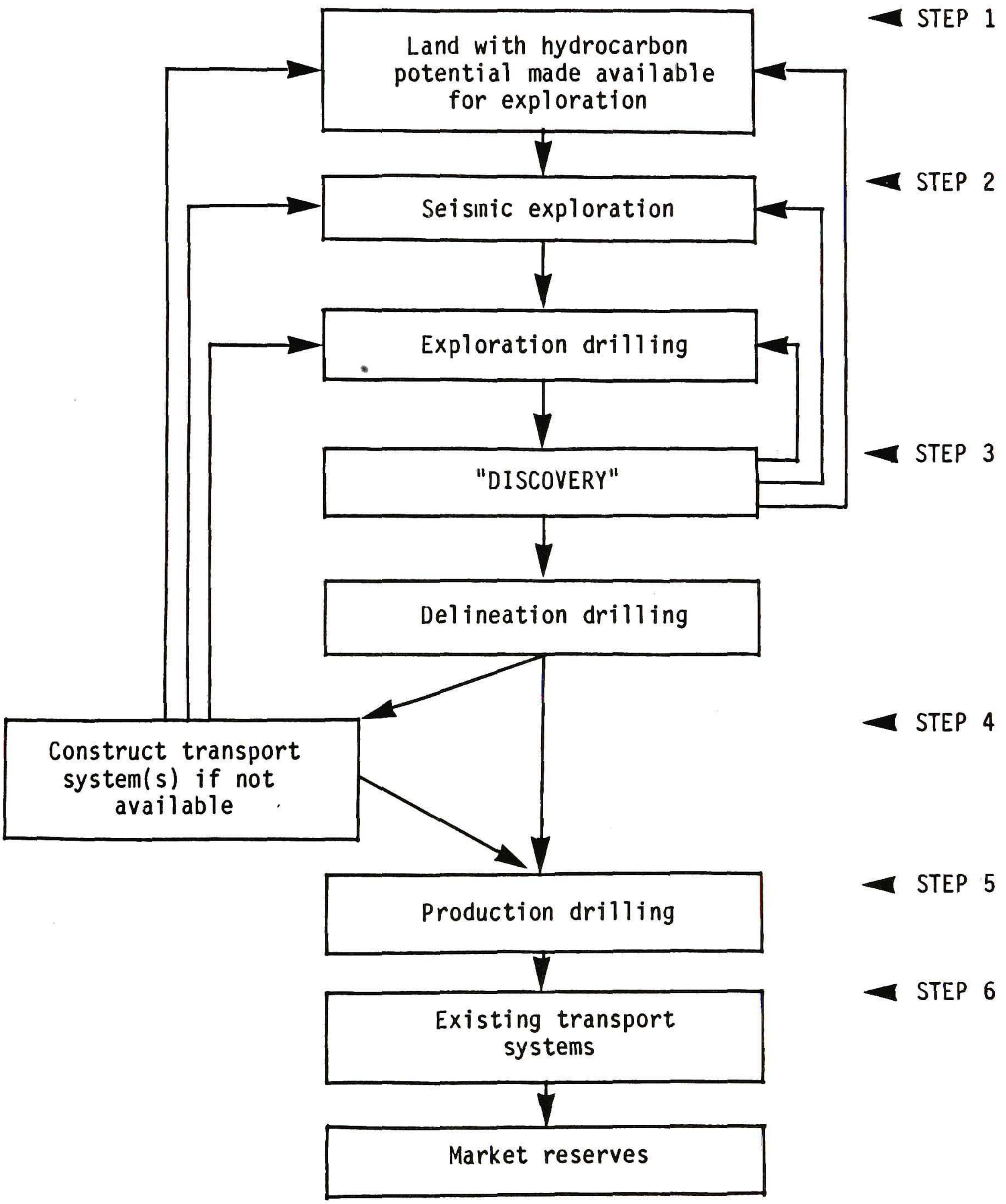
Each step in the above sequence is dependent upon the previous one. In addition, attaining any particular step may encourage or accelerate activity in previously attained steps within adjacent areas. For example, a discovery may spur additional exploratory surveys or the construction of a pipeline which in turn may cause increased exploration activity, as any newly discovered reserves would have immediate access to the marketplace (Figure 1). The above outline of the sequence of development and the figure referred to assume regulatory approvals are implicit upon reaching stage one.

Hydrocarbon development within the MEMP study area has been underway for a number of years and is presently occurring in three geographic areas:

1. the Norman Wells area, where the completion of an oil pipeline to Alberta has made necessary additional production drilling in the Norman Wells field and has spurred interest in exploration activities;

FIGURE 1

THE DEVELOPMENT PROCESS



2. the Colville Lake area, where recently initiated seismic and exploratory drilling is proceeding; and

3. the Mackenzie Delta area, where exploration over the last 25 years has resulted in the discovery of both oil and gas reserves and where exploration is continuing.

Future development within the MEMP study area is dependent primarily upon the presence or absence of systems to transport discovered hydrocarbons. Several pipeline systems are presently proposed or being considered. Decisions to proceed or not proceed with these pipeline systems will be critical events shaping the nature and pace of development within the area over the next 20 years.

Existing hydrocarbon development in the several regions of the study area illustrates regional differences with respect to the overall development process. The Norman Wells region attained the final stage of development many years ago and is now experiencing additional final stage expansion while in the Colville Lake area development has reached only the second stage. The Mackenzie Delta region is stalled between stages three and four. Large portions of the study area with hydrocarbon potential have not yet been released for exploratory activity.

The progression through development stages experienced by the several regions within the study area and the spin-off effects of development within one region upon others is an important consideration in any effort to anticipate or predict the course, nature and timing of development as it relates to environmental monitoring. In recognizing the step-wise nature of development and the spin-off effects it is, however, equally important to differentiate between events or developments which actually exist and those that are planned, proposed or simply considered. To assist in this differentiation the following definitions will apply:

- planned - put forward officially by one or more organizations and supported by detailed documentation,

- proposed - put forward officially by one or more organizations and supported by preliminary documentation,

- **considered** - put forward unofficially by a number of individuals or one or more organizations without documentation.

With respect to scenarios of future development two additional definitions apply:

- **expected** - that which might reasonably arise from some set of circumstances or body of facts in a rational world,

- **assumed** - arbitrarily put forward for the purpose of scenario development.

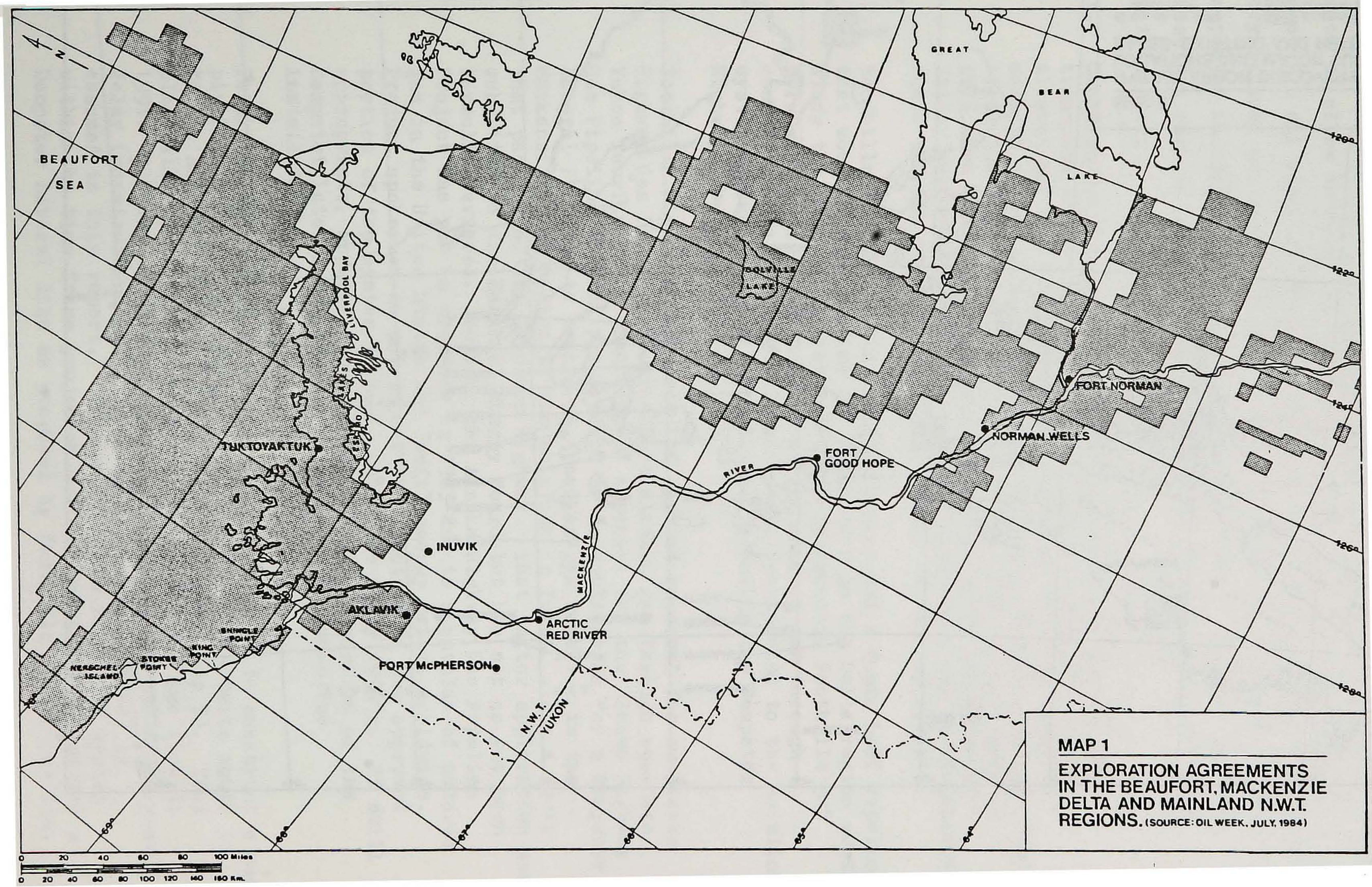
These words, when highlighted by **double striking** in the text, will carry the meanings set out above.

3.0 PAST AND PRESENT HYDROCARBON DEVELOPMENT

Hydrocarbon development within the study area addressed by the Mackenzie Environmental Monitoring Program began in 1914 with the staking of claims at a site approximately 50 miles downstream of Fort Norman at a location eventually named Norman Wells (Map 1). Drilling began in 1919 and oil was discovered in 1920. A topping plant was constructed in 1921 by Imperial Oil Limited and since then production from the Norman Wells field has supplied regional fuel requirements. Until interest in the Mackenzie River Delta region developed in the late 1950's, most hydrocarbon activity in the MEMP study area was centered on Norman Wells. In 1961, the first exploratory well was drilled in the Mackenzie Delta and since then interest has been increasingly focused on the Delta region and nearby offshore areas of the Beaufort Sea. Interest in hydrocarbon exploration has recently been extended to a region lying east of the Mackenzie River and north of Great Bear Lake in what is called the Colville Lake area. In addition, the construction of a 324 mm oil pipeline from Norman Wells to Zama Lake, Alberta has spurred exploratory activity in the Norman Wells region and production drilling in the Norman Wells field.

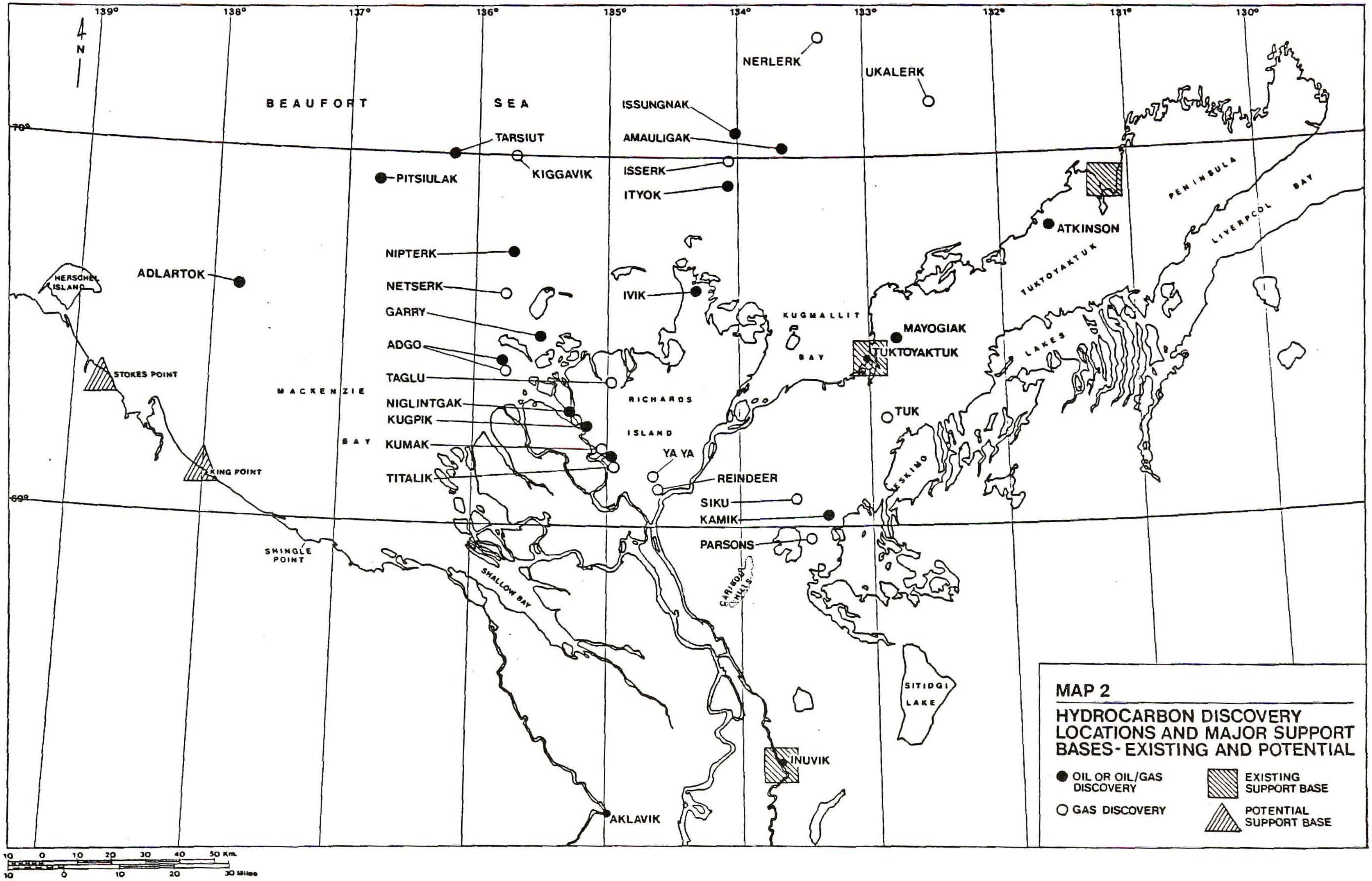
To date, approximately 900 wells have been drilled in the study area. Most of these have been associated with the Norman Wells field but more than 150 wells have been completed in onshore areas of the Mackenzie Delta and more than 50 at offshore locations adjacent to the Delta. In addition to oil reserves discovered at Norman Wells, reserves of oil and gas have been discovered at both onshore and offshore locations in the Mackenzie Delta region (Map 2). Exploration in the Colville Lake region and areas adjacent to Norman Wells have not resulted in the announcement of additional discoveries. Exploration activity is continuing in the Delta, Colville Lake and Norman Wells regions (Map 1).

Past activity in the Norman Wells field was supported from the community that grew up adjacent to the field. Ongoing exploration in the region is also supported from Norman Wells as is exploration in the Colville Lake region. In the Delta region, exploratory activity has been supported from the communities of Inuvik and Tuktoyaktuk and from a number of bases located in northern portions of the Delta.



MAP 1

EXPLORATION AGREEMENTS IN THE BEAUFORT, MACKENZIE DELTA AND MAINLAND N.W.T. REGIONS. (SOURCE: OIL WEEK, JULY, 1984)



MAP 2

HYDROCARBON DISCOVERY LOCATIONS AND MAJOR SUPPORT BASES - EXISTING AND POTENTIAL

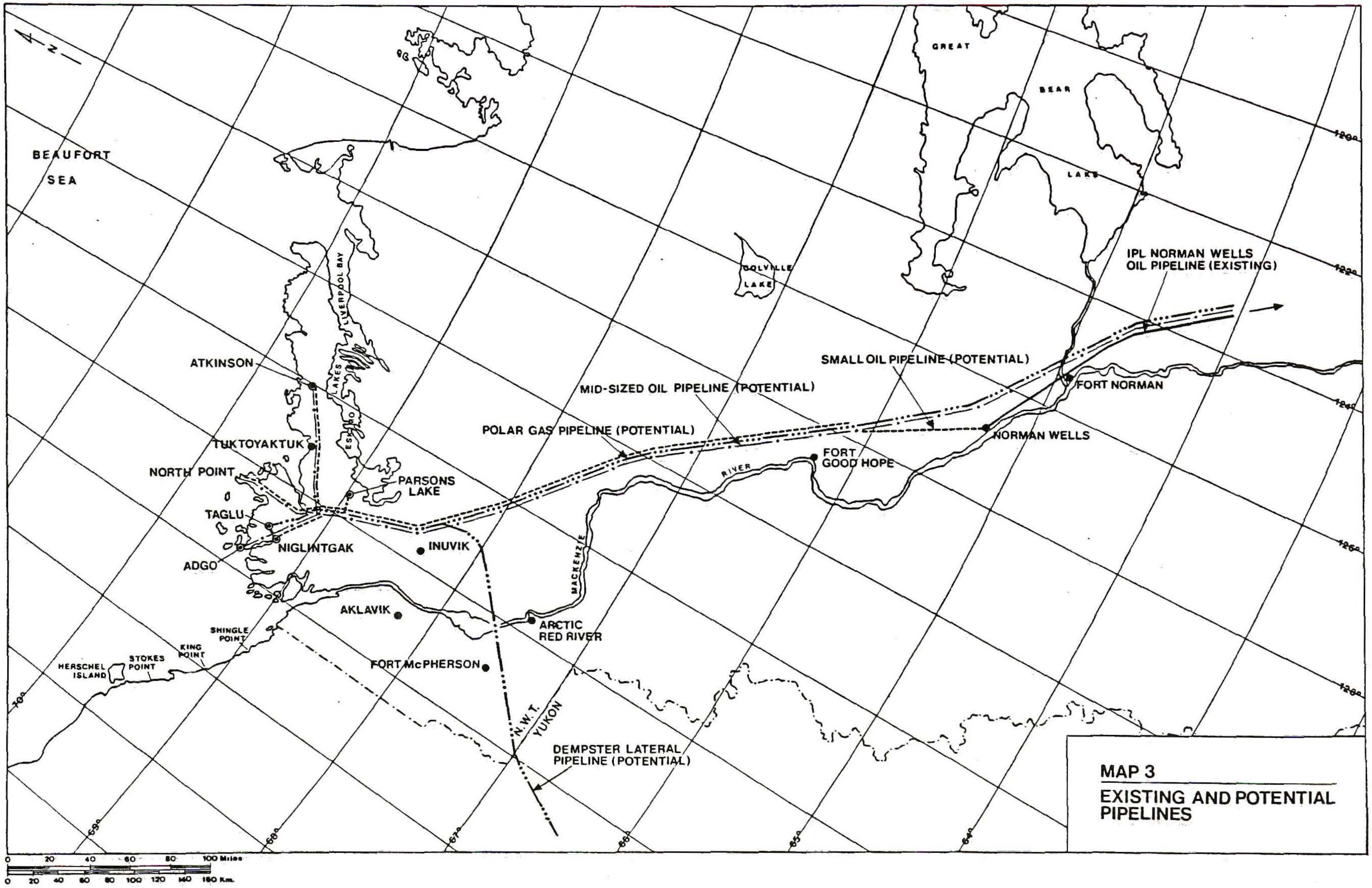
To date, hydrocarbon reserves in the MEMP study area have been produced only from the Norman Wells field. Production from that field is presently being increased to allow movement of crude oil to Zama Lake via the recently completed IPL oil pipeline (Map 3). Previously, a 690 km pipeline designed to carry refined products from Norman Wells to Whitehorse, Yukon Territory was completed in 1943 but was subsequently abandoned. A number of plans have been put forward to move reserves discovered in the Mackenzie Delta region to market:

1. Canadian Arctic Gas Study Limited proposed and planned the transport of gas reserves from the Delta region together with Alaskan gas via a pipeline from northern Alaska to southern markets routed across the Alaskan and Yukon North Slope and south along the Mackenzie River Valley. This plan was abandoned in 1977 when a moratorium on pipeline activity in the Mackenzie Valley was recommended by the Berger Commission and an alternative route through southern Yukon was viewed as more acceptable.

2. Foothills Pipe Lines Ltd. initially proposed a Maple Leaf Pipeline that would carry Canadian gas reserves from the Delta region south along the Mackenzie River Valley. Subsequently Foothills put forward a plan which involved moving Alaskan gas through southern Yukon along with Canadian gas transported to the mainline system in Yukon, via a lateral line following the Dempster Highway.

3. Foothills Pipe Lines (Yukon) Ltd. gained approval for an Alaska Highway Gas Pipeline to transport Alaskan gas through southern Yukon Territory. A condition of approval for the Alaska Highway Gas Pipeline was the preparation of an application for a Dempster Lateral Pipeline to transport Canadian gas reserves in the Mackenzie Delta region to the mainline in Yukon, along a route that paralleled the Dempster Highway. That latter application was submitted to the National Energy Board but has not as yet been formally reviewed. Work on the Alaska Highway Gas Pipeline Project was put in abeyance in 1983 due to a surplus of natural gas in the United States and "soft" energy prices worldwide. Project spokesmen do not expect construction of the approved portion of the system to begin until the early 1990's. If still appropriate, approval would be sought for completion of the Dempster Lateral portion of the system after mainline installation.

4. Polar Gas has recently submitted an application to construct a gas pipeline to move gas reserves from the Mackenzie Delta south to Edson, Alberta via the Mackenzie River Valley (Map 3). That plan calls for construction to start in 1987 and gas flow in 1991. A delay in this schedule now seems likely and a one year delay (construction start in 1988, fast flow in 1992) is assumed in this report. Completion of The Polar Gas system within the time frame projected would eliminate the need for a Dempster Lateral line as proposed by Foothills Pipe Lines Ltd.



MAP 3

EXISTING AND POTENTIAL PIPELINES

5. Esso Resources Canada Limited is considering the possible construction of a "small" oil pipeline (@ 300 mm diameter) from the Mackenzie Delta to Norman Wells. Such a pipeline would carry onshore Delta oil reserves to market via an interconnection with the IPL Norman Wells Pipeline. Throughput would be limited to excess capacity available in the IPL Norman Wells Pipeline. Construction in the early 1990's is thought possible.

6. The feasibility of a mid-sized (400 mm to 600 mm) oil pipeline which would move onshore and/or offshore reserves from the Mackenzie Delta region to Zama Lake, Alberta is presently being considered (Map 3).

7. Marine transport of oil and gas reserves using arctic tankers has been proposed and documented by Dome Petroleum and others. Examination of these proposals has been part of the development of a Beaufort Environmental Monitoring Program (BEMP). While the offshore focus of such marine transport proposals removes them from consideration within the present MEMP exercise, consideration of onshore developments to support offshore activity is appropriate.

Future hydrocarbon development throughout the study area will be shaped by the kind and timing of transport system(s) put in place. The extent to which putting transport systems in place can transform and drive other development activity is presently being illustrated in the Norman Wells area. Completion of the IPL Oil Pipeline has sparked interest in exploration in the immediate vicinity of Norman Wells and in regions lying to the north and south. Construction of other pipelines in the MEMP study area can be expected to have similar effects. Alternately, if pipeline proposals are not acted upon and/or other incentives for exploration cease to exist, exploration in the area can be expected to slow and eventually stop.

4.0 FUTURE HYDROCARBON DEVELOPMENT

The transport systems selected to move hydrocarbon reserves and the timing of installation of those systems will play a major role in shaping the nature and intensity of hydrocarbon development within the MEMP study area. Future development can be viewed as falling within two categories:

1. activities directly associated with transport systems, such as production drilling, processing and gathering systems; and

2. activities which can be expected to "spin-off" from the development of transportation systems and directly associated activities, such as additional exploration in areas adjacent to the transportation system.

Figure 2 shows the sequence of transportation system development now completed, planned or being considered. The following sections briefly outline the major potential transport developments as well as other forms of hydrocarbon development that may result in each case.

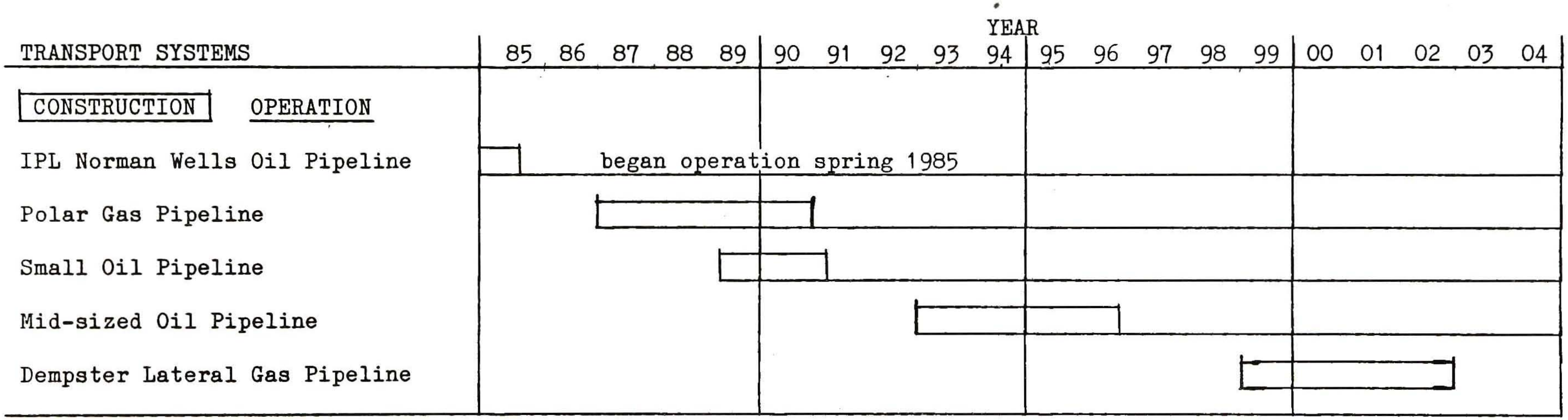
4.1 The IPL 324 mm Oil Pipeline

Construction of a 324 mm diameter oil pipeline from Norman Wells to Zama Lake, Alberta was completed in early 1985. That pipeline will transport 4,000-5,000 m^3 of oil per day. At least in initial stages of operation oil will be drawn entirely from the Norman Wells field. Development drilling in the Norman Wells field to support pipeline start-up has been underway for several years. Approximately 160 wells for production and injection will be drilled from mainland as well as natural and artificial island sites in the Mackenzie River. Reservoir production is being managed and enhanced through controlled water flooding. Collector lines to transport oil from drill sites to a pre-processing facility at Norman Wells have been put in place. Oil will be injected into the pipeline at Norman Wells from the pre-processing plant. Refining will take place south of the 60th parallel.

To date oil discoveries in the region have been limited to the Norman Wells field. As a result, use of the pipeline to transport other reserves from the region cannot be directly anticipated. However, the installation of a

FIGURE 2

SCHEDULES PUT FORWARD BY PROPONENTS OF
PLANNED/PROPOSED TRANSPORT SYSTEMS
WITHIN THE MEMP STUDY AREA



transport system has and will continue to spur additional exploration drilling and connection to additional reserves can be expected to occur if discoveries are made. Use of the Norman Wells Pipeline to transport Mackenzie Delta oil by way of a connecting pipeline is being considered (see 4.4).

4.2 The Polar Gas 914 mm Gas Pipeline

Polar Gas has proposed the construction of a 914 mm high pressure gas transmission line to carry Mackenzie Delta gas reserves to Edson, Alberta. The planned system in its initial configuration will carry approximately 22 million m^3/day. Plans set out in The Polar Gas application call for start of construction in 1987 and first gas flow in 1991. A delay of at least one year in the plan seems likely and is assumed to be the case in this report. The approximate locations of the mainline and northern laterals within the study area are shown on Map 3.

The Polar Gas system is designed to initially transport onshore gas reserves at Taglu, Niglintgak and Parson Lake (Map 4). Gas from other onshore and possibly offshore reserves will in all likelihood be transported by the Polar Gas line as reserves in the initially connected field are exhausted or as the pipeline system is upgraded in terms of throughput by the addition of compression power, compression facilities or by looping. Plans for upgrading the system have not been expressed by Polar Gas but the addition of compression power might reasonably be expected to begin within five to ten years of initial operation.

Development drilling and construction of processing facilities can be expected to support initial pipeline gas flows in 1992. A summary of activities/facilities that might be expected in association with construction of the planned Polar Gas pipeline is presented in Table 1.

4.3 A Potential Mid-sized Oil Pipeline

Some northern operators have begun to study (consider) the feasibility of a mid-sized oil pipeline (400-600 mm) to carry both onshore and offshore oil reserves from the Mackenzie Delta south along the Mackenzie River Valley

TABLE 1

ACTIVITIES/FACILITIES/EVENTS ASSOCIATED WITH CONSTRUCTION OF THE POLAR GAS PIPELINE

DIRECTLY ASSOCIATED ACTIVITIES/FACILITIES/EVENTS

- construction of production drilling pads at Taglu, Niglintgak and Parsons
- construction of a central processing facility at Taglu, Niglintgak and Parsons
- construction of flowlines between production pads and central processing locations
- drilling of production wells at locations above
- operation of central gas processing facilities
- increased activity at Inuvik, Tuktoyaktuk, along the Dempster Highway and along Mackenzie River barge routes and winter roads to support above
- ongoing "work-over" drilling activity at production sites
- ongoing production drilling at initially chosen production sites to replace wells exhausted
- placement of flowlines to carry hydrocarbon liquids from gas processing facilities to an oil pipeline system for transport, if the latter exists; flowlines to allow the transport of gas produced at oil production sites to gas plants, if the latter exist
- additional production drilling by operators not involved in initial production (above) at new locations with probable construction of separate processing facilities causing in turn additional associated activity similar to that outlined above

INDIRECTLY ASSOCIATED OR "SPIN OFF" ACTIVITIES/FACILITIES/EVENTS

- increased interest in exploration activity and therefore increased seismic survey and exploratory drilling
- the discovery of new reserves as a result of increased exploration activity (above)
- positive feedback from new discoveries causing an intensification of development incentive

to Zama Lake, Alberta. Scheduling is at present extremely tentative but construction might reasonably be expected to follow construction of a gas transmission line and therefore begin in 1993 and be complete in 1996 or 1997. Failure to expedite construction of a gas pipeline in the early 1990's could allow an earlier effort to be made with respect to an oil line. Offshore reserves would likely be brought to shore at North Point on Richards Island. The onshore portion of the line would traverse Richards Island to a Mackenzie River crossing near Swimming Point and proceed south in a corridor that closely parallels that proposed for the Polar Gas Pipeline. The likely pipeline route within the study area is shown on Map 3. Lateral or gathering lines from offshore and onshore reserves might join the mainline system just outlined at appropriate points in both onshore and offshore locations (Map 4).

An oil pipeline of 400 to 600 mm diameter could carry between 15 000 and 47 000 m^3/day which would likely require connection to more than one producing field. Both offshore and onshore reserves could be candidates. Offshore fields that might be developed first are those in the vicinity of North Head (Amauligak, Tarsuit, or Esso's recent discovery at Nipterk). Onshore reserves could include Adgo, Atkinson, Tuktoyaktuk, Niglintgak, Ivik, Kugpik, Kumak and/or Mayogiak. Given the capacity of the proposed pipeline and its anticipated completion in the mid 1990's, it is unlikely that the line's capacity would be enhanced through looping or twinning before the year 2005 which is the end of the MEMP scenario period although increased pumping capacity might be installed to maximize throughput within five years of initiating operation.

As with the other pipeline systems described, supporting facilities such as production drilling and processing platforms would be put in place to coincide with the pipeline's anticipated completion. In part these facilities will be offshore and therefore outside the terms of reference for MEMP. However, at least one and perhaps two onshore fields may be involved in the initial drilling programs to supply reserves to the mid-sized line. In addition, reserves transported from offshore locations will intensify activity in the region and be reflected onshore at support bases and along barge routes and winter roads on the Mackenzie River. Offshore reserves transported to North Head on Richards Island will create a requirement for

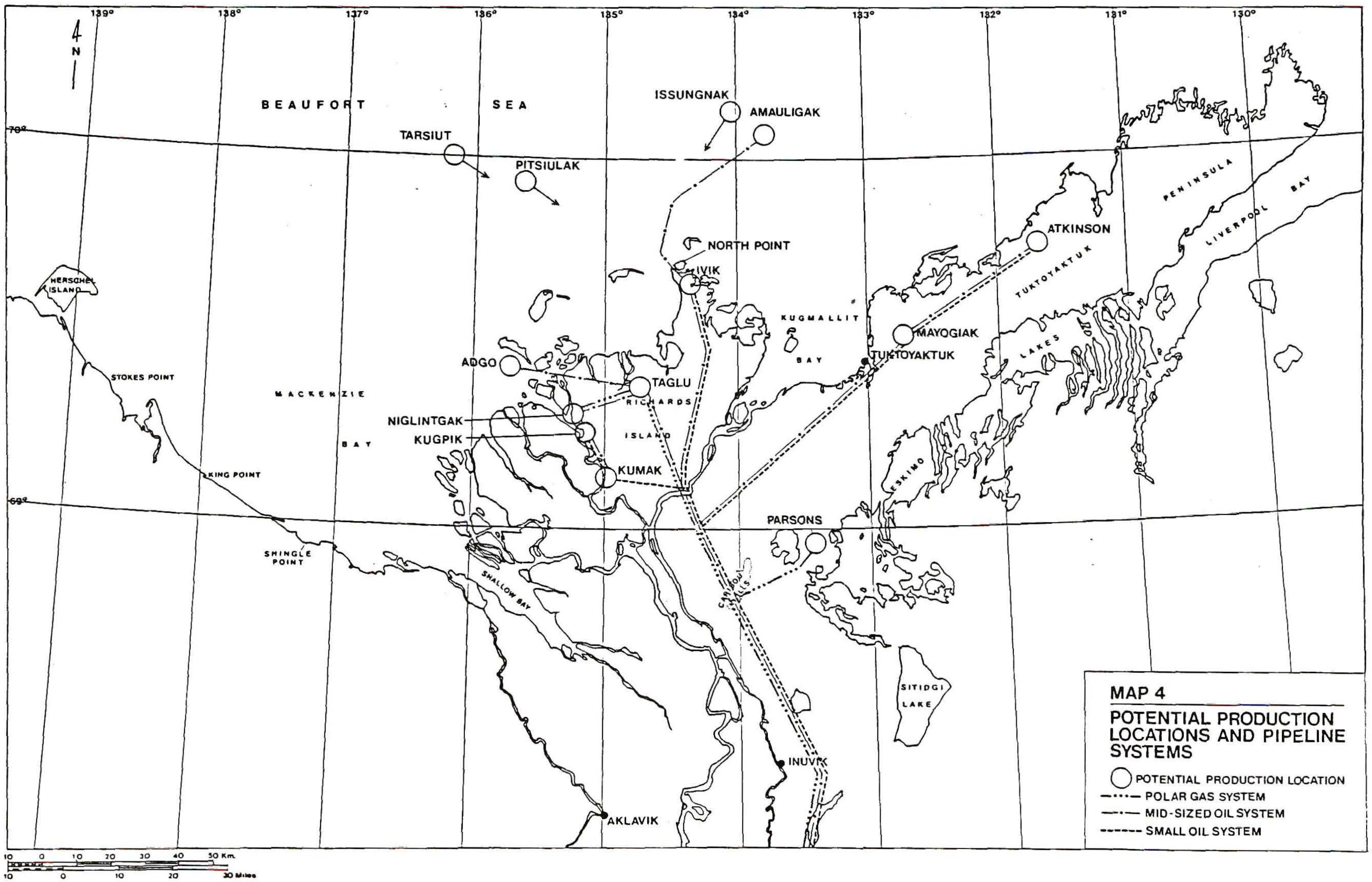

139°
138°
137°
136°
135°
134°
133°
132°
131°
130°
70°
69°
N
BEAUFORT SEA
ISSUNGNAK
AMAULIGAK
TARSIUT
PITSIULAK
NORTH POINT
IVIK
ATKINSON
PENINSULA
LIVERPOOL BAY
TUKTOYAKTUK
KUGMALLIT BAY
MAYOGIAK
TUKTOYAKTUK
LAKES
HERSCHEL ISLAND
STOKES POINT
MACKENZIE BAY
ADGO
TAGLU
RICHARDS ISLAND
NIGLINTGAK
KUGPIK
KUMAK
KING POINT
SHINGLE POINT
SHALLOW BAY
PARSONS
ESKIMO
SITIDGI LAKE
INUVIK
AKLAVIK
MAP 4
POTENTIAL PRODUCTION LOCATIONS AND PIPELINE SYSTEMS
POTENTIAL PRODUCTION LOCATION
POLAR GAS SYSTEM
MID-SIZED OIL SYSTEM
SMALL OIL SYSTEM
10 0 10 20 30 40 50 Km.
10 0 10 20 30 Miles

TABLE 2

ACTIVITIES/FACILITIES/EVENTS ASSOCIATED
WITH CONSTRUCTION OF A MID-SIZED OIL PIPELINE

DIRECTLY ASSOCIATED ACTIVITIES/FACILITIES/EVENTS

- selection of an offshore oilfield for production
- construction of islands/platforms at an offshore site to support production drilling, processing and storage facilities
- construction of a pipeline to bring offshore production ashore
- increased activity at shore support bases related to above items
- selection of one or possibly two onshore oilfields for production
- construction of drilling/production pads to support production drilling, processing and storage facilities at onshore production sites; drilling of production wells
- construction of overland pipelines to carry produced oil (both onshore and offshore) to a common point for injection into a mid-sized oil pipeline; production from wells and oil processing
- ongoing "work-over" activity at onshore and offshore production sites
- ongoing production drilling at initial production sites to replace production from exhausted wells
- placement of flowlines from gas processing facilities, if these exist, to points on the oil pipeline for the transport of hydrocarbon fluids produced at gas plants; flowlines to carry produced gas from oil production sites to gas production facilities, if the latter exist
- decisions by government and operators with reserves in fields other than those selected above to proceed with production drilling in order to bring reserves to market, causing additional directly associated activities/facilities/events as already outlined

INDIRECTLY ASSOCIATED OR "SPIN OFF" ACTIVITIES/FACILITIES/EVENTS

- increased interest in exploration activity and therefore increased seismic survey and exploratory drilling throughout the MEMP area
- the discovery of new reserves as a result of increased exploration activity (above)
- positive feedback from new discoveries causing an intensification of exploratory effort and incentive to plan and construct additional facilities to transport products to market

metering and storage facilities at or near the point of land-fall. Summaries describing pipeline construction, development drilling and oil processing systems are included in section 5.0.

A summary of activities/facilities that might be expected in association with a mid-sized oil line is presented in Table 2.

4.4 A Potential Small Diameter Oil Pipeline

Esso Canada Resources Limited is presently considering a "small" oil pipeline (@ 300 mm) to carry Mackenzie Delta oil reserves south to market via an interconnection with the Norman Wells Pipeline. Construction of such a system is considered possible by the early 1990's. The pipeline route would follow essentially that put forward by Polar Gas for a gas pipeline south from the Delta region to the vicinity of Norman Wells (Map 4). Gathering laterals would be installed on the Tuktoyaktuk Pennisula and possibly Richards Island. Reserves at the above two locations would be the primary candidates for development. Possible production sites are Ivik, Kumak, Kugpik, Niglintgak, Atkinson, Tuk, Mayogiak and Kamik (Map 2).

The maximum carrying capacity of the 300 mm diameter oil pipeline system would be @ 8 000 m^3/day but throughput would be determined by the availability of excess capacity in the Norman Wells Pipeline. Excess capacity is presently available, if additional pumping power were installed, and is expected to increase by 1991 due to decreased production from the Norman Wells field. Such limited capacity could likely be supplied from one or two onshore fields using production pads of 20-40 wells at each field. Despite the relatively limited carrying capacity of a small oil pipeline, installation of such a system could be expected to spur interest in exploration and development in the Mackenzie Delta area and throughout the MEMP study area.

Production drilling and processing facilities at the fields chosen to supply the small oil pipeline would be scheduled for completion to match that of the pipeline.

TABLE 3

ACTIVITIES/FACILITIES/EVENTS ASSOCIATED
WITH CONSTRUCTION OF A "SMALL" OIL PIPELINE

DIRECTLY ASSOCIATED ACTIVITIES/FACILITIES/EVENTS

- construction of production drilling/processing pads at one or possibly two onshore oilfield locations on the Tuktoyaktuk Peninsula or Richards Island

- production drilling at each site(s) chosen above

- construction of processing facilities at the site(s) chosen above and placement of pipeline laterals from production sites to an injection point on the mainline system

- operation of production/processing facilities

- increased activity at Inuvik, possibly Tuktoyaktuk, along the Dempster Highway and along river barge routes and winter roads to support above

- ongoing "work-over" drilling activity at production sites

- placement of flowlines from gas processing facilities, if these exist, to injection points on the oil pipeline to allow the transport of hydrocarbon fluids produced during gas processing; flowlines to carry gas produced at oil production facilities to gas processing facilities, if the latter exist

- ongoing production drilling at initially chosen site(s) to replace production from exhausted wells

- additional production drilling and processing by operators not involved in the initial production (above) at new locations causing additional associated activity similar to that outlined above

INDIRECTLY ASSOCIATED OR "SPIN OFF" ACTIVITIES/FACILITIES/EVENTS

- increased interest in exploration activity in the Mackenzie Delta region and throughout the MEMP study area

- discovery of new reserves as a result of increased exploration activity (above)

- positive feedback from new discoveries increasing incentives for development that other smaller support bases previously active at Tunnunuk Point, Swimming Point, Point Farewell and Pullen Island would be re-activated to support onshore as well as offshore development in the immediate vicinity of the Delta. Of the two new support bases, only the facility on the western side of the Delta falls within the terms of reference for MEMP. The existing and proposed development at McKinley Bay is located on artificial substrate lying immediately offshore.

On the western edge of the Mackenzie River Delta development of port facilities has been proposed at both King Point and Stokes Point. Of the two, King Point has received the most active recent consideration with proposals for port development being pursued by both Peter Kiewit and Sons Ltd. and a partnership between Montreal Engineering Company Limited and Interlog Consultants Limited. The former proposal involves the construction of a port, camp facilities and a road inland to a quarry site. The primary purpose of the undertaking would be the quarrying and sale of rock to American and Canadian Beaufort Sea operators. Secondary income would/could be derived from expediting/storing material and providing a base for offshore drilling operations. The Montreal Engineering Company Limited/ Interlog Consultants Limited proposal is for the creation of a "private port" which would presumably derive income through offerring a wide variety of port facilities to Beaufort Sea operators. Both groups have made formal applications for surface leases but to date these applications have not been dealt with.

Previously, the possible requirement for deep water port facilities on the western edge of the Mackenzie Delta was addressed in the Beaufort Sea-Mackenzie Delta Environmental Impact Statement. In that document both Stokes Point and King Point were considered as candidate sites for port development and the possibility of an all weather road being constructed from the Dempster Highway to the chosen site was suggested. Spokesmen for companies supporting the Beaufort Sea-Mackenzie Delta Environmental Impact Statement presently suggest a road link to a western port is not necessary.

All proposals put forward previously by Beaufort Sea operators as well as more recent proposals involve the establishment of deep water docking facilities, substantial material storage, aircraft landing facilities and relatively large camps for operating and itinerant personnel.

A summary of activities and facilities that might be expected to be associated with development of a small oil pipeline system is presented in Table 3.

4.5 The Dempster Lateral Pipeline

As part of the plan put forward for the Alaska Highway Gas Pipeline system, Foothills Pipe Lines (Yukon) Ltd. proposed a Dempster Lateral Gas Pipeline to carry Canadian gas reserves from the Mackenzie Delta to the mainline system in Yukon. Plans for the mainline Alaska Highway Gas Pipeline system are presently in abeyance but may possibly be re-activated in the early to mid 1990's. If the mainline system were to be completed in the mid to late 1990's a Dempster lateral might be constructed in the late 1990's and early years of the next century. Such development would be appropriate only if the Polar Gas Pipeline or similar system were not in place at that time.

Development activities associated with a Dempster Lateral Gas Pipeline would be similar in most respects to those set out for the Polar Gas Pipeline (Table 1) with the exception that indirectly associated or spin-off activity would tend to occur in the Mackenzie Delta area and in Yukon Territory rather than along the Mackenzie River Valley.

4.6 Offshore Development

While development and activity in offshore locations is outside the terms of reference for MEMP, consideration of shore based facilities and activities which will result from or support offshore development is not. Facilities which presently support offshore exploration are located primarily in Tuktoyaktuk with important but secondary support facilities in Inuvik. Because both communities are important centers of transport and transhipment for the entire region, they can be expected to continue as centers of activity during ongoing development.

Other support bases have been proposed for offshore development. These include a major support base and facility on the western side of the Mackenzie Delta at either King or Stokes Point and a site along the Tuktoyaktuk Peninsula at McKinley Bay. It might reasonably be expected

5.0 DEVELOPMENT ACTIVITIES AND FACILITIES

Previous sections have outlined the state of hydrocarbon development in several regions within the MEMP study area together with major transport system proposals which will control future development. Accepting the nature and timing of the several transport proposals put forward a picture of the kind and direction of future development can be perceived. That picture is one of accelerating development over the next 20 years. While that is likely an accurate impression of the future development, uncertainties exist with respect to the timing and therefore the intensity of development. Hydrocarbon market conditions directly influence the viability of pipeline systems. Conditions which caused transport systems considered technically feasible to be uneconomic would slow and possibly eliminate hydrocarbon development in the study area. The discovery of hydrocarbon reserves in both the Colville Lake region and in areas adjacent to Norman Wells is also uncertain. Failure to locate reserves would of course directly affect future hydrocarbon activity and development in those areas.

As uncertainties cannot be avoided and because potential development would vary widely in response to factors of uncertainty, it may be desirable to examine a range of scenarios. Selection of the most appropriate single scenario or group of scenarios will be an important step in the MEMP effort. To assist in the evaluation of potential scenarios, a series of activity summaries is included (following). These are designed to describe the nature and general intensity of each activity and/or facility in terms that can be related to environmental disturbance or concern. Additional information will be available to meet specific demands during the workshop and/or additional summaries can be prepared. Checklists of facilities and activities associated with hydrocarbon development follow.

FACILITIES

Camps	Permanent Access Roads
Temporary Roads	Temporary Airstrips
Permanent Roads	Permanent Airstrips
Temporary Access Roads	Temporary Wharves

Permanent Wharves

Staging Sites

Borrow Pits

Support Bases

Exploration Drill Sites

Production Drill Sites (platforms)

Oil Processing Facilities

Gas Processing Facilities

Gathering Lines

Gathering System Terminal(s)

Fuel Storage Facilities

Right-of-way

Oil Pipelines

Gas Pipelines

Pump Stations

Compressor Stations

Topping Plant(s)

Water Supply

Fuel Storage

Reclamation

Tree Harvesting for Wood Chips

Gravel/Borrow Removal

Gravel/Borrow Placement

Water Injection

Gas Injection

ACTIVITIES

Ground Transportation

Air Transportation

Water Transportation

Clearing

Grading/Ditching

Blasting

Water Withdrawal

Domestic Waste Disposal

Industrial Waste Disposal

Exploration Drilling

Delineation Drilling

Pipeline Construction

Pipeline Operation

Gas Processing

Oil Processing

SUMMARY DESCRIPTION

SEISMIC EXPLORATION

Seismic surveys vary widely in character depending upon the specific information sought. Some involve three to four men traversing survey lines in summer carrying sophisticated light-weight sensors. The more usual approach involves large crews, the use of heavy equipment and explosives. The latter surveys are usually undertaken in winter over frozen ground.

SURFACE DISTURBANCE:	- ranges from slash line to minor surface disturbance involving 0.5 - 0.8 ha/km
PERSONNEL:	- depending upon the nature of surveys being completed, crew size can vary from 4-60
ACCOMODATION:	- in most cases a mobile camp that moves with the work on a daily basis
MOBILE EQUIPMENT:	- 1-6 light units[1] - 0-10 medium units - 0-6 heavy units
ACCESS:	- usually via temporary winter roads and along cleared survey track; in some cases by helicopter
FREIGHT TO SITE:	- consumables by helicopter and/or supply vehicle
AIRCRAFT:	- infrequent helicopter support
FUEL:	- to support type and numbers of mobile equipment, transported in mobile tanks; resupply along survey line or along other appropriate access routes; recent surveys have required 700 to 900 l/km surveyed
AIR EMISSIONS:	- fuel combustion
FLUID WASTES:	- domestic - nil to 8 m^3/day to ground - industrial wastes - nil
SOLID WASTES:	- domestic - incinerated - industrial - nil
NOISE:	- vehicular operation
GRAVEL REQUIREMENTS:	- nil
DURATION OF ACTIVITY:	- for complete survey - days to several months - at any one location - fraction to several days

1 light units under 3 tonnes; medium units 3-10 tonnes; heavy units 10+ tonnes; super heavy units 50+ tonnes.

SUMMARY DESCRIPTION

SEISMIC EXPLORATION
(cont'd)

REGIONAL ACTIVITY/TIME PROFILE*
km (000) seismic survey

Region	Total To Date	1985-89	1990-94	1995-99	2000-04	Cumulative Total
Norman Wells		**16	16	10	10	52**
Colville Lake		**28	70	100	80	278**
Mackenzie Delta		**51	130	120	80	381**

* The level of future exploration activity in the MEMP study area is dependent upon a number of variables. In the short-term the availability of additional land for exploration, the nature of fiscal arrangements affecting exploration expenditures and land claims are factors which may affect decisions by firms active in exploration. Other factors having longer-term significance include world energy prices, the result of ongoing exploration efforts and the presence/absence/likelihood of transport systems to move potential discoveries to market. As a result of these several factors most firms active in seismic exploration within the MEMP study area can not predict future levels of effort beyond the budgetary period in which they are presently operating.

Future levels of seismic exploration indicated in the above table are **assumed** and are based on the scenario outlined in section 6.0.

** Statistical summaries for seismic surveys reviewed used units not easily combined. Prior to 1981 seismic survey effort was expressed as "seismic crew months" (Indian and Northern Affairs Canada, 1984) while recent summaries (Canada Oil and Gas Lands Administration, Annual Reports) express seismic survey effort as "km of seismic survey shot". To appreciate the magnitude of previous seismic activity and its distribution, MEMP participants can consider the following:

- between 1961 and 1981 a total of 1786 crew months of seismic work was completed in Yukon Territory and N.W.T. Effort varied from an annual low of 5 crew months in 1979 to a high of 235 crew months in 1972.
- recent statistics expressed as thousands of kms of seismic survey shot by year are:

	1984	1983	1982	1981	Total
- all Canada lands	63.8	106.7	117.8	84.8	383.1
- mainland territories	5.3	2.7	3.5	.3	11.8
- Mackenzie Delta/Beaufort Sea	7.9	7.6	6.3	13.0	34.8

SUMMARY DESCRIPTION

EXPLORATION DRILLING

Exploration drilling can vary widely in character depending upon site conditions, equipment used and season of drilling. In the Delta region drilling equipment is usually supported on gravel pads or upon pile supported platforms. Access in Delta locations may be by helicopter or more usually over winter roads; barge transport is often utilized during open water periods. In other areas drilling may be completed in winter on frozen ground with little site preparation other than clearing and levelling.

SURFACE DISTURBANCE:	- 2-3 ha
PERSONNEL:	- 30-50
ACCOMODATION:	- temporary portable camp
MOBILE EQUIPMENT:	- during site preparation 5-10 light units[1] 10-20 heavy units - during operation 3-6 light units 2-3 heavy units
ACCESS TO SITE:	- winter roads (most cases) - barge transport (some delta locations) - helicopter transport (some remote locations)
FREIGHT TO SITE:	- for rig, camp and consumables 300 truck loads initial 150 truck loads resupply; or 1500 helicopter lifts initial 600 helicopter lifts resupply - for gravel pad if used 1500 truck loads
FREIGHT FROM SITE:	- for rig and camp 75 trucks; or 30 helicopter lifts - for gravel if salvaged 1200 truck loads
AIRCRAFT:	- for helicopter rig - 5-10 flights/day during drilling for resupply - for land supported drilling - 2 flights/day using light fixed or rotary wing craft
FUEL:	- 10 000 l/day (includes all activities/requirements)
FUEL STORAGE:	- 40 000 l when resupply possible - 600 000 l to 1 500 000 l when resupply not possible (freeze-up and break-up)

[1] light units under 3 tonnes; medium units 3-10 tonnes; heavy units 10+ tonnes; super heavy unit 50+ tonnes.

SUMMARY DESCRIPTION

EXPLORATION DRILLING
(cont'd)

AIR EMISSIONS:	- fuel combustion - brief flaring from well possible
FLUID WASTES:	- domestic 4-7 m^3/day to sump - used mud and cuttings 1000-2000 m^3/well to sump
SOLID WASTES:	- domestic - incinerated daily - industrial drill cuttings 200-400 m^3/well to sump
NOISE:	- 65 to 75 dBA @ 20 m - attenuates to background @ 500-1000 m
GRAVEL REQUIREMENTS:	0 to 50,000 m^3 depending upon site conditions and use of pile supports
DURATION OF ACTIVITY:	60-120 days

REGIONAL ACTIVITY/TIME PROFILE*
of exploration wells

Region	Total To Date	1985-89	1990-94	1995-99	2000-04	Cumulative Total
Norman Wells	400+	50	70	30	25	575+
Colville Lake	7	35	70	70	60	242
Mackenzie Delta	146	64	150	100	65	525

* The level of future exploration activity in the MEMP study area is dependent upon a number of variables. In the short-term the availability of additional land for exploration, the nature of fiscal arrangements affecting exploration expenditures and land claims are factors which may affect decisions by firms active in exploration. Other factors having longer-term significance include world energy prices, the result of ongoing exploration efforts and the presence/absence/likelihood of transport systems to move potential discoveries to market. As a result of this complex of factors most firms undertaking exploration in the area are unable to confidently predict levels of exploration effort beyond the immediate budgetary period in which they are operating.

Future levels of exploratory drilling effort indicated in the above table are **assumptions** based on the scenario outlined in section 6.0.

SUMMARY DESCRIPTION

PIPELINE CONSTRUCTION

Pipeline construction can involve widely varying levels of effort depending upon the size and nature of pipe being installed. For gathering lines, small crews using limited equipment are involved in localized areas. For transmission lines, construction effort is divided into sections called "spreads". Each spread is completed by a spread crew responsible for all activity within the assigned area. Spread crews can vary in size from 400 to 800 men. Length of spread is determined by the length of the construction season (usually three winter months) and the difficulty anticipated due to terrain. Spread lengths can vary from 100 to 200 km and for any project several spreads may be active along the pipeline route in any one season.

SURFACE DISTURBANCE:	- right-of-way (ROW) 2.5-3.5 ha/km - access roads, stockpile sites, compressor/ pump stations an average of @ 1 ha/km
PERSONNEL:	- mainline construction 600-800/spread - facility construction (compressor/pump stations) 50-200
ACCOMODATION:	- temporary, portable camps
MOBILE EQUIPMENT:	- mainline construction spread light 100[1] medium 100 heavy 100 super heavy 10 plus 150 specialized partially mobile pieces of equipment
ACCESS:	- along a limited number of winter access roads to ROW - most movement (access) along ROW
FREIGHT TO SITE:	- pipe - cast weights - select backfill - pump/compressor components
AIRCRAFT:	- light helicopter at each mainline camp for medi-vac and intermittent survey
FUEL:	- for equipment operation; moved from stockpile sites or storage sites at camps daily by fuel (service) trucks; recent small pipeline installation used @ 15 000 l/km for mobile equipment only;

[1] light units under 3 tonnes; medium units 3-10 tonnes; heavy units 10+ tonnes; super heavy units 50+ tonnes.

SUMMARY DESCRIPTION

PIPELINE CONSTRUCTION
(cont'd)

FUEL: (cont'd)		big inch estimates for north, such as Alaska Highway Gas Pipeline, involve > 300 000 l/km for mobile equipment
	-	for space heating @ 4 gals/man/day
AIR EMISSIONS:	-	fuel combustion
FLUID WASTES:	-	domestic 0.2-0.3 m^3/man/day to lagoons or treatment plants at camps
	-	industrial - test fluids to ground or to lagoons/treatment facilities
SOLID WASTES:	-	domestic - incinerated with remains to landfill
	-	industrial - primarily spoil to ground; other to landfill
GRAVEL/FILL REQUIREMENTS:	-	1000-3000 m^3/km - includes requirements for all ROW and facilities (access roads, camp pads etc.)
DURATION OF ACTIVITY:	-	spread duration 60-120 days
	-	project duration 1-3 years

REGIONAL ACTIVITY/TIME PROFILE*
km of mainline pipeline constructed

Region	Total To Date	1985-89	1990-94	1995-99	2000-04	Cumulative Total
Norman Wells	290**	100	200	100	0	690
Colville Lake	0	150	300	150	0	600
Mackenzie Delta	0	75	150	75	0	300

* Assumes construction dates presently predicted by pipeline proponents apply and relies on a geographic partitioning of the MEMP study area as follows:

Mackenzie Delta region = tidewater to Inuvik = 150 km
Colville Lake region = Inuvik to Ft. Good Hope = 300 km
Norman Wells region = Ft. Good Hope to Ft. Norman = 200 km

** Includes recently completed IPL oil pipeline of which approximately 90 km lies within the study area and the Canol Pipeline of which 200 km is assumed to lie within the defined MEMP study area.

SUMMARY DESCRIPTION

PIPELINE OPERATION

Gas and oil pipelines are designed to operate with a minimum of maintenance effort. Product movement is achieved through the operation of pumps/compressors at intervals along the pipeline. The pipe is maintained so as to be physically secure through regular right-of-way (ROW) maintenance and chemical conditions both within and around the pipe are monitored and, if necessary, controlled. Personnel and equipment required for maintenance are a small fraction of that required for construction. The nature of contractual arrangements for the delivery of product by a pipeline operator are such that a premium is placed on preventive maintenance leading to uninterrupted flow of product. Unplanned interruptions in flow are viewed as emergencies and dealt with as such.

SURFACE DISTURBANCE:	- areas disturbed during construction are stabilized and a cover of low growing vegetation is planted or encouraged to grow, primarily for erosion control; areas near compressors/pumps/fuel storage are cleared of vegetation to prevent fires; access to and along the ROW is maintained at least in the form of a single vehicle width track
PERSONNEL:	- varies with area and type of pipeline; Polar Gas anticipate @ 60 persons working from each of two district centers (Inuvik and Norman Wells) along @ 650 km of pipeline in the MEMP area
ACCOMODATION:	- operations personnel generally live in communities in which their operations offices are located; provision for temporary accomodation at pump/compressor facilities and at other remote locations frequently visited by operations staff are characteristically part of northern operations
MOBILE EQUIPMENT:	- for each operations district responsible for 200-300 km of pipeline light 10-20 medium 5-10 heavy 10-20
STATIONARY EQUIPMENT:	- for gas pipelines of 800-1 000 mm diameter, working near capacity, compressor stations of 10-15 000 kW power at about 100 km spacing would be required; chilling adds @ 50% - for oil pipelines of around 500 mm diameter, working near capacity, pump stations of around 4 000 kW would be required every 60 to 80 km

SUMMARY DESCRIPTION

PIPELINE OPERATION
(cont'd)

ACCESS:	- access to all pipeline facilities (ROW) must be available at all times to allow emergency repair
	- for normal operations much of the "available" access will not be used or will be used within predetermined time periods to avoid disturbance
AIRCRAFT:	- each operations district will have or regularly use 1-2 light aircraft (fixed or rotary wing)
FUEL:	- to operate vehicle equipment - diesel
	- to operate stationary equipment - natural gas
AIR EMISSIONS:	- fuel combustion
FLUID WASTE:	- domestic to community systems or lagoons
	- industrial lubricants etc recycled or incinerated
SOLID WASTE:	- inconsequential amounts
GRAVEL/FILL REQUIREMENTS:	- for access and ROW maintenance > 10 m^3/km/year
DURATION OF ACTIVITY:	- 10-50 years +

REGIONAL ACTIVITY/TIME PROFILE*
km of pipeline operated

Region	Total To Date	1985-89	1990-94	1995-99	2000-04	Cumulative Total
Norman Wells	90**	90	290	490	490	
Colville Lake	0	0	300	600	600	
Mackenzie Delta	0	0	150	150	300	

* Assumes construction dates presently predicted by pipeline proponents apply and relies on georgraphic positioning of the MEMP study area as follows:

Mackenzie Delta region = tidewater to Inuvik = 150 km
Colville Lake region = Inuvik to Ft. Good Hope = 300 km
Norman Wells region = Ft. Good Hope to Ft. Norman = 200 km

** Assumes 90 km of IPL Pipeline lies within MEMP study area.

SUMMARY DESCRIPTION

PRODUCTION DRILLING

Production drilling is similar to exploratory drilling in most respects but may involve multiple rigs active at a single site over longer periods of time. The activity consists of drilling a number of wells for use in producing reserves in quantity and/or for re-injection of unwanted produced materials (produced water, surplus gas or oil). At a production site drilling activity continues at a reduced rate after production begins as a result of well-workovers and the requirement for additional wells to maintain production.

Plans for the Delta region call for production clusters consisting of multiple wells drilled directionally from a single support pad or platform. More than one platform may be involved in the development of a single field. Production drilling in other regions within the MEMP area may vary from that planned on the Delta and more closely resemble conventional approaches with widely spaced single wells.

In a production cluster situation processing equipment will be placed on the production drilling pads/platforms and the two activities (production drilling and production processing) will occur simultaneously, in close proximity, for the productive life of the field.

SURFACE DISTURBANCE:	- 4 to 5 ha at site - 10 to 45 ha at gravel source - 20-40 ha for access roads in a multi-cluster situation
PERSONNEL:	- 50 to 150 depending upon stage of activity
ACCOMMODATION:	- portable camp(s)
MOBILE EQUIPMENT:	- during site preparation 20 light[1] 200+ heavy - during drilling 3-5 light 2-5 medium 10-20 heavy
ACCESS TO SITE:	- temporary winter roads - over permanent access roads from wharves - via STOL aircraft or helicopters
FREIGHT TO SITE:	- for rigs (3), camp and initially required consumables 800 truck loads initial 150 truck loads resupply if drilling 5-10 wells - for gravel pad 10 000+ truck loads

1 light units under 3 tonnes; medium units 3-10 tonnes; heavy units 10+ tonnes.

PRODUCTION DRILLING
(cont'd)

FREIGHT FROM SITE:	- for rigs (3) and camp 300 truck loads - for gravel if salvaged 10 000 + truck loads
AIRCRAFT:	- light aircraft (fixed-wing or rotary) 4-6 flights/day - medium fixed-wing 1/day - heavy fixed-wing 1/week
FUEL:	- 30 000 l/day assuming 3 rigs
FUEL STORAGE:	- during freeze-up/break-up @ 2 000 000 l
AIR EMISSIONS:	- fuel combustion - brief flaring from well tests
FLUID WASTES:	- domestic 10-30 m^3/day to sump(s) - used mud and cuttings 1000-2000 m^3/well to sump(s) - wash water 10-30 m^3/day to sump(s)
SOLID WASTES:	- domestic - incinerated - industrial - 200-400 m^3/well to sump
GRAVEL REQUIREMENTS:	- 200-300 thousand m^3
DURATION OF ACTIVITY:	- depending upon number of wells required and number of rigs used, initial drilling of production and disposal wells could be completed in @ 6 months. One rig would likely be kept at the site for well workovers and future drilling requirements. The latter activities would continue for the duration of production (20 years).

REGIONAL ACTIVITY/TIME PROFILE

# of Production Clusters	To Date	1985-89	1990-94	1995-99	2000-05
Mackenzie Delta	0	0	15	20	20
Colville Lake	0	0	0	0	0
Norman Wells	8+	10	12	14	18

Above figures are based on present activity at Norman Wells and the scenario outlined in section 6.0. It is assumed production drilling in the Colville Lake area will be completed at widely spaced single wells rather than clusters. Numbers of production wells assumed for Colville Lake in the four time periods are 0, 30, 55 and 50 (see section 6.0).

SUMMARY DESCRIPTION

PRODUCTION PROCESSING

Plans for processing produced hydrocarbons in the Delta area involve placement of processing equipment on support adjacent to or contiguous with that used for production drilling. In other parts of the study area processing facilities will not necessarily be in close proximity to production wells.

Processing of gas involves the removal of hydrocarbon liquids and drying (removal of water) before injection into transmission pipelines. Oil processing involves the separation of hydrocarbon fluids from entrained gas and water. In both cases, produced water is usually disposed of to injection wells. Hydrocarbon fluids produced in the gas process are used for fuel on-site, piped to adjacent oil processing facilities or re-injected. Similarly, gas produced at oil processing facilities can be re-injected, used as fuel or marketed, if transportation systems are nearby.

In Delta regions surface disturbance, personnel, accomodation, construction equipment and access to sites will be similar to and in most cases shared with those outlined for production drilling (see previous summary). Additional freight to and from the site will arise from the completion of processing facilities as well additional industrial emissions and wastes.

6.0 A POSSIBLE DEVELOPMENT SCENARIO

A multitude of possible hydrocarbon scenarios for the MEMP area can be formulated. The scenario outlined on the following pages is based on past and existing development in the MEMP study area and upon the authors views of what is likely to occur in future. MEMP participants may disagree with all or part of the scenarios presented. Discussion of points of difference within the various workshop groups and at general participant meetings is essential if a scenario suitable for supporting workshop decisions concerning environmental monitoring is to be developed.

The following scenario is relatively optomistic. It sees two of the proposed transport systems, the Polar Gas Pipeline and the Mid-sized Oil Pipeline, going ahead on a schedule which approximates that presently desired by the proponents. It assumes additional hydrocarbon discoveries in the Mackenzie Delta region and in the Colville Lake region but not near Norman Wells. Levels of seismic exploration, exploration drilling, oil and gas production, oil and gas processing and increases in the capacity of transport systems that might reasonably be expected to arise are assumed and inserted in appropriate sequences.

ACTIVITIES, FACILITIES, EVENTS WITHIN THE MEMP STUDY AREA

MACKENZIE HYDROCARBON DEVELOPMENT SCENARIO

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
TRANSPORT SYSTEM(S)																						
CONSTRUCTION OPERATION																						
1. 324 mm Norman Wells to Zama Lake oil pipeline																						
2. 914 mm Mackenzie Delta to Edson natural gas pipeline																						
3. 400 - 600 mm Mackenzie Delta to Zama Lake oil pipeline																						
• kilometres (00) of mainline pipe installed and operating	1	1	1	1	1	1	1	1	8	8	8	8	8	14	14	14	14	14	14	14	14	@ 14
• kilowatts (000) of power (pump/compression/chilling) operating	1	1	1	1	1	1	1	1	23	23	23	23	23	46	46	46	46	46	46	46	46	@ 46
• # of pump/compressor stations operating	1	1	1	1	1	1	1	1	3	3	3	3	9	9	9	9	9	9	9	9	9	9
• # of heater stations operating	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Transport systems included in the scenario are those now in place, planned or being considered.

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
ADDITIONAL DISCOVERY OF HYDROCARBONS																						
1. Norman Wells region																						
oilfield	1																					1
gas field	0																					0
2. Colville Lake region																						
oilfield	0																					0
gas field	0						$\boxed{1}$					$\boxed{1}$					$\boxed{1}$					3

cont'd

MACKENZIE HYDROCARBON DEVELOPMENT SCENARIO (cont'd)

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
3. Mackenzie Delta (onshore)																						
oilfield	4				$\boxed{1}$					$\boxed{1}$					$\boxed{1}$					$\boxed{1}$		8
gas field	3							$\boxed{2}$						$\boxed{2}$					$\boxed{2}$			9
4. Beaufort Sea (offshore)																						
oilfield	3			$\boxed{2}$					$\boxed{2}$					$\boxed{2}$					$\boxed{2}$			11
gas field	3				$\boxed{2}$					$\boxed{2}$					$\boxed{2}$					$\boxed{2}$		11

Discovery of additional hydrocarbon reserves is assumed for scenario purposes.

SEISMIC EXPLORATION (000) km of survey completed	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
1. Norman Wells region	*	2	2	2	5	5	5	5	2	2	2	2	2	2	2	2	2	2	2	2	2	52*
2. Colville Lake region	*	2	3	3	10	10	10	15	15	15	15	20	20	20	20	20	20	15	15	15	15	278*
3. Mackenzie Delta region	8	7	7	7	10	20	20	20	30	30	30	30	25	25	20	20	20	15	15	15	15	381*

A level of seismic exploration activity reflective of recent trends is inserted in the first several years of the scenario. As the scenario develops levels of seismic exploration are assumed to reflect likely reaction to the announcement and installation of transportation systems and the announcement of additional hydrocarbon discoveries assumed above.

* Statistics for seismic survey are difficult to relate to the study regions identified for MEMP. Statistics kept before 1981 were generally expressed as "seismic crew months". Since 1981 statistics published by COGLA are expressed as "km of seismic shot". In both pre 1981 and recent data summaries figures are given for regions not directly comparable to those of most use in MEMP. To give MEMP participants an appreciation of the magnitude of previous activity the following statistics are included here:

- between 1960 and 1981 a total of 1786 crew months of seismic work was completed on Yukon and NWT lands.

- statistics for recent years expressed as thousands km seismic shot

	1984	1983	1982	1981	TOTAL
- all Canada Lands	63.8	106.7	117.8	84.8	373.1
- mainland territories	5.3	2.7	3.5	.3	11.8
- Mackenzie Delta-Beaufort Sea	7.9	7.6	6.3	13.0	34.8

MACKENZIE HYDROCARBON DEVELOPMENT SCENARIO (cont'd)

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	YEAR 85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
EXPLORATION DRILLING # of wells																						
1. Norman Wells region	400+	10	5	5	15	15	15	15	15	15	10	10	5	5	5	5	5	5	5	5	5	575+
2. Colville Lake region	7	5	5	5	10	10	10	20	20	10	10	10	20	20	10	10	10	20	10	10	10	242
3. Mackenzie Delta region	146	7	7	10	20	20	30	30	30	30	30	20	20	20	20	20	15	15	15	10	10	525

A level of exploration drilling activity reflective of recent trends is inserted in the first several years of the scenario. As the scenario develops additional drilling can be expected to result from the announcement and completion of transport systems and is assumed to result from the announcement of additional discoveries as these are made.

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
PRODUCTION DRILLING # of wells																						
1. Norman Wells region	90	10	10	10	10	10	12	12	12	12	12	14	14	14	14	14	18	18	18	18	18	380
2. Colville Lake region	0								5	10	15	15	10	10	10	10	10	10	10	10	10	135
3. Mackenzie Delta region	0						30	60	30	40	30	30	30	30	30	30	30	30	30	30	30	490

Production drilling inserted in the scenario includes that now being completed at the Norman Wells field to supply the recently completed IPL Oil Pipeline and that expected to maintain future pipeline throughput. Also inserted is an assumed level of drilling required to prepare for and support gas pipeline and oil pipeline operation shown under "transportation systems". Discovery of natural gas and production is assumed for the Colville Lake area. Assumed production drilling figures include allowance for drilling of additional wells to maintain production lost through exhaustion of initially drilled wells.

Approaches to production drilling will be different in the several study regions. In the Mackenzie Delta area drilling will be concentrated on a small number of drilling pads from which individual wells will be directionally drilled to tap different portions of the reservoirs. In the Colville Lake area it is likely that wells will be independently located. In the Norman Wells area both approaches will be used.

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
• multiple well pads																						
Norman Wells region	9			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27
Colville Lake region	0																					0
Mackenzie Delta region	0					1	7	7	3	3	3	3	3	3	3	3	3	3	3	3	3	54

MACKENZIE HYDROCARBON DEVELOPMENT SCENARIO (cont'd)

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005

Producing wells require maintenance "workover drilling" which in many respects resembles drilling activity proper. As a result activity at production well-sites can be expected to be ongoing on an intermittent basis (once per year) at single independently located wells and continuously at directionally drilled clusters.

Production at any well usually consists of a mixture of oil, gas (liquid and gaseous hydrocarbons) formation water and quantities of formation detritus or other entrained materials. To allow transport of gas to processing facilities where it can be properly conditioned for injection into transport systems some level of on-site production processing is attempted. Such processing usually consists of separation of water and detritus, separation of gaseous and liquid hydrocarbon, re-injection of produced but unwanted materials and injection of gas to a small diameter flowline for transport to centralized facilities. These activities require outside activity and equipment.

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
GAS PROCESSING AT A CENTRALIZED FACILITY																						
CONSTRUCTION / OPERATION																						
1. Norman Wells region	0																					0
2. Colville Lake region	0									1												1
3. Mackenzie Delta region	0						3															3

Produced natural gas requires a degree of treatment and conditioning before injection into transmission lines. The number and location of gas plants shown here reflects those proposed/planned in the Mackenzie Delta area to support a transmission line (Polar Gas 914 mm) as well as a single plant assumed for the Colville Lake area.

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
GATHERING LINE SYSTEMS FOR GAS PROCESSING # km installed that year																						
1. Norman Wells region	0																					0
2. Colville Lake region	0									50	50		50		50		50		50		50	350
3. Mackenzie Delta region	0						50	50		50		50		50		50		50		50		400

Figures shown reflect those expected to support the initial requirements of gas plants proposed/planned/assumed above as well as those required to connect additional production sites to processing plants as initially drilled production wells are exhausted.

MACKENZIE HYDROCARBON DEVELOPMENT SCENARIO (cont'd)

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
OIL PROCESSING AT PRODUCTION CLUSTERS # of facilities																						
1. Norman Wells region	0																					0
2. Colville Lake region	0																					0
3. Mackenzie Delta region												2										2

Oil processing facilities shown are those required to support the mid-sized oil pipeline (production from one offshore field and two onshore fields). Only onshore facilities are shown. Oil is assumed not to exist in the Colville Lake region. Oil in the Norman Wells area is presently processed at a centralized facility (see below).

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
OIL PROCESSING AT CENTRALIZED FACILITIES # of facilities																						
1. Norman Wells region	1																					1
2. Colville Lake region	0																					0
3. Mackenzie Delta region	0																					0

Oil from production sites in the Norman Wells field is presently gathered via a 40 kilometre long pipeline which carries it to central processing facilities in Norman Wells. Production techniques for oil in the Mackenzie Delta area are outlined in the previous section. Oil is assumed to be absent from the Colville Lake area.

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	TOTAL TO 2005
GATHERING LINE SYSTEMS FOR OIL (PRE-MAINLINE INJECTION) # km installed that year																						
1. Norman Wells region	40																					40
2. Colville Lake region	0																					0
3. Mackenzie Delta region	0										100	50										150

Gathering lines assumed are those necessary to connect two producing oil fields (onshore) to a common injection point on the mid-sized oil pipeline proposed.

MACKENZIE HYDROCARBON DEVELOPMENT SCENARIO (cont'd)

ACTIVITY/FACILITY/EVENT	TOTAL TO DATE	YEAR																				TOTAL TO 2005
		85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	
SUPPORT BASES																						
CONSTRUCTION # — OPERATION																						
1. Norman Wells region	0																					0
2. Colville Lake region	0																					0
3. Mackenzie Delta region	2						1															3

7.0 SOURCES OF INFORMATION CONCERNING DEVELOPMENT

BEAUFORT-DELTA OIL PROJECT LIMITED. undated.
Application to the National Energy Board in the matter of a Mackenzie River Valley oil pipeline.
- Volume II, Part 2: Facilities (location and description)
- Volume III, Part 2: Facilities (construction and maintenance)

Prepared by Beaufort-Delta Oil Project Limited, Calgary, Alberta (application not submitted).

CANADIAN ARCTIC GAS STUDY LIMITED. undated.
Application to the National Energy Board in the matter of a Mackenzie River Valley gas pipeline.
- Environmental Statement, Section 14.d, Chapter 5, Summarized project description
- Location, design and capacity of facilities, Section 8
- Connecting pipeline facilities, Section 9
- Operations and maintenance plans, Section 13b

Prepared by Canadian Arctic Gas Study Limited, Calgary, Alberta.

DOME PETROLEUM LIMITED, ESSO RESOURCES CANADA LIMITED AND GULF CANADA RESOURCES INC. 1982.
Environmental Impact statement for hydrocarbon development in the Beaufort Sea-Mackenzie Delta region.
- Volume 2, Development systems
- Volume 4, Biological and physical effects

Prepared by Dome Petroleum Limited, Esso Resources Canada Limited and Gulf Canada Resources Inc., Calgary, Alberta.

F.F. SLANEY & COMPANY LIMITED. 1974.
Environmental program, Mackenzie Delta N.W.T., impact assessment, Part 2, Summary of the development proposal. Prepared for Imperial Oil Limited, Gulf Oil Canada Limited, Shell Canada Limited and Arctic Gas Study Limited by F.F. Slaney & Company Limited, Vancouver, B.C.

F.F. SLANEY & COMPANY (ALBERTA) LIMITED. 1977.
Investigations of the aquatic resources of the Parsons Lake region and environmental impact assessment of the Parsons Lake gas development, Part 2, Description of the proposed development. Prepared for Gulf Oil Canada Limited by F.F. Slaney & Company (Alberta), Calgary, Alberta.

FOOTHILLS PIPE LINES (YUKON) LTD. 1976.
Application to the National Energy Board in the matter of an Alaska Highway gas pipeline.
- Volume 3, Facilities

Prepared by Foothills Pipe Lines (Yukon) Ltd., Calgary, Alberta.

FOOTHILLS PIPE LINES (YUKON) LTD. 1979.
Environmental Impact Statement for the Alaska Highway Gas Pipeline Project, Section 4.0 - Description of proposal - specific aspects. Foothills Pipe Lines (South Yukon) Ltd., Calgary, Alberta

FOOTHILLS PIPE LINES (YUKON) LTD. 1979.
Application to the National Energy Board in the matter of an Alaska Highway oil pipeline (amended application).
- Volume 3, Facilities and material specifications
Prepared by Foothills Pipe Lines (Yukon) Ltd., Calgary, Alberta.

FOOTHILLS PIPE LINES (YUKON) LTD. 1979.
Application to the National Energy Board in the matter of a Dempster Highway lateral gas pipeline.
- Volume 3, Facilities
Prepared by Foothills Pipe Lines (Yukon) Ltd., Calgary, Alberta

FOOTHILLS PIPE LINES (SOUTH YUKON) LTD. 1981.
Engineering, construction and environmental aspects of alternative design modes: submission 4-1 addendum to the environmental impact statement for the Alaska Highway Gas Pipeline.
Prepared by Foothills Pipe Lines (South Yukon) Ltd., Calgary, Alberta.

FOOTHILLS PIPE LINES (SOUTH YUKON) LTD. 1981.
Project description and update for addenda submissions: submission 2-1: addendum to the environmental impact statement for the Yukon section of the Alaska Highway Gas Pipeline.
Prepared by Foothills Pipe Lines (South Yukon) Ltd., Calgary, Alberta.

FOOTHILLS PIPE LINES (SOUTH YUKON) LTD. 1981.
Approach to watercrossing design and construction planning - submission 4-5: addendum to the environmental impact statement for the Yukon section of the Alaska Highway Gas Pipeline.
Prepared by Foothills Pipe Lines (South Yukon) Ltd., Calgary, Alberta.

FOOTHILLS PIPE LINES (SOUTH YUKON) LTD. 1981.
Aspects of project noise - submission 7-3: addendum to the environmental impact statement for the Yukon section of the Alaska Highway Gas Pipeline.
Prepared by Foothills Pipe Lines (South Yukon) Ltd., Calgary, Alberta.

FOOTHILLS PIPE LINES (SOUTH YUKON) LTD. 1981.
Waste disposal - submission 6-2: addendum to the environmental impact statement for the Yukon section of the Alaska Highway Gas Pipeline.
Prepared by Foothills Pipe Lines (South Yukon) Ltd., Calgary, Alberta.

FOOTHILLS PIPE LINES (SOUTH YUKON) LTD. 1981.
Fuels and other hazardous materials - submission 7-4: addendum to the environmental impact statement for the Alaska Highway Gas Pipeline. Prepared by Foothills Pipe Lines (South Yukon) Ltd., Calgary, Alberta.

GULF OIL CANADA LIMITED. 1975.
Parsons Lake Development Land Tenure Submission. Gulf Oil Canada Limited, Calgary, Alberta.

GULF OIL CANADA LIMITED. 1976.
Parsons Lake Development Land Tenure Submission Deficiency Response. Gulf Oil Canada Limited, Calgary, Alberta.

GULF OIL CANADA LIMITED. 1977.
Parsons Lake Development Land Tenure Submission Update: January 1977. Gulf Oil Canada Limited, Calgary, Alberta.

POLAR GAS PROJECT. 1984.
Application to the National Energy Board in the matter of a Mackenzie River Valley gas pipeline.
- Volume III, Facilities
Prepared by Polar Gas Project, Toronto, Ontario.

8.0 LITERATURE CITED

CANADA OIL AND GAS LANDS ADMINISTRATION. 1985.
The Canada Oil and Gas Lands Administration annual report 1984. Minister of Supply and Services Canada.

CANADA OIL AND GAS LANDS ADMINISTRATION. 1984.
The Canada Oil and Gas Lands Administration annual report 1983. Minister of Supply and Services Canada.

CANADA OIL AND GAS LANDS ADMINISTRATION. undated.
The Canada Oil and Gas Lands Administration annual report 1982. Department of Energy, Mines and Resources and Department of Indian Affairs and Northern Development.

NORTHERN OIL AND GAS OPERATIONS DIVISION. 1981.
North of 60 oil and gas statistical report No. 3 1920-1981. Minister of Supply and Services Canada.

OILWEEK. 1984.
Mackenzie/Beaufort Sea/N.W.T./Yukon exploration agreements. A supplement to Oilweek, July 30, 1984. Oilweek, Calgary.

APPENDIX B

LAND SUBSIDENCE AS A RESULT OF FLUID WITHDRAWAL

prepared by

J.E. McComiskey

GULF CANADA RESOURCES INC.

Calgary, Alberta

LAND SUBSIDENCE AS AS RESULT OF FLUID WITHDRAWAL

Deformation of surface terrain associated with the production of oil and gas can be caused by compaction of reservoir rocks when fluids are withdrawn. Subsidence due to withdrawal of fluids can occur when: a) reservoir fluid pressures are lowered, b) reservoir rocks are compactible (usually uncemented) and/or are unable effectively to resist deformation upon the transfer of load from the fluid phase to the grain-to-grain contacts, and c) overburden lacks internal self-support and can easily deform downward.

Rieke III and Chilingarian (1974) reported that the 1969 International Symposium of Land Subsidence in Tokyo found that the main lithological and structural characteristics of subsidence areas included the following:

1. Sediments are unconsolidated and lack appreciable cementation.

2. Sediment section is thick.

3. Porosity of sands is high: 20-40%.

4. Sands are interbedded with clays, fine silts and/or siltstones, and shales.

5. Fluid production is voluminous.

6. Age of sediments is Miocene or younger in the case of oil-producing areas.

7. Producing formations are located at shallow depths: 300-1000 metres.

8. Overburden is composed of structurally weak sediments.

9. In oil-producing areas, the reservoir beds have flat or gentle dips at the structure crest.

10. Tension-type faulting, often with a graben central block, present.

The susceptibility of a formation to subsidence is dependent on factors such as the degree of compaction due to previous depth of burial during geologic time, types of clays, shape and size of sand grains, the relative proportions of interbedded clays and sands. Subsidence can only occur if there is a load transfer upon fluid removal. The static load represents the effective weight of the overburden material and is referred to as the geostatic pressure. The maximum amount of load transfer possible at a particular depth is equal to the fluid or hydrostatic pressure at that point.

The mechanism by which the load could change is as follows: the geostatic pressure gradient is equal to the sum of the intergranular (grain-to-grain load) and hydrostatic pressure gradients. As fluid is withdrawn from the reservoir, the hydrostatic pressure decreases and the buoyant effect of the fluid is lost. The intergranular load increases and the geostatic load decreases. An increase in intergranular pressure can cause compaction with the amount depending on the nature of the reservoir rocks. Sands and silts can be compacted by grain rearrangement and crushing, while plastic flow can occur in argillaceous sediments.

History

There are several areas of land subsidence related to oil and gas production. Examples are Goose Creek, Texas; Lake Maracaibo, Venezuela; Niigata, Japan; the Po Delta, Italy; and Long Beach, California (Bissel and Chilingarian 1975). The most dramatic of these was the subsidence that occurred at Long Beach in the 1940's and 1950's, above the Wilmington oil field. Oil was being produced from seven zones between depths of 760 and 1800 metres in Recent to Miocene age sediments. The productive zones were 23-70% sand with porosities ranging from 24-34%. Subsidence occurred during that time over an area of 57 square kilometers to a maximum depth of about 9 m at the centre of the "bowl" created.

Mackenzie Delta Situation

The problem of land subsidence due to fluid withdrawal in the Mackenzie Delta area appears to be variable. Land overlying oil reservoirs is not expected to experience any subsidence as the operators will likely utilize pressure maintenance techniques such as water injection during production. Gas fields considered in the Delta area are as follows: Shell - Niglintgak; Esso - Taglu; Gulf - YaYa (North and South) and Parsons Lake.

Shell identified the potential for subsidence problems in a 1979 report. The main gas-bearing reservoir in the Niglintgak field, the A sand, is thick, unconsolidated and near-surface, indicating the subsidence could be a significant problem. Shell concluded that a subsidence bowl could form as the field is depleted, with a 90% chance that the maximum subsidence after 25 years of production will be 0.5 m. There is about a 10% chance that the subsidence would be as much as 2.6 m. As land elevations in the area are only about 0.5 - 2.0 metres above the river water level, severe subsidence could lead to flooding of some land areas, which in turn could cause thawing and collapse of the upper 2 - 3 metres of ice-rich ground. Maximum subsidence was predicted to possibly occur under the river about 0.3 kilometres south southeast of the B-19 well, potentially altering the river channel itself (Shell 1979).

Esso, in looking at the subsidence potential for the Taglu field, concluded that it would not be a serious problem due to the depth of the reservoir and to the fact that it was of limited areal extent (A. Telford, pers. comm.).

Gulf's Parsons Lake field contains gas in the Parsons sandstone which is Lower Cretaceous in age. The prospective gas-bearing sands lie at an approximate depth of 2600 - 2800 metres. The sands at YaYa North lie at a depth of about 1700 - 2070 metres in sediments of Lower Eocene to Upper Oligocene, while those at YaYa South are at 1920 - 2470 metres in Lower Eocene sediments (A. Bienia, pers. comm.). The age and depth of these sands would seem to preclude the possibility of land subsidence in these areas being a problem.

LITERATURE CITED

Bissel, H.J. and G.V. Chilingarian. 1975. Subsidence. In: G.V. Chilingarian and K.H. Wolfe (Editors). Compaction of coarse-grained sediments, I. Elsevier, Amsterdam, p. 167-245.

Ricke III, H.H. and G.V. Chilingarian. 1974. Compaction of argillaceous sediments. Elsevier, Amsterdam. 424 p.

APPENDIX C

LIST OF PARTICIPANTS
1985 MACKENZIE ENVIRONMENTAL MONITORING
PROJECT WORKSHOP

LIST OF PARTICIPANTS
1985 MACKENZIE ENVIRONMENTAL MONITORING PROJECT WORKSHOP
Edmonton, Alberta
November 4-8, 1985

Alberta Adams
Mackenzie Delta Regional Council
Box 1509
Inuvik, N.W.T. XOE OTO
Research Interests: Wildlife and harvest management.

Jim Allard
Metis Association
Fort Good Hope
Northwest Territories
Research Interests: Wildlife and harvest management.

Lorraine Allison
Salix Enterprises Limited
Box 200
Cowley, Alberta TOK OPO
Research Interest: Resource harvesting, social and cultural changes.

Terry Antoniuk
Gulf Canada Resources Inc.
P.O. Box 130
Gulf Canada Square
Calgary, Alberta T2P 2H7
Research Interests: Fisheries biology, northern development.

Alex Aviugana
Box 2123
Inuvik, N.W.T. XOE OTO
Research Interests: Wildlife and harvest management.

Alan Birdsall
LGL Limited
9768 Second Street
Sidney, B.C. V8L 3Y8
Research Interests: Resource management; environmental biology.

Bill Brakel
Environment Canada
Twin Atria #2
2nd Floor, 4999 - 98 Avenue
Edmonton, Alberta T6B 2X3
Research Interests: Northern economic and environmental change.

Doug Bruchett
Petro Canada Resources
P.O. Box 2844
Calgary, Alberta T2P 3E3
Research Interests: Social effects of hydrocarbon development.

Andrew Cullen
Northern Affairs Program
Indian and Northern Affairs
Box 1500
Yellowknife, N.W.T. X1A 2R3
Research Interests: Effects monitoring.

Debbie DeLancey
Fort Good Hope
Northwest Territories
Research Interests: Resource harvesting; social and cultural changes.

Lynne Dickson
Environment Canada
2nd Floor, 4999 - 98 Avenue
Edmonton, Alberta T6B 2X3
Research Interests: Waterfowl biology.

Lee Doran
Polar Gas
Box 90
Toronto, Ontario M5L 1H3
Research Interests: Environmental effects of linear development

George Edwards
Hunters and Trappers Association
Aklavik
Northwest Territories XOE 0A0
Research Interests: Wildlife and harvest management.

Albert Elias
Holman Island, N.W.T. XOE 0S0
Research Interests: Wildlife and harvest management.

Bob Everitt
ESSA Environmental and Social Systems Analysts Limited
Box 12155 - Nelson Square
Vancouver, B.C. V6Z 2H2
Research Interests: Research planning, resource harvesting.

Susan Fleck
Department of Renewable Resources
Government of Northwest Territories
Yellowknife, N.W.T. X1A 2L9
Research Interests: Wildlife management.

Alan Gell
Invermuir Road
R.R. #2
Sooke, B.C. V0S 1N0
Research Interests: Terrain and geomorphology.

Ron Graf
Department of Renewable Resources
Government of Northwest Territories
Yellowknife, N.W.T. X1A 2L9
Research Interests: Wildlife biology management.

Rick Hurst
Indian and Northern Affairs Canada
Northern Environment
Les Terrasses de la Chaudiere
Ottawa, Ontario K1A 0H4
Research Interests: Impact assessment and monitoring.

Harvey Jessup
Department of Renewable Resources
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6
Research Interests: Wildlife management.

Michael Jones
ESSA Environmental and Social Systems Analysts Limited
Suite 102
66 Isabella Street
Toronto, Ontario M4Y 1N3
Research Interests: Modeling, aquatic ecology.

Rick Josephson
Department of Fisheries and Oceans
501 University Crescent
Winnipeg, Manitoba R3T 2N6
Research Interests: Resource management; fish biology.

David Krutko
Beaufort/Delta DIZ Society
P.O. Box 30
Fort McPherson, N.W.T. X0E 0J0
Research Interests: Wildlife and harvest management.

Peter McCart
Box 78
Spruce View, Alberta T0M 1V0
Research Interests: Fish biology; effects of development on fish.

John McDonald
ESL Environmental Sciences Limited
2035 Mills Road
Sidney, B.C. V8L 3S1
Research Interests: Environmental assessment, hydrology.

Fred McFarland
Northern Environment Directorate
Indian and Northern Affairs Canada
Ottawa, Ontario K1A 0H4
Research Interests: Effects of industrialization of the north, wildlife biology.

Margaret McLaren
LGL Limited
P.O. Box 457
King City, Ontario LOG 1KO
Research Interests:: Wildlife biology.

Peter McLaren
LGL Limited
P.O. Box 457
King City, Ontario LOG 1KO
Research Interests: Waterfowl biology impact assessment.

Peter McNamee
ESSA Environmental and Social Systems Analysts Limited
Suite 102
66 Isabella Street
Toronto, Ontario M4Y 1N3
Research Interests: Ecological modelling; research planning.

Steve Matthews
Department of Renewable Resources
Government of Northwest Territories
6th Floor, Courthouse
Yellowknife, N.W.T. X1A 2L9
Research Interests: Wildlife management, northern development

Maurice Mendo
Great Bear DIZ Society
Fort Norman
Northwest Territories
Research Interests: Wildlife and harvest management.

Mike Miles
M. Miles & Associates Limited
502 Craigflower Road
Victoria, B.C. V9A 2V8
Research Interests: Hydrology, impacts of development on streams.

David Mossop
Department of Renewable Resources
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon Y1A 2C6
Research Interests: Avian ecology, raptor biology.

Heather Myers
Department of Renewable Resources
Government of Northwest Territories
Yellowknife, N.W.T. X1A 2L9
Research Interests: Utilization of resources.

Wendy Nixon
Canadian Wildlife Service
Room 202
204 Range Road
Whitehorse, Yukon Y1A 4X4
Research Interests: Wildlife biology.

Pamela Norton
PN Research Projects
P.O. Box 2296
Sidney, B.C. V8L 3S8
Research Interests: Harvesting of white whales, marine mammal biology.

Chris O'Brien
Dene Nation
Box 2338
Yellowknife, N.W.T. X1A 2P7
Research Interests: Northern resource use; environmental effects of development.

Ed Pessah
Dome Petroleum
P.O. Box 200
Calgary, Alberta
T2P 2H8
Research Interests: Environmental effects of hydrocarbon development.

Archie Pick
Interprovincial Pipelines (N.W.) Ltd.
P.O. Box 398
Edmonton, Alberta T5J 3N7
Research Interests: Environmental effects of linear developments.

Jim Pierrot
Mackenzie/Great Bear DIZ Society
P.O. Box 449
Norman Wells, N.W.T. X0E 0V0
Research Interests: Wildlife and harvest management.

Aaron Sekerak
LGL Limited
9768 Second Street
Sidney, B.C. V8L 3Y8
Research Interests: Arctic fish biology; effects of northern development on aquatic resources.

Cal Sikstrom
ESSO Resources Canada Limited
237 - 4th Avenue S.W.
Calgary, Alberta T2P 0H6
Research Interests: Fish biology; effects of hydrocarbon development.

Nicholas Sonntag
ESSA Environmental and Social Systems Analysts Limited
Box 12155 - Nelson Square
Vancouver, B.C. V6Z 2H2
Research Interests: Research planning, environmental impacts.

Jeff Stein
Department of Fisheries and Oceans
501 University Crescent
Winnipeg, Manitoba R3T 2N6
Research Interests: Fisheries management.

David Stone
Indian and Northern Affairs Canada
Les Terrasses de la Chaudiere
Ottawa, Ontario K1A 0H4
Research Interests: Environmental effects of northern development

Tom Strong
Department of Fisheries and Oceans
Marine Mammal Management
501 University Crescent
Winnipeg, Manitoba R3T 2N6
Research Interests: Marine mammal biology, harvesting.

Dave Sutherland
Environmental Protection Service
Environment Canada
Yellowknife, N.W.T. X1A 2N3
Research Interests: Environmental effects of development.

Glen Sutherland
ESSA Environmental and Social Systems Analysts Limited
Box 12155 - Nelson Square
Vancouver, B.C. V6Z 2H2
Research Interests: Environmental monitoring, modelling.

Dave Thomas
Arctic Laboratories Limited
2045 Mills Road
Sidney, B.C. V8L 3S1
Research Interests: Chemical limnology, chemistry of hydrocarbons and contaminants.

Peter Usher
P.J. Usher Consulting Services
Box 4815, Station E
Ottawa, Ontario K1S 5H9
Research Interests: Social change in the north, resource utilization.

John Ward
Dome Petroleum
P.O. Box 200
Calgary, Alberta T2P 2H8
Research Interests: Ornithology; environmental effects of hydrocarbon development.

Robert Wolfe
Alaska Department of Fish and Game
Subsistence
Box 3-2000
Juneau, Alaska 99802
Research Interests: Resource utilization.

Walt Younkin
Hardy Associates (1978) Limited
221 - 18th Street S.E.
Calgary, Alberta T2E 6J5
Research Interests: Terrestrial ecology, geomorphology.