Environmental Studies No. 69

Beaufort Region Environmental Assessment and Monitoring Program (BREAM)

Final Report for 1991/1992

Canada

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Northern Affairs Program

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Dave Bernard acted as facilitator for the technical meetings of the Community-based Concerns Working Group and the Impact Hypothesis Working Group, while Patricia Vonk was the rapporteur for the latter meeting. Subgroup discussions during the project workshop were recorded and the results of these discussions (Section 4) were written by Rolph Davis, Jeff Green, David Thomas, Michael Lawrence and Patricia Vonk. The workshop facilitators are thanked for their diligent efforts: Peter McNamee, Don Meisner, Mike Rose, Carol Murray and Don Robinson - all of ESSA Environmental and Social Systems Analysts Ltd.

Wayne Duval was responsible for overall project management, organization of the technical meetings and interdisciplinary workshop, and preparation of Sections 1 and 2 of this report. Simon Skey assisted with project management activities and was responsible for all contractual matters related to the project. Overall coordination of the report was the responsibility of Patricia Vonk of Axys Environmental Consulting Ltd. Ms. Vonk also prepared various report sections (Sections 3 and 7) and the Project Updates (Appendix K). Sections 5 (community-based concerns) was prepared by Lois Little, while the oil spill scenarios presented in Section 6 were prepared by Ian Buist and Steve Potter. Simon Skey and Hui Sim assisted in preparation of the final report.

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EXECUTIVE SUMMARY

This report summarizes activities that occurred in the second year (1991/92) of the Beaufort Region Environmental Assessment and Monitoring Program (BREAM).

BREAM was initiated in 1991 by Indian and Northern Affairs Canada, Environment Canada, and the Department of Fisheries and Oceans as a planning component of the Northern Oil and Gas Action Program (NOGAP). Its objectives are to: (1) establish research and monitoring priorities related to future oil and gas development and transportation in the Beaufort Sea, Mackenzie Delta and Mackenzie Valley; and (2) to assist in the assessment of the possible impacts of these future developments on the environment, its resources and resource uses by northerners. BREAM combines and builds on the efforts of two earlier projects of this type -- the Beaufort Environmental Monitoring Project (BEMP) and the Mackenzie Environmental Monitoring Project (MEMP). The broader scope of BREAM includes consideration of catastrophic oil spills, environmental concerns of northern communities potentially affected by industry activities, and several contemporary issues such as global climate change and cumulative impacts of industrial development in the region. In addition, BREAM places a greater emphasis on use of traditional and local knowledge through more involvement of northerners in project planning activities and workshops.

The first year of BREAM focused primarily on a range of planning activities to help determine the direction of the program over the next few years. The results of the Planning Phase are presented in the BREAM Final Report for 1990/91, Environmental Studies No. 67, Indian and Northern Affairs Canada.

This report discusses each of the activities that occurred in the second year of BREAM, including meetings of each of the three Technical Working Groups (Existing Impact Hypothesis, Community-Based Concerns, and Catastrophic Oil Spills), followup work completed by each group, and an interdisciplinary workshop held to review several existing and new impact hypotheses related to routine aspects of hydrocarbon development and transportation in the study area.

Planning Meetings

Four planning meetings were held as part of BREAM in the 1991/1992 fiscal year. These included a project initiation meeting and technical meetings of each of the three Working Groups established for specific components of the project.

A one-day project initiation meeting was held in late November 1991 in Vancouver, B.C. The objectives of this meeting were to identify specific tasks to be completed by each of the Technical Working Groups, determine the scope and contents of background documents to be prepared by these groups for future meetings and workshops, discuss procedures for evaluating impact significance, and discuss project milestones and schedules necessary to achieve the milestones.

Hydrocarbon Development Scenario

A section of this report describes the most current hydrocarbon development and transportation scenario for the Beaufort Sea and Mackenzie Delta and Valley region. It includes a review of current industry projections on the timing and location of future exploration, production and transportation aspects of development, which provided the necessary focus for evaluating impact hypotheses formulated for BREAM.

Impact Hypotheses

During the Impact Hypothesis Working Group Meeting, participants reviewed 14 of the existing 21 BEMP hypotheses and 22 of the existing 25 MEMP hypotheses that were found to be valid as a result of a review conducted during the 1990/1991 BREAM program. Of these 36 impact hypotheses, many were restructured, reworded, combined or eliminated to reflect new information, or changes in the development scenario or the scope of BREAM relative to its predecessors. An additional three hypotheses were developed to deal with the effects of lake water drawdown on Arctic cisco and broad whitefish, offshore activities on the bowhead whale harvest, and dredging in the Husky Lakes on lake trout. The review led to formulation of 32 BREAM impact hypotheses, some of which were identified for a detailed evaluation, while others were considered valid but not necessary to evaluate at present.

The primary focus of the 1991/1992 BREAM workshop was on reviewing the BREAM impact hypotheses related to routine aspects of hydrocarbon development and transportation to determine research and monitoring priorities for BREAM and NOGAP over the next two years. During the workshop, the participants were charged with the responsibilities of: (1) reviewing the hypotheses in terms of the adequacy of existing information; (2) conducting a preliminary assessment of each hypothesis; and (3) identifying future research and monitoring requirements. The following table indicates those impact hypotheses for which further research and monitoring was recommended by workshop participants.

Hypothesis		Recommended Future Research or Monitoring
#	Description	
R-1	Bowhead Whales vs Offshore Development	Conduct aerial surveys of bowhead distribution in conjunction with analyses of satellite data to determine plume conditions. Program to be conducted in at least one year, and preferably two years, while there is no industrial activity.
R-2	Beluga Whale Harvest vs Offshore Development	(1) Expand ongoing research on the regional climatic effects of global warming to include the effects on the fast ice zone, as well as the pack ice zone. (2) Include measure of hunter effort (catch per unit effort) in ongoing monitoring of beluga harvest. (3) Integrate FJMC study results once they are available in 1994.
R-11	Fish Harvest vs Production and Shorebase Contaminants	(1) Examine metal levels in fish and marine mammals of the western Arctic. (2) Conduct a taste testing program.

R-13	Cisco and Whitefish vs Freshwater Intakes	Complete ongoing studies of Tuktoyaktuk Peninsula watershed hydrology as it relates to fish utilization and efforts to model the hydrometeorology of selected watersheds. Implement hydrologic/fish utilization monitoring studies when specific development scenarios indicate a requirement for water withdrawal from lakes on Tuktoyaktuk Peninsula and Richards Island.
R-16	Arctic and Red Fox vs Offshore and Onshore Facilities	Assess wildlife use of abandoned gravel extraction sites, artificial gravel sources and undisturbed fluvial landforms to compare the extent and types of wildlife uses of these sites.
R-17	Caribou vs Traffic on Roads	(1) Research effects of the highway and hunting on crossings of the highway in terms of caribou activity budgets and energy balance. (2) Research the factors that influence the distribution and abundance of parasitic insects, and the degree of insect harassment to caribou; address mosquitoes, as well as warble and bot flies.
R-19	Waterfowl, Furbearers and Fish vs Local Land Subsidence	(1) Examine the pattern of surface flows across shorebird nesting habitat in the Delta. (2) Determine the distribution of shorebird habitat on the Delta. (3) Monitor for drainage barriers and land subsidence along the proposed pipeline. (4) Monitor changes in water levels and distribution in shorebird habitat. (5) Monitor the distribution of nesting shorebirds and their productivity on the Delta.
R-23	Waterfowl vs Presence of Onshore Camps	(1) Research effects of camps and disposal sites on local densities of fox, and in turn, its effect on predation rates to local waterfowl populations. (2) Research the extent to which foxes would vacate established territories to occupy other feeding areas.
R-24	Waterfowl, Fish and Muskrat vs Regional Land Subsidence	(1) Quantify the potential for land inundation. (2) Determine effects of land inundation on wildlife and fish.
R-26	Fish vs Wastes, Spills and Other Contaminant Sources	(1) Determine the relative importance of local and LRTAP sources for the major contaminants in the study region. (2) Identify which contaminant pathways are most relevant to each harvest group of the area.

Community-Based Concerns

The working group met in Yellowknife for two days in February, 1992 to introduce the BREAM process to representatives of northern communities, and to determine some of the environmental issues of importance to northerners. The northern communities at this meeting were represented by the:

- Inuvialuit Game Council, Inuvialuit Settlement Region;
- Joint Secretariat, Inuvialuit Settlement Region;

- Gwich'in Tribal Council, Gwich'in Settlement Region; and
- Shihta Regional Council/Development Impact Zone Committee, Sahtu Region.

Food sources and the overall quality of the northern environment were identified as being the fundamental ecological concerns that must be addressed by BREAM. In particular, these concerns are related to: (1) baseline data collection and monitoring; (2) fish quality; (3) solid waste disposal and associated contamination; (4) catastrophic oil spills; (5) refined oil spills; (6) an east-west pipeline route; (7) effects of increased ambient noise and traffic; and (8) cumulative effects of industrial developments. Reflecting traditional knowledge, new northern environmental monitoring and assessment authorities (i.e. Inuvialuit and Gwich'in structures), and better communication of research and monitoring results, are three themes which underlie most process-related issues and concerns. A preliminary model for accessing and incorporating traditional and local knowledge into decisions related to environmental research and monitoring and their communication was developed.

Recommended followup activities are to: (1) pursue discussions to identify and link BREAM with a parallel process to address social and economic concerns associated with hydrocarbon development; (2) complete a review of existing publications to assess the extent of documented community-based ecological concerns; and (3) improve communications with communities by expanding the distribution of BREAM Project Updates.

Catastrophic Oil Spills

The 1991/1992 activities for the Catastrophic Oil Spill Working Group focussed on those tasks that could be accomplished within the scope of this year's program in preparation for a workshop on catastrophic oil spills in the future. These included preparing a list of Valued Ecosystem Components (VECs), developing a series of oil spill scenarios, and formulating new impact hypotheses relating these VECs and spill scenarios.

Participants reviewed the lists of VECs presented in earlier BEMP and MEMP reports and suggested that a revised list be tentatively adopted for this component of BREAM. Major VEC groups included: (1) air quality; (2) surface and groundwater quality; (3) coastlines; (4) landscape quality; and (5) populations, harvest and quality of marine and marine-associated mammals, terrestrial mammals, fish, birds and epontic organisms.

Six oil spill scenarios were developed by the working group. Additional scenarios will need to be developed to address refined fuel spills.

Future BREAM Activities

1. Environmental Assessment Methodology

While it is important that environmental assessment be an integral part of BREAM and play a role in future project workshops, it is equally important that the methodology selected for this program be consistent with the requirements of the Environmental Impact Review Board (EIRB) and government agencies to ensure its usefulness in the review of future project applications. For this reason, it is recommended that the results of the EIRB review of assessment methodologies be considered during selection of an assessment methodology for BREAM. Because of the timing of the EIRB report (scheduled for completion by year end), selection/development of an assessment methodology for BREAM can not occur prior to the 1992/1993 workshop. However, it is important that a procedure be developed as part of future work of the program. The Chairpersons of the Technical Working Groups should meet to examine the methodology established for the EIRB and select a procedure for BREAM that will satisfy the needs of all the groups.

2. Community-based Concerns

Many of the concerns identified by the Community-based Concerns Group (i.e. fish quality, increased ambient noise and traffic, cumulative effects of industrial developments) are either reflected in existing BREAM impact hypotheses related to routine aspects of development or have now been addressed through the addition of new linkages to these hypotheses. While there may be additional community-based environmental concerns that need to be addressed through BREAM, it will be necessary to have one or two more meetings of the Technical Working Group prior to any full workshop to: (1) clearly define these concerns; and (2) refine the process by which traditional and local knowledge is accessed and incorporated into the process. The Working Group should review the issues and concerns (e.g., related to food quality, contaminants and downstream effects of pulp mills) discussed in the Phase I BREAM report (INAC 1991) to ensure that they have been brought forward and adequately incorporated into the BREAM impact hypotheses presented in this year's report.

One of the primary concerns of northern communities that has yet to be addressed through BREAM is catastrophic oil spills and its potential impact on harvestable resources and their habitat. Concerns related to the effects of spills and cleanup on resource harvesting will be addressed through impact hypotheses that have been developed around spill scenarios involving offshore well blowouts and onshore pipeline ruptures. The Community-based Concerns Working Group should review these hypotheses to ensure that they adequately address community environmental concerns as well as scientific concerns.

3. Catastrophic Oil Spills

Catastrophic oil spills have been and continue to be one of the primary concerns of northerners related to future hydrocarbon development in the region. For this reason, the primary emphasis for 1992/1993 BREAM activities should be placed on this issue. Several tasks need to be undertaken by the Working Group prior to a workshop dealing with oil spills. A planning meeting should occur at the outset of the 1992/1993 BREAM program to: (1) discuss specific tasks to be completed by the Working Group and any background documents that must be prepared in advance of future meetings and workshops; (2) select key participants for the interdisciplinary workshop; and (3) discuss the details of the scope of the workshop.

4. Routine Aspects of Hydrocarbon Development and Transportation

As a result of activities of the Impact Hypothesis Working Group this year and the success of the interdisciplinary workshop in achieving its objectives, there is no need for the Working Group to conduct any further work during the 1992/1993 BREAM program.

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Le présent rapport donne un bref aperçu des activités de la deuxième année (1991-1992) de fonctionnement du Programme de surveillance et d'évaluation environnementales dans la région de Beaufort (PSEERB).

Le PSEERB a été lancé en 1991 par les ministères des Affaires indiennes et du Nord canadien, de l'Environnement et des Pêches et des Océans comme composante de planification du Programme d'initiatives pétrolières et gazières dans le Nord (PIPGN). Ce programme a pour objectifs : 1) d'établir les priorités de la recherche et de la surveillance liés aux projets pétroliers et gaziers et au réseau de transport dans le delta et la vallée du Mackenzie; et 2) de participer à l'évaluation des répercussions éventuelles de ces futures mises en valeur sur l'environnement, ses ressources et l'utilisation des ressources par les habitants du Nord. Le PSEERB combine et poursuit les efforts de deux projets antérieurs de même nature -- le Programme de surveillance environnementale dans la mer de Beaufort (PSEMB) et le Programme de surveillance environnementale du Mackenzie (PSEM). De portée plus vaste, le PSEERB comprend l'examen des déversements désastreux de pétrole, des préoccupations d'ordre environnemental des populations du Nord éventuellement touchées par les activités industrielles et plusieurs questions contemporaines comme le changement climatique du globe et les répercussions cumulatives du développement industriel dans la région. De plus, le PSEERB met davantage l'accent sur l'utilisation des connaissances locales et traditionnelles en accroissant la participation des habitants du Nord aux activités de planification des projets et aux ateliers.

Durant sa première année de fonctionnement, le PSEERB s'est surtout concentré sur des activités de planification visant à déterminer son orientation pour les quelques prochaines années. Les résultats de cette phase de planification sont publiés dans le rapport final du PSEERB de 1990-1991, Étude environnementale n° 67, Affaires indiennes et du Nord canadien.

Le présent rapport aborde chacune des activités qui ont eu lieu au cours de la deuxième année de fonctionnement du PSEERB, notamment les réunions de chacun des trois groupes de travail technique (hypothèses existantes sur les répercussions, préoccupations communautaires en matière d'environnement et déversements désastreux de pétrole), le travail de suivi réalisé par chaque groupe et l'atelier interdisciplinaire tenu afin d'examiner les diverses hypothèses, existantes et nouvelles, sur les répercussions se rapportant aux aspects courants de l'exploitation et du transport des hydrocarbures dans la région visée par l'étude.

Réunions de planification

Quatre réunions de planification ont eu lieu dans le cadre du PSEERB au cours de l'année financière 1991-1992 : une réunion de lancement de projet et des réunions techniques

de chacun des trois groupes de travail créés pour traiter des composantes particulières du projet.

Une réunion de lancement du projet d'une journée a eu lieu à la fin de novembre 1991 à Vancouver (C.-B.). Cette réunion avait pour objectifs de préciser les tâches particulières devant être accomplies par chacun des trois groupes de travail technique, de déterminer la portée et le contenu des documents de base que ces groupes devront rédiger aux fins des prochaines réunions et ateliers, de discuter des méthodes servant à évaluer l'importance des répercussions et de discuter des jalons du projet et des échéanciers qui permettront de les atteindre.

Scénario relatif à la mise en valeur des hydrocarbures

Une partie du rapport décrit le scénario le plus courant touchant l'exploitation et le transport des hydrocarbures dans les régions de la mer de Beaufort et du delta et de la vallée du Mackenzie. Elle tient compte de l'étude des prévisions actuelles de l'industrie pour ce qui est du moment et du lieu des activités liées à la prospection, à la production et au transport. Celles-ci sont nécessaires pour évaluer la validité des hypothèses formulées dans le cadre du PSEERB.

Hypothèses sur les répercussions

Lors de la réunion du groupe de travail chargé des hypothèses sur les répercussions, les participants ont examiné 14 des 21 hypothèses existantes du PSEMB et 22 des 25 hypothèses actuelles du PSEM qui ont été jugées valides par suite d'un examen mené dans le cadre du programme du PSEERB de 1990-1991. Parmi ces trente-six hypothèses, nombreuses sont celles qui ont été restructurées, reformulées, combinées ou éliminées afin de tenir compte de nouveaux renseignements ou de modifications survenues dans le scénario de mise en valeur ou de la nouvelle portée du PSEERB par rapport à ses prédécesseurs. Trois nouvelles hypothèses ont été élaborées afin de traiter des répercussions de la prise d'eau de lac sur le cisco de l'Arctique et le corégone tschir, des activités extracôtières sur la récolte de la baleine boréale et du dragage des lacs Husky sur le touladi. L'examen a mené à la formulation par le PSEERB de 32 hypothèses dont certaines feront l'objet d'une évaluation détaillée tandis que d'autres ont été confirmées sans qu'il ne soit nécessaire de les évaluer à l'heure actuelle.

L'atelier de 1991-1992 du PSEERB avait comme but principal l'examen des hypothèses sur les répercussions associées aux aspects courants de l'exploitation et du transport des hydrocarbures en vue de déterminer les priorités en matière de recherche et de surveillance du PSEERB et du PIPGN durant les deux prochaines années. Au cours de l'atelier, les participants devaient notamment : 1) examiner les hypothèses relativement à l'exactitude de l'information existante; 2) mener une évaluation préliminaire de chaque hypothèse; et 3) préciser les futurs besoins en matière de recherche et de surveillance. Le tableau suivant énonce les hypothèses sur les répercussions à l'égard desquelles d'autres travaux de recherche et de surveillance ont été recommandés par les participants à l'atelier.

Hypothèse		Recherche et surveillance recommandées
N°	**Description**	
R-1	Baleine boréale et exploitation extra-côtière	Effectuer des levés aériens de la répartition des baleines boréales parallèlement à l'analyse des données obtenues par satellite afin de déterminer l'état du panache. Le programme durera au moins un an et, de préférence deux ans, tandis que ne se déroule aucune activité industrielle.
R-2	Récolte des bélugas et exploitation extracôtière	(1) Élargir la recherche courante sur les répercussions climatiques régionales du réchauffement de la planète afin d'y inclure les répercussions sur la zone de la banquise côtière ainsi que sur la zone du pack. (2) Inclure une mesure de la surveillance courante des efforts des unités chasseurs (l'effort équivaut au nombre de prises par unité) liés à la récolte des bélugas. (3) Intégrer les résultats de l'étude du CMGP lorsqu'ils seront disponibles en 1994.
R-11	Récolte de poisson, production et polluants du rivage	(1) Examiner les niveaux de métal dans le poisson et dans les animaux marins de l'Arctique de l'Ouest. (2) Mener un programme de mesure des goûts.
R-13	Cisco, corégone et prises d'eau douce	Terminer les études courantes sur l'hydrologie du bassin hydrographique de la péninsule de Tuktoyaktuk en ce qui a trait à l'utilisation du poisson et aux tentatives de modéliser l'hydrométéorologie des bassins hydrographiques sélectionnés. Mettre en oeuvre les études de surveillance de l'utilisation des poissons et les études hydrologiques lorsque des scénarios particuliers de mise en valeur font état de la nécessité de prendre de l'eau des lacs de la péninsule de Tuktoyaktuk et de l'île Richards.
R-16	Renard arctique, renard roux et installations côtières	Évaluer l'utilisation par la faune des sites d'extraction de gravier abandonnés, des sources artificielles de gravier et des zones fluviales non perturbées afin de comparer l'étendue et les types d'utilisation de ces lieux par la faune.
R-17	Caribou et circulation routière	(1) Effectuer des recherches sur les répercussions des routes et de la chasse sur le franchissement des routes en ce qui a trait au bilan des activités et au bilan énergétique des caribous. (2) Effectuer des recherches sur les facteurs qui influencent la distribution et l'abondance des insectes parasites ainsi que le niveau de harcèlement du caribou par les insectes, notamment des moustiques, des hypodermes ainsi que des oestres.

R-19	Oiseaux aquatiques, animaux à fourrure, poissons et affaissement local de terrain	(1) Examiner le mouvement des eaux de ruissellement dans l'aire de nidification des oiseaux dans le delta. (2) Déterminer la répartition de l'habitat des oiseaux de rivage dans le delta. (3) Surveiller les obstacles au drainage et l'affaissement du sol le long du pipeline proposé. (4) Surveiller les changements dans les niveaux d'eau et la répartition de l'habitat des oiseaux de rivage. (5) Superviser la répartition de la nidification des oiseaux de rivage et leur productivité dans le delta.
R-23	Oiseaux aquatiques et présence des camps sur les berges	(1) Effectuer des recherches sur les répercussions des camps et des sites d'enfouissement sur la densité locale du renard et, ensuite, les répercussions de cette dernière sur les taux de prédation des populations locales d'oiseaux aquatiques. (2) Effectuer des recherches afin de dire dans quelle mesure les renards abandonnent des territoires établis afin d'aller occuper d'autres zones d'alimentation.
R-24	Oiseaux aquatiques poisson et rat musqué et affaissement régional du terrain	(1) Quantifier le potentiel d'inondation du sol. (2) Déterminer les répercussions de l'inondation des terres sur la faune et le poisson.
R-26	Le poisson et les déchets, les déversements et autres sources de pollutants	(1) Déterminer l'importance relative des sources locales et le TGPDA des principaux polluants dans la région visée par l'étude. (2) Déterminer quelles trajectoires des polluants se rapportent à chaque groupe de récolte de la région.

Préoccupations communautaires en matière d'environnement

Le groupe de travail s'est réuni à Yellowknife pendant deux jours en février 1992 afin de présenter le processus du PSEERB aux représentants des collectivités du Nord et identifier les questions environnementales qui les préoccupent. À cette réunion, les collectivités du Nord étaient représentées par :

- le Conseil inuvialuit de gestion du gibier, région visée par le règlement de la revendication des Inuvialuit.
- le Comité mixte, région visée par le règlement de la revendication des Inuvialuit;
- le Conseil tribal des Gwich'in, région visée par le règlement avec les Gwich'in; et
- le Conseil régional des Shihtas/Comité de la région touchée par les répercussions de la mise en valeur, région du Sahtu.

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Les sources alimentaires et la qualité générale de l'environnement nordique ont été retenues au titre des préoccupations écologiques fondamentales que doit aborder le PSEERB. Plus particulièrement, ces préoccupations concernent : 1) la cueillette des données de base et la surveillance; 2) la qualité du poisson; 3) l'élimination des déchets solides et la contamination connexe; 4) les déversements désastreux de pétrole; 5) les déversements d'huile raffinée; 6) un tracé de pipeline d'est en ouest; 7) les répercussions de l'augmentation du bruit ambiant accru et de la circulation; et 8) les effets cumulatifs du développement industriel. La reconnaissance des valeurs traditionnelles, les nouvelles administrations d'évaluation et de surveillance environnementales du Nord (ex. : organismes inuvialuit et gwich'in) et une meilleure communication des résultats de la recherche et de la surveillance sont les trois thèmes qui sous-tendent la plupart des questions et préoccupations liées au processus. On a élaboré un modèle préliminaire d'accessibilité et d'intégration des connaissances locales et traditionnelles aux décisions se rapportant à la recherche et à la surveillance environnementales et à leur communication.

Les activités de suivi recommandées sont : 1) poursuivre les discussions afin de rattacher le PSEERB à un processus parallèle qui traitera des préoccupations sociales et économiques liées à l'exploitation des hydrocarbures et en préciser les modalités; 2) effectuer un examen des publications courantes permettant d'évaluer la portée des préoccupations communautaires documentées en matière d'écologie; et 3) améliorer les communications avec les collectivités en élargissant la diffusion des mises à jour des projets du PSEERB.

Déversements désastreux de pétrole

Les activités 1991-1992 du groupe de travail sur les déversements désastreux de pétrole ont principalement porté sur les tâches qui pourraient être réalisées dans le cadre du programme de cette année afin de préparer un futur atelier sur les déversements désastreux de pétrole. Ces activités ont comporté la rédaction d'une liste des composantes valorisées d'un écosystème (CVE), l'élaboration d'une série de scénarios de déversement désastreux et la formulation de nouvelles hypothèses sur les répercussions se rapportant à ces composantes valorisées et scénarios de déversement.

Les participants ont examiné les listes des CVE présentées dans les rapports précédents du PSEMB et du PSEM et ont suggéré qu'une liste révisée soit provisoirement adoptée pour cette composante du PSEERB. Les principaux groupes de CVE sont : 1) la qualité de l'air; 2) la qualité des eaux de surface et de la nappe phréatique; 3) les eaux côtières; 4) la qualité du paysage; et 5) les peuplements, la récolte et la qualité des mammifères marins et des animaux marins connexes, des mammifères terrestres, des oiseaux, des poissons et des organismes fixés au substrat.

Le groupe de travail a élaboré six scénarios de déversement désastreux. D'autres scénarios devront être élaborés afin de traiter les déversements d'huile raffinée.

RAPPORT FINAL 1991-1992 DU PSEERB

Prochaines activités du PSEERB

1. Méthode d'évaluation environnementale

Bien qu'il importe que l'évaluation environnementale fasse partie intégrante du PSEERB et joue un rôle dans les prochains ateliers du projet, il est tout aussi important que la méthode choisie aux fins de ce programme soit conforme aux exigences du Conseil d'examen des répercussions environnementales (CERE) et des organismes centraux afin d'assurer leur utilité durant l'examen des prochaines applications du projet. C'est pourquoi il est recommandé de tenir compte des résultats de l'examen des méthodes d'évaluation par le CERE lors de la sélection d'une méthode d'évaluation du PSEERB. Compte tenu de la date de publication du rapport du CERE (dont l'achèvement est prévu pour la fin de l'exercice financier), la sélection et l'élaboration d'une méthode d'évaluation du PSEERB ne peuvent avoir lieu avant qu'ait lieu l'atelier de 1992-1993. Cependant, il importe qu'une formule soit élaborée comme partie des futurs travaux du programme. Les présidents des groupes de travail technique devraient se rencontrer pour examiner la méthode choisie par le CERE et choisir une méthode pour le PSEERB qui répondra aux besoins de tous les groupes.

2. Préoccupations communautaires en matière d'environnement

Bon nombre des préoccupations précisées par les groupes communautaires qui s'intéressent aux questions environnementales (soit la qualité du poisson, l'augmentation du bruit ambiant et de la circulation, les effets cumulatifs du développement industriel) sont soit exprimées dans les hypothèses actuelles sur les répercussions du PSEERB traitant des aspects courants de l'exploitation ou ont déjà été traités par l'ajout de nouveaux liens à ces hypothèses. Bien qu'il existe peut-être d'autres préoccupations communautaires en matière d'environnement qui devraient être traitées par le PSEERB, le groupe de travail technique devra se rencontrer une fois ou deux avant la tenue de tout atelier dans le but de : 1) définir clairement ces préoccupations; et 2) améliorer la façon dont les connaissances locales et traditionnelles sont rendues accessibles et intégrées au processus. Le groupe de travail devra examiner les questions et les préoccupations (liées à la qualité de la nourriture, aux polluants et aux répercussions des usines de pâtes et papier sur les eaux en aval) discutées dans le rapport de la phase I du PSEERB afin d'assurer qu'elles ont été présentées et intégrées de façon pertinente aux hypothèses du PSEERB sur les répercussions qui sont présentées dans le rapport de cette année.

Une des principales préoccupations des collectivités du Nord n'ayant pas encore été traitée par le PSEERB a trait aux déversements désastreux de pétrole et à leurs répercussions sur les ressources récoltables et leur habitat. Les préoccupations liées aux effets des déversements et au nettoyage des ressources seront traitées selon des hypothèses élaborées à partir de scénarios de déversements mettant en scène des éruptions incontrôlées de puits au large des côtes et de bris de pipeline à terre. Le groupe de travail sur les préoccupations communautaires en matière d'environnement devrait examiner ces hypothèses afin d'assurer qu'elles traitent de façon appropriée des préoccupations communautaires en matière d'environnement ainsi que des préoccupations scientifiques.

3. Déversements désastreux de pétrole

Les déversements désastreux de pétrole ont été et continuent d'être l'une des principales préoccupations des habitants du Nord en ce qui concerne l'exploitation future des hydrocarbures dans la région. C'est pourquoi, les activités 1992-1993 du PSEERB porteront principalement sur cette question. Le groupe de travail devra entreprendre plusieurs tâches avant d'organiser un atelier traitant des déversements désastreux. Une réunion de planification doit avoir lieu au début du programme 1992-1993 du PSEERB pour : 1) discuter des tâches particulières que le groupe de travail doit effectuer et de tout document d'information qui doit être rédigé préalablement aux prochaines réunions et ateliers; 2) choisir les participants clés de l'atelier multidisciplinaire; et 3) discuter des détails touchant l'étendue de l'atelier.

4. Aspects courants de l'exploitation et du transport des hydrocarbures

Comme résultante des activités de cette année du groupe de travail sur les hypothèses sur les répercussions et de la réussite de l'atelier multidisciplinaire dans l'atteinte de ses objectifs, il n'est pas nécessaire que le groupe de travail mène d'autres travaux durant l'année 1992-1993 du programme du PSEERB.

1. INTRODUCTION AND BACKGROUND

The Beaufort Region Environmental Assessment and Monitoring Program (BREAM) was initiated in 1991 by Indian and Northern Affairs Canada, Environment Canada, and the Department of Fisheries and Oceans to assist in the planning component of the Northern Oil and Gas Action Program (NOGAP). Its objectives are to: (1) establish research and monitoring priorities related to future oil and gas development and transportation in the Beaufort Sea, Mackenzie Delta and Mackenzie Valley; and (2) assist in the assessment of the possible impacts of these future developments on the environment, its resources and resource uses by northerners. BREAM combines and builds on the efforts of two earlier projects of this type -- the Beaufort Environmental Monitoring Project (BEMP) and the Mackenzie Environmental Monitoring Project (MEMP). Like its predecessors, BREAM is a process that ensures that environmental research and monitoring is fully integrated with exploration and development plans, and helps to identify areas where further information gained through research and monitoring is needed to assess the impact of industrial development.

While BREAM can be viewed as a continuation of these earlier programs, it also has much broader objectives and scope. In addition to addressing the potential environmental impacts of routine aspects of oil and gas development, BREAM also considers catastrophic oil spills, environmental concerns of northern communities potentially affected by industry activities, and several contemporary issues such as global climate change and cumulative impacts of industrial development in the region. The process provides for greater emphasis on use of traditional and local knowledge through more involvement of northerners in project planning activities and workshops. Another objective of BREAM is to act on recommendations of the Beaufort Steering Committee (BSSC 1991) in terms of completing an evaluation of the most appropriate impact assessment methodology for future environmental assessment in this region.

The fundamental role of BREAM is to identify information needed for decision-making. These decision-making needs will not be static but will change with time as some issues are resolved through research and assessment activities and new issues arise due to changes in the development scenario, results of recommended research and monitoring activities, site-specific land-use conflicts, etc. As BREAM is an iterative process, it will be capable of responding to the dynamic nature of information needs. It was within this overall context that meeting participants during Phase I Planning Meeting (Section 2.1) defined the following four overall objectives of BREAM. It was also stressed that these objectives are considered interim and may be refined as necessary later in the program in keeping with the iterative nature of this process.

1. To review and evaluate environmental impact assessment needs for decision-making, the state of knowledge related to scientific and community-based concerns, and related to the hydrocarbon development and transportation scenario for the region.

2. To establish the necessary lines of communication, consultation and participation between government, industry and local communities.

3. To provide the focus for what needs to be known for assessment purposes and to make decisions through establishment of a prioritized list of necessary research, monitoring and assessment activities.

4. To develop and implement the iterative process and framework to achieve the above objectives.

This is the second year of BREAM; last year (1990/1991) was the planning phase of the project, which involved a range of activities to help determine the direction of the project this year and in subsequent years. A planning meeting, involving government and industry representatives as well as several consultants, was held to determine the focus and priorities of BREAM relative to BEMP and MEMP and the more recent work of the BSSC. In addition, a number of research and monitoring programs completed in the Beaufort Sea and Mackenzie Valley regions since the previous BEMP and MEMP reviews were summarized. The results of these studies as well as conclusions and recommendations of participants in the planning meeting are presented in the 1990/1991 BREAM Final report (INAC 1991).

This report discusses activities that occurred in the second year of the project, including meetings of the three Working Groups (Existing Impact Hypothesis, Community-based Concerns, and Catastrophic Oil Spills), followup work completed by each group, and an interdisciplinary workshop held to review several existing and new impact hypotheses related to routine aspects of hydrocarbon development and transportation in the study area.

2. PLANNING ACTIVITIES

2.1 Review of 1990/1991 Planning Phase of BREAM

The BREAM Planning Meeting during Phase I of this project was held on March 19-20, 1991 in Calgary, and was attended by representatives of Indian and Northern Affairs Canada (INAC), the Department of Fisheries and Oceans (DFO), Environment Canada, the Fisheries Joint Management Committee (FJMC), petroleum industry and pipeline companies, and several consultants from the project team. A background document outlined the general objectives of BREAM and how the project would differ from its predecessors (BEMP and MEMP).

During this meeting, it was emphasized that while the need for information relevant to assessing the impacts of hydrocarbon development existed throughout the 1970s and 1980s, in many cases, acquisition of this information was not structured in a way that it could be focused on significant scientific issues. Some research programs became more focused as a result of BEMP and MEMP, while others were eliminated because they could not be defended in terms of their relevance to environmental assessment. One of the greatest merits of BEMP/MEMP was that they were iterative processes, with each subsequent workshop furthering the goal of ensuring that research in the region provided relevant information.

The need for BREAM to avoid some perceived and known shortcomings of BEMP and MEMP was stressed during Phase I. One area in particular identified in the Planning Meeting was the failure of either process to consider catastrophic oil spills. These initiatives focused on routine aspects of hydrocarbon exploration and transportation and, therefore, explicitly excluded evaluation of research and monitoring related to environmental emergencies such as a major well blowout or oil pipeline rupture.

Notwithstanding the low risk of major spills and the associated difficulty in assigning research and monitoring priorities to low-risk events, it was concluded that BREAM is compelled to deal with major spills, not only in terms of setting research and monitoring priorities, but also from an environmental assessment perspective. It was stressed, however, that major spills should not overwhelm the new process because they are still a low probability event relative to other impact sources, which are far more likely to exist if hydrocarbon development proceeds.

BEMP and MEMP were structured around impact hypotheses and followed a scientific process not particularly well-suited to addressing many community-based concerns. It was noted in the Planning Meeting that some of these concerns would be difficult, if not impossible, to monitor within a scientific framework. There is also an apparent problem related to communication of scientific knowledge to the native community, which was also voiced strongly during this second year of BREAM (Section 5.6.2).

During the March 1991 Planning Meeting, considerable time was devoted to the discussion of the merits and shortcomings of incorporating community-based concerns into BREAM. Several important points were made during this discussion (INAC 1991) and are repeated below:

- It may be beneficial to have a broader perspective through evaluation of community-based environmental concerns. By bringing regulators into the process, they would be exposed to these broader issues.
- Community-based concerns will have to be addressed through some other process if not included within the scope of BREAM.
- It will be important to maintain a proper balance between northern and southern participants during BREAM workshops.
- Although BREAM is not presently constrained in terms of the scope of issues it can address, there will be some issues (e.g., social concerns) that must be dealt with through another process.
- Some community-based issues will be focused on concerns of specific individuals such as the harvest of one hunter or trapper (where a population affect could be unmeasurable), while others will be larger issues such as global warming.

It was concluded that BREAM should address community-based environmental, but not social, concerns. The latter were viewed as important but more appropriately addressed through some other process.

While BEMP and MEMP both attempted to use traditional knowledge by having representatives of HTAs participate in the evaluation of some impact hypotheses, it was agreed that an even greater effort should be placed on obtaining and using both traditional and local knowledge during BREAM.

During the Planning Meeting, it was concluded that the spatial boundaries of the program should not only encompass the regions within the scope of both BEMP and MEMP but also be extended to include the proposed pipeline corridor south of Norman Wells to the Alberta-NWT border. Extension of the geographic scope of the project to include Alaskan offshore waters was discussed but no conclusion was reached.

It was agreed that the temporal bounding of BREAM must occur in relation to the development scenario, but must also reflect the decision-making process. The assessment portion of BREAM must encompass the entire period from planning, through construction and operation to decommissioning of production and transportation facilities.

The "actions" to be evaluated through BREAM are to include oil and gas industry activities *per se*, as well as associated or related activities that may be discussed during any future public reviews. It was considered practical to break these actions into categories associated with three major modules: exploration, production and transportation.

In BEMP and MEMP, the "indicators" (something that can be measured that is important and will reflect a change due to an action) were termed Valued Ecosystem Components (VECs). VECs were defined as "*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*". Because it was concluded that community-based social concerns should be addressed through some other process, this form of indicator was deemed suitable for BREAM even though it must address a broad range of scientific and community-based environmental concerns.

It was agreed in Phase I that in any given year, BREAM would have four phases:

1. Planning Phase;
2. Review and Evaluation Phase;
3. Working Sessions; and
4. Reporting Phase.

This overall framework is the same as that followed during BEMP and MEMP and was expanded to be also suitable for BREAM. The tools that would be employed in the program would be expanded from those used in BEMP and MEMP and could include: (1) development of structured impact hypotheses; (2) technical meetings of discipline specialists and workshops; (3) literature reviews and other project outputs.

During the March 1991 Planning Meeting, each of the existing BEMP and MEMP hypotheses were reviewed in light of: (1) the current hydrocarbon development scenario; (2) concern at a local vs. regional level; and (3) new information available since the last reviews of relevant research to determine whether they should be re-evaluated and included within the scope of BREAM. Of the 21 previous BEMP hypotheses, participants recommended that 14 be brought forward to BREAM; a larger proportion (22 of 25) of the earlier MEMP hypotheses were concluded to be still valid for this project.

As indicated earlier, the two primary additional issues that were to be addressed during BREAM were concluded to be major oil spills and community-based environmental concerns, although a number of other potential concerns were identified by participants during the planning meeting. These encompassed some fairly site-specific issues such as noise from gas processing facilities, as well as broader issues such as global climate change and cumulative impacts of development.

Participants in the Planning Meeting concluded their discussions by developing an Action Plan for BREAM. Major components of this Action Plan included:

- Creation of a Steering Group from the program sponsors;
- Creation of three Technical Working Groups (Impact Hypothesis, Catastrophic Oil Spills, Community-based Concerns);
- Determination of an assessment methodology to be used for the assessment component of the project;
- Liaison with federal and territorial government agencies, other regulatory bodies, and organizations representing northern communities to develop support for the project;
- Preparation of Project Updates; and
- Organization of one or more interdisciplinary workshops to address existing or new impact hypotheses, including those that may be developed for either catastrophic oil spills or community-based concerns.

2.2. Planning Activities in 1991/1992

Four planning meetings were held as part of BREAM in the 1991/1992 fiscal year. These included a Project Initiation Meeting and technical meetings of each of the three Working Groups established for specific components of the project. The following sections briefly describe the objectives and conclusions of each planning session, cross-referencing other parts of the report that provide more detail on the activities of the Impact Hypothesis, Community-based Concerns and Catastrophic Oil Spills Working Groups.

2.2.1 Project Initiation Meeting

A one-day project initiation meeting was held on November 25, 1991 in Vancouver, B.C. The objectives of this meeting were to identify specific tasks to be completed by each of the Technical Working Groups, determine the scope and contents of background documents to be prepared by these groups for future meetings and workshops, discuss assessment procedures in evaluating impact significance, and discuss project milestones and schedules necessary to achieve the milestones. The meeting was attended by the Chairpersons of each Working Group, as well as representatives from industry and government.

It was noted during the project initiation meeting that, at the request of the sponsoring agencies, the focus of the 1991/1992 BREAM program would be changed from that described in the proposal. The emphasis this year would be placed on review of existing (BEMP and MEMP) and new impact hypotheses related to routine aspects of hydrocarbon development rather than catastrophic oil spills. A 3-day interdisciplinary workshop would be held to re-evaluate the existing hypotheses and examine new ones developed by the Impact Hypothesis Working Group in order to determine research and monitoring needs under NOGAP over the next two years. To focus the 1991/1992 BREAM program on catastrophic oil spills did not seem appropriate since substantial work in this area has been completed by the various task groups of the Beaufort Sea Steering Committee (BSSC). To conduct a workshop dealing with community-based concerns this fiscal year would also be inappropriate because it would require more than four months to adequately formulate impact hypotheses, establish the appropriate procedures to address these concerns and obtain the necessary support and participation from northern communities.

The following summarizes the conclusions of the project initiation meeting.

2.2.1.1 Impact Hypothesis Working Group

- The planning meeting of the Impact Hypothesis Working Group would be extended from two to three days to allow the Catastrophic Oil Spill Working Group to join the meeting on the third day to discuss issues related to onshore and offshore oil spills. During the first two days, the Working Group would be responsible for reviewing existing BEMP and MEMP impact hypotheses that are to be re-evaluated as part of BREAM, as well as developing new ones for consideration at the interdisciplinary workshop. This would involve review of the project overviews presented in the 1990/1991 BREAM Final Report, revision of the wording of some impact hypotheses and associated linkages, and addition of linkages to consider other issues such as cumulative impacts and global climate change.

- In preparation of the planning meeting, members of the Working Group would be responsible for reviewing new research that has been conducted since the release of the 1990/1991 BREAM Report, and determining which impact hypotheses require re-evaluation at the interdisciplinary workshop and preparing the rationale for this decision.

- Considerable discussion was directed at how the issue of global climate change would be dealt with and what accomplishments are expected for this fiscal year. It was noted that global climate change is an area of increasing concern and that a number of studies have been initiated. It was agreed that BREAM should be prepared to deal with this issue and that at least some initial work such as developing new impact hypotheses or adding new linkages to existing hypotheses should be completed this year. A background paper would be prepared in advance of the planning meeting in support of this task.

- It was agreed that assessment of cumulative effects would be incorporated into the BREAM process through selection of an appropriate assessment methodology.

2.2.1.2 Community-based Concerns Working Group

- The Chairperson of the Community-based Concerns Working Group would be responsible for contacting the various native groups (Sahtu, Inuvialuit, Gwich'in and Deh Cho) and the GNWT, and identifying representatives that would participate in this group.

- In preparation for the planning meeting, a background paper would be prepared and distributed to community representatives to explain the objectives and history of BREAM, the Terms of Reference of the Working Group, and how ongoing community involvement in the process will ensure that traditional knowledge is used to a greater extent in determining research needs.

- The planning meeting would be attended by the study team members of the working group, as well as 4-5 community and government representatives. The objective of this meeting would be to identify some new community issues that can be adequately addressed by BREAM. It was agreed that emphasis must be placed on environmental issues of these communities and that it is outside the scope of BREAM to deal with social issues.

- It was also agreed that community representatives should participate in the interdisciplinary workshop to become more familiar with the process. The planning meeting would, therefore, serve to prepare these individuals for the workshop.

2.2.1.3 Catastrophic Oil Spills Working Group

- The Catastrophic Oil Spill Working Group would attend the third day of the 3-day Impact Hypothesis Working Group Technical Meeting to develop one or more impact hypotheses to assess the effects of an offshore well blowout and oil pipeline ruptures into the Mackenzie River. These hypotheses would not be evaluated during this year's workshop but rather will be the focus of some future BREAM meeting or workshop.

2.2.1.4 Assessment Procedure for Evaluating Impact Significance

- The assessment procedure selected for BREAM should comply with the requirements and procedures considered appropriate by agencies involved in the review of future project applications.

- The impact assessment procedure developed by Duval and Vonk (1991) would be considered for use in BREAM. On the recommendation of the BSSC, the EIRB will be reviewing this methodology as a potential methodology for EIRB hearings.

2.2.2 Impact Hypothesis Working Group

A planning meeting of the Impact Hypothesis Working Group was held on January 28-30, 1992 in Vancouver, B.C. The objectives of this meeting were to identify those existing (BEMP and MEMP) impact hypotheses that should be re-evaluated at the project workshop, develop new hypotheses to reflect changes in the development scenario and scope of the project, identify experts that should attend this workshop, and select an appropriate assessment procedure for BREAM. While use of the impact hypothesis structure is successful in identifying areas where further research and monitoring are needed, it does not provide the mechanism by which the significance of potential impacts can be determined. In past years with BEMP and MEMP, the impact significance has been implicitly stated. As part of the expanded scope of BREAM, it was one of the objectives of the 1991/1992 program to select an assessment methodology that would lead to defensible conclusions on the significance of potential impacts of hydrocarbon development in order to formalize and structure decision-making regarding research and monitoring priorities.

A set of criteria was established to determine which hypotheses would be evaluated as part of BREAM this year. The working group reviewed 14 of the existing 21 BEMP hypotheses and 22 of the existing 25 MEMP hypotheses that were found to be valid as a result of a review conducted during the 1990/1991 BREAM program. Each of these 36 impact hypotheses were reviewed in light of: (1) the current hydrocarbon development scenario; (2) new information available since the last reviews of relevant research; (3) the increased scope of BREAM or new legislation; (4) new interpretation of existing information; and (5) whether the hypothesis remains unanswered and addresses important issues. Those impact hypotheses for which the potential effects were considered untestable or unknown or for which adequate information exists for assessment purposes, were excluded from further evaluation this year. This results of this review are presented in Table 2-1, which includes the screening decisions, future actions recommended by the Working Group, and a suggested list of expertise needed for the project workshop.

Of the existing 36 impact hypotheses, many were restructured, reworded, combined or eliminated to reflect changes in the scope of the project and the development scenario, and new information. An additional three hypotheses were developed to deal with the effects of lake water drawdown on Arctic cisco and broad whitefish, offshore activities on the bowhead whale harvest, and dredging in Husky Lakes on the lake trout population. The result of the review was 32 BREAM impact hypotheses, some of which were identified for a detailed evaluation, while others were considered valid but not necessary to evaluate this year. It was agreed during the Planning Meeting that a background paper including the revised impact hypotheses and the rationale for exclusion/inclusion of hypotheses be prepared and distributed in advance of the workshop.

The working group agreed that the assessment methodology described in Duval and Vonk (1991) would be appropriate for BREAM. Some minor revisions were made to the procedure, and some of the terminology was defined within the context of BREAM. The assessment procedure is discussed in more detail in Section 4.2.

TABLE 2-1

BREAM IMPACT HYPOTHESES, SCREENING DECISIONS AND FUTURE ACTIONS

BREAM #	OLD #	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION	ACTION	SUGGESTED EXPERTISE
BREAM R-1	BEMP 1	Bowhead Whale	Ship traffic, seismic programs, and active offshore platforms/artificial islands will cause a reduction in the western Arctic population of bowhead whales.	Valid	**Detailed evaluation** in workshop due to new information and re-interpretation of existing information	D. Schell M. Bradstreet C. George D. Fissel R. MacDonald E. Carmack
BREAM R-2	BEMP 2 MEMP 19	White Whale Harvest	(a) offshore structures will reduce the white whale harvest; (b) frequent icebreaker traffic in the landfast ice will increase harvest; and (c) open-water ship traffic in the Mackenzie Estuary will alter white whale distribution and lead to changes in harvest levels.	Valid	**Brief evaluation** in workshop in relation to site-specific conflicts, climate change on landfast ice, and Beluga Protection Plan; combine hypotheses; add link related to barge traffic	L. Harwood IGC rep P. Kimmerley B. Maxwell S. Cosens
BREAM R-3	BEMP 3	Ringed and Bearded Seal	Marine vessel activities, seismic activities, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of ringed and bearded seal populations in the Beaufort Sea.	Valid but untestable	**Summary** - No need to re-evaluate at this time; current development scenario does not warrant additional work	I. Stirling T. Smith M. Kingsley
BREAM R-4	BEMP 4	Ringed Seal	Increased frequency of ice breaker traffic through the landfast ice will reduce ringed seal pup production and population levels.	Valid but untestable and insignifi-cant	**Summary** - Wording changed to remove reference to Amundsen Gulf; no further work required	I. Stirling T. Smith M. Kingsley B. Kelly S. Innes
BREAM R-5	BEMP 5	Bearded Seal	Icebreaker traffic in the transition (shear) zone will reduce bearded seal pup production.	Valid but untestable	**Summary** - No action required	I. Stirling T. Smith M. Kingsley J. Burns

TABLE 2-1 (CONT)

BREAM #	OLD #	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION	ACTION	SUGGESTED EXPERTISE
---	BEMP 6	Ringed Seal and Polar Bear	Icebreaker traffic in Amundsen Gulf will affect the ringed seal and polar bear populations.	Invalid	**No action** - Eliminated given current development scenario	
BREAM R-6	BEMP 7	Polar Bear Harvest	The presence of active facilities will result in increased polar bear mortality **and reduced harvest levels**.	Valid	**Summary** - Add linkage related to attraction of seals and bears to open water in lee of offshore structures as well as to reduced harvest levels (hypothesis wording altered to reflect the latter); some new information but no need to evaluate in workshop	M. Taylor I. Stirling S. Amstrup Schweinsburg J. Lentfor
BREAM R-7	BEMP 8	Polar Bear Harvest	Offshore hydrocarbon development activities will reduce the harvest of polar bears.	Valid	**Summary** - No further work recommended given current development scenario	
BREAM R-8	BEMP 9	Polar Bear Harvest	Chronic (episodic) oil spills resulting from normal petroleum hydrocarbon development activities within and adjacent to the marine environment will result in localized mortality of polar bears **and reduced harvest levels**.	Valid	**Summary** - add linkage related to reduced harvest levels (hypothesis wording altered to reflect this change); adequate information exists, no need to evaluate in workshop; Polar Bear Oil Spill Response Plan should be revisited before major development takes place	I. Stirling M. Taylor S. Amstrup Schweinsburg J. Lentfor R. Hurst Veterinarian

TABLE 2-1 (CONT)

BREAM #	OLD #	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION	ACTION	SUGGESTED EXPERTISE
BREAM R-9	BEMP 10 MEMP 10	Waterbirds	Chronic (episodic) oil spills resulting from normal petroleum hydrocarbon development activities **within and adjacent to the marine environment will reduce the abundance of certain species of waterbirds.**	Valid	**Summary** - hypotheses consolidated; new information available but no additional work required	D. Ward L. Dickson
---	BEMP 11	Eiders and Diving Ducks	Oil slicks in open water areas around offshore structures during periods of ice cover will cause increased mortality of eiders and diving ducks.	Valid	**No action** - previously combined with BEMP 10	
BREAM R-10	BEMP 12 MEMP 7	Waterfowl	Disturbance associated with hydrocarbon development in or near staging, moulting or nesting areas will affect the abundance and distribution of waterfowl.	Valid	**Summary** - hypotheses consolidated; linkages reworded to include effects of compressor noise; adequate information exists	D. Ward L. Dickson
BREAM R-11	BEMP 13	Fish Harvest	Shorebases and shallow-water production facilities will release (a) hydrocarbons and (b) heavy metals at sufficient levels such that fish harvest will be reduced through tainting and heavy metal accumulation.	Valid	**Summary** - linkages 1 and 3 of Hypothesis 13A reworded to include contaminants derived from air emissions; wording changed in linkage 4 of hypothesis 13B to remove reference to human health; active area of research but no need to re-evaluate at present time	
---	BEMP 14	Broad Whitefish	Nearshore structures will disrupt the nearshore band of warm brackish water and reduce the broad whitefish population.	Invalid	**No action** - eliminated due to current development scenario	

TABLE 2-1 (CONT)

BREAM #	OLD #	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION	ACTION	SUGGESTED EXPERTISE
---	BEMP 15	Arctic Cisco	Nearshore structures will disrupt the nearshore band of warm brackish water and reduce the Arctic cisco population.	Invalid	**No action** - eliminated due to current development scenario	
BREAM R-12	BEMP 16	Arctic Cisco and Broad Whitefish	The construction of shorebases and development of shallow-water production fields will result in a decrease in the populations of Arctic cisco and broad whitefish.	Valid	**Detailed evaluation** in workshop due to new information and concerns related to shorebases; wording changed in linkages and figure boxes to include references to pipeline landfall, brackish water, and effects on fish movement	B. Bond L. Lockhart B. Fechhelm E. Birchard E. Carmack R. MacDonald
---	BEMP 17	Broad Whitefish and Arctic cisco	**Marine** water intakes will reduce populations of broad whitefish and Arctic cisco.	Invalid	**Summary** - invalid with respect to marine water intakes (hypothesis wording altered to reflect this); eliminated due to current development scenario	
BREAM R-13	---	Broad Whitefish and Arctic cisco	Freshwater intakes will reduce populations of broad whitefish and Arctic cisco.	Valid but mitigable	**Detailed Evaluation** - new BREAM hypothesis developed to address effects of lake water drawdown	Not Reviewed; Same group as R-12 above with possible additions?
---	BEMP 18	Air Quality	Air emissions associated with aircraft and marine traffic; and operations of drill rigs, offshore platforms and shorebases will adversely affect air quality.	Invalid	**No action** - air quality not a VEC; effects of contaminants from atmospheric sources considered in BREAM R-11	

TABLE 2-1 (CONT)

BREAM #	OLD #	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION	ACTION	SUGGESTED EXPERTISE
BREAM R-14	BEMP 19	Bearded Seal	Dredging and deposition of spoils will reduce the bearded seal population.	Valid but untestable	**Summary** - no action required	
BREAM R-15	BEMP 20	Fish, Birds and Mammals	The discharge of drill cuttings contaminated with oil-based drilling muds during hydrocarbon exploration or production will reduce populations of fish, birds or mammals or will decrease the harvest of these resources due to hydrocarbon accumulation in tissues.	Valid	**Summary** - No need to re-evaluate at this time but should be revalidated in future workshop addressing community-based concerns	
---	BEMP 21	Bowhead Whale and Harvest	Tanker traffic and minor oil spills associated with the westward transport of Canadian Beaufort oil will cause reductions in the western Arctic population of bowhead whales and/or the harvest of this population by the Alaskan Inupiat.	Invalid	**No action** - eliminated because the current development scenario does not include tanker traffic	
BREAM R-16	MEMP 1	Arctic and Red Fox	The presence of offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a **change** in the number of Arctic and red foxes.	Valid	**Summary** - new information available which increases predictive capabilities; wording of hypothesis changed	B. Slough Cor Smitz
BREAM R-17	MEMP 2	Caribou	Increased traffic on **roads near or adjacent to insect-relief habitat** will decrease the number of caribou and alter their distribution.	Valid	**Detailed evaluation** in workshop due to new information and restructuring of hypothesis to exclude reference to roads leading to Mt. Fitton and King Point (hypothesis wording altered to reflect this change)	D. Russell W. Nixon D. Kline

TABLE 2-1 (CONT)

BREAM #	OLD #	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION	ACTION	SUGGESTED EXPERTISE
BREAM R-18	MEMP 3	Grizzly Bear	Gravel extraction, construction, seismic exploration and other development activities, and the presence of camps and garbage will decrease the number of grizzly bears and alter their distribution.	Valid	**Summary** - new information available to support previous conclusions regarding validity but no need to re-evaluate in workshop	P. Clarkson D. Shideler J. Nagy
BREAM R-19	MEMP 4	Waterfowl, Semi-aquatic Furbearers and Fish	**Water withdrawals and land subsidence resulting from hydrocarbon development activities will change the abundance and distribution of waterfowl, semi-aquatic furbearers and fish.**	Valid	**Detailed evaluation** in workshop due to major restructuring of hypothesis to include waterfowl and fish, as well as local subsidence along pipelines and roads in Mackenzie Delta and Valley	Industry rep. J. Hynes B. Bond B. Franzin B. Hecky B. Slough K. MacInnes Hydrologist
BREAM R-20	MEMP 5	Moose	Oil and gas development construction and clearing activities and the presence of an above-ground pipeline **and above-ground gathering systems** will change the abundance and distribution of moose.	Valid	**Brief evaluation** in workshop due to new information and inclusion of above-ground gathering systems (hypothesis reworded to reflect this change)	C. Smitz D. Larson P. Latour T. Spearing
BREAM R-21	MEMP 6	Marten	Oil and gas exploration and development activities that alter habitat permanently or temporarily will influence the distribution and abundance of marten.	Valid	**Detailed evaluation** in workshop due to new information, rewording of links 9 and 10 to include effect on quality of marten, and addition of linkage related to displacement through sensory disturbance	B. Slough J. Nagy K. Poole P. Latour

TABLE 2-1 (CONT)

BREAM #	OLD #	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION	ACTION	SUGGESTED EXPERTISE
BREAM R-22	MEMP 8	Raptors	Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptors.	Valid	**Summary** - no action required	C. Shank D. Mossop
BREAM R-23	MEMP 9	Waterfowl	The presence of camps and garbage disposal sites will attract predators that will lead to changes in the local abundance of waterfowl.	Valid	**Summary** - no action required	
BREAM R-24	MEMP 11	Waterfowl, Fish and Muskrat	Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat	Valid	**Summary** - no need to re-evaluate in workshop; wording of linkage 1 changed to clearly reflect regional land subsidence resulting from oil and gas extraction; wording of links 6,7 and 8 changed to abundance and distribution of waterfowl, fish and muskrat	Industry rep. S. Blasco J. Hynes B. Bond B. Franzin B. Hecky B. Slough K. MacInnes Hydrologist
---	MEMP 12	Air Quality	Air emissions resulting from oil and gas development and operation will adversely affect air quality.	Invalid	**No action** - air quality not considered a VEC	
---	MEMP 13	Fish Quality	Increased local disturbance due to activities related to hydrocarbon development will result in decreases in fish quality.	Invalid	**No action** - Was concluded to be invalid in 1985/86 MEMP report	
BREAM R-25	MEMP 14	Fish	Improved access and fishing pressure will decrease the abundance of fish and affect their distribution.	Valid	**Summary** - new information available	

TABLE 2-1 (CONT)

BREAM #	OLD #	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION	ACTION	SUGGESTED EXPERTISE
BREAM R-26	MEMP 15	Fish	Water discharge and accidental oil/chemical spills will lead to unpotable water and decreased acceptability of fish as a food source.	Valid	**Summary** - active area of research but no need to re-evaluate in workshop; should be revalidated in support of future work by community-based concerns group	
BREAM R-27	MEMP 16	Fish and Fish Harvest	The construction and presence of linear corridors will affect the number, distribution and quality of fish and fishing success.	Valid	**Summary** - hypothesis restructured to link food production directly to abundance and distribution of fish and to link the latter to fishing success	R. Fisher B. Hecky
---	MEMP 17	Wolverine	Wolverines attracted to camps and garbage will be killed as nuisance animals, thus reducing the population.	Invalid	**No action** - Info suggests this would be rare event	
BREAM R-28	MEMP 18	White Whale Harvest	Wage employment will change the harvest of white whales.	Valid	**Summary** - no need to re-evaluate in workshop	L. Harwood A. Carpenter A. Aviguana A. Elias
---	MEMP 20	White Whale Harvest	Competition by non-locals will change the number of white whales landed and increase mortality in the population.	Invalid	**No action** - no longer an issue because internally regulated by FJMC	

TABLE 2-1 (CONT)

BREAM #	OLD #	VEC	HYPOTHESIS STATEMENT	SCREEN DECISION	ACTION	SUGGESTED EXPERTISE
BREAM R-29	MEMP 21 MEMP 23	Birds, Fish and Mammals	Changes in access will affect the harvest of birds, fish and mammals.	Valid	**Summary** - restructure MEMP 21 to include birds, fish and mammals; link access directly to numbers and distribution of resources; unlikely given current development scenario; no further research/monitoring required	P. Usher J. Nagy
BREAM R-30	MEMP 22	Resource Harvesting	Increased levels of wage employment will change the total annual harvests of resources by communities in the region.	Valid	**Summary** - linkages reworded in relation to units of production; present revised hypothesis to community-based concerns group	M. Fabjan T. Rothie A. Aviguana
---	MEMP 24	Resource Harvesting	Industrial activities in harvesting areas will reduce the harvests of mammals, birds and fish because of conflicts between industry and harvesters over land use.	---	**No action** - eliminated because land use and compensation issues are outside scope of BREAM	
---	MEMP 25	Resource Harvesting	Increases in hunting by non-locals will restrict harvests by local natives.	Invalid	**No action** - no longer an issue due to claim agreements	
BREAM R-31	---	Bowhead Whale Harvest	**Rolph Davis** to develop new hypothesis on effects of offshore activities on bowhead harvest.	---	**Detailed Evaluation** will be required in workshop	To be determined
BREAM R-32	---	Birds, Fish and Mammals	**Mike Lawrence** to develop new hypothesis on effects of dredging in Husky Lakes.	---	**Detailed Evaluation** will be required in workshop	To be determined

2.2.3 Community-based Concerns Working Group

This group held its first planning meeting during 1991/1992 to begin the evaluation of how BREAM as a process can best address community-based concerns and to identify some of the environmental issues of importance to northerners. Section 5 of this report summarizes the results of this meeting and can be used to plan future activities of BREAM in relation to these issues. One of the most important products of this meeting was a conceptual model of a process for accessing and incorporating traditional and local knowledge and community concerns into BREAM. The need for another process that will address socio-economic concerns related to hydrocarbon development was also identified, as such issues are outside the scope of the BREAM process.

The Chairperson of this working group also assisted in the selection of community representatives from the Inuvialuit, Gwich'in, and Sahtu regions that attended the project workshop held in Richmond, B.C. during early May, 1992.

Outstanding planning activities that should be completed by this working group and/or the program sponsors include a review of existing documents that document community-based ecological concerns, and effort to involve future participation of representatives of the Deh Cho region in BREAM.

2.2.4 Catastrophic Oil Spills Working Group

The members of the Catastrophic Oil Spill Working Group attended the third day of the planning meeting involving the Impact Hypothesis Working Group. The results of this planning meeting included selection of Valued Ecosystem Components for future assessment in relation to a major oil spill, identification of a series of oil spill scenarios, and preliminary structuring of several new impact hypotheses. Additional work in the latter two areas was completed after the planning meeting by both the Catastrophic Oil Spill and Impact Hypothesis working groups. These outputs of BREAM in 1991/92 are fully described in Section 6.

Because major oil spills were not addressed during the project workshop this year, representatives of this working group did not participate in the 3-day meeting.

Outstanding work to be completed by the Catastrophic Oil Spill Working Group includes the preparation of additional scenarios related to refined oil product spills to help address community concerns expressed in the Community-based Concerns planning meeting, and preparation of background materials required for any future BREAM workshop focusing on major spills in offshore and onshore environments.

3. BEAUFORT REGION HYDROCARBON DEVELOPMENT SCENARIO

3.1 Introduction

The following describes the likely nature and scope of future hydrocarbon development in the Mackenzie Valley and Delta, and nearshore and offshore regions of the Beaufort Sea. It includes a review of current industry projections on the timing and location of future exploration, production and transportation aspects of development, which will provide the necessary focus for evaluating the validity of impact hypotheses formulated for BREAM.

The information presented below has been taken largely from the Hydrocarbon Development Scenario presented in the 1990/91 BREAM Final Report, and reflects changes in the scenario that have occurred since the release of the report. Much of this latter information was presented by an industry representative (E. Birchard, Esso) at the Interdisciplinary Workshop held this fiscal year.

3.2 Exploration and Production

3.2.1 Background

To date, production of hydrocarbon reserves within the BREAM study area has only occurred at the Norman Wells field. Oil production began in 1921, when a topping plant was constructed by Imperial Oil Limited. Hydrocarbon activity continued to focus primarily on Norman Wells until the 1950s, when interest extended into the Mackenzie Delta area. In the mid 1980s, a number of new wells were drilled at Norman Wells to increase production from this field, and a small diameter oil pipeline was constructed.

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. To date, more than 200 wells have been completed and a number of significant oil and gas finds have been discovered. While only a single well has been drilled at some sites, a number of wells have been completed at others in an effort to define the volume and extent of petroleum reserves. Despite these significant discoveries, high expectations of this region have not been met. Unlike the Alaskan North Slope where a small number of large, prolific fields exist, the Mackenzie/Beaufort region is characterized by a large number of smaller, widely scattered reserves due to highly structured and fractured sedimentary strata. Production from these fields will be more difficult and expensive, requiring more extensive gathering systems than those used in Alaska.

Although the most attractive prospects in this region have likely been examined, exploration for oil and natural gas has continued, being stimulated at times by oil prices and the perceived need for gas. Exploration activity is presently occurring in three geographic areas: Norman Wells, Colville Lake, and the Mackenzie Delta/Beaufort Sea. Most of this work is being completed largely to meet existing commitments. For example, wells drilled by Esso at their Tuk tertiary gas/oil field (20 km south of the hamlet of Tuktoyaktuk) were to satisfy prior commitments with the Inuvialuit Petroleum Corporation. There is little activity by Petro-Canada in the Colville Lake area at present, although there have been some significant discoveries. Renewed interest in exploration could follow development/pipeline initiatives and increased activity by other companies.

Minimal exploration and seismic work is expected to continue in the short term (i.e. 3-5 years). Some industry representatives expect only 0-3 wells to be drilled in any given year, although there is the potential for additional drilling commitments (albeit small) because of crown and settlement land sales in the region. In the offshore, most exploration will probably be completed either in the summer from drilling platforms and bottom-founded structures, or in winter within the landfast ice zone. It is expected that exploration activity in the Norman Wells and Colville Lake regions will continue to be supported from Norman Wells, while activity in the Mackenzie Delta/Beaufort Sea will be supported from the communities of Inuvik, Tuktoyaktuk and a number of bases located in the northern part of the Delta.

While the exploration phase is expected to continue through the 1990s, there is interest on the part of the petroleum industry to develop both oil and gas reserves in the Beaufort region over the long term. From the producers' perspective, there is no priority in terms of whether oil or gas development comes first. In recent years, they have been cautiously pursuing the production of natural gas from the Delta. In 1989, the three principal Delta Gas reserve owners, Esso Resources Canada, Gulf Canada Resources and Shell Canada received conditional approval from the National Energy Board (NEB) for the right to export approximately 9.2 trillion ft^3 (tcf) of natural gas from the Mackenzie Delta area. This significant decision represents an important step needed to proceed with a request for a Certificate to construct a pipeline along the Mackenzie Valley. In 1991, A Statement of Principles was signed between these three major producers and the three main pipeline companies (Polar Gas, Foothills and Interprovincial) interested in a Mackenzie Valley pipeline to establish a Joint Venture. The initial purpose of a joint venture would be to obtain the necessary approvals to build a mutually-acceptable transportation system to transport Mackenzie Delta gas to southern pipeline infrastructures. It is anticipated that development of a gas pipeline would provide a major stimulus for further exploration and delineation drilling of already discovered fields.

Although the Mackenzie Delta has large proven gas reserves, production of Mackenzie Delta gas is not viewed as being economically viable at the present time due to a surplus and current low price of this commodity, and the existence of a lower cost alternate supply source. As a result, industry is not currently pro-active in pursuing development of these reserves. This situation, however, would likely change when prices and market demand increase.

Oil development is largely reserve driven. Although world oil prices are presently a limiting factor in the production of oil from the Beaufort/Mackenzie Delta region, the primary concern is that insufficient oil reserves have been discovered to date to justify production. The producers believe that if other significant onshore and offshore reserves like those in the Amauligak structure are found, development would be economically feasible (E. Birchard, pers. comm.). At this time, the most probable scenario for the first phase of development would involve a small diameter oil pipeline to bring oil from the Delta on stream with existing infrastructure in Alberta.

3.2.2 Possible Development Scenarios

The sequence and schedule of development of proven oil and gas reserves in the region is uncertain and will depend on several factors including the nature of the initial development plan and the transportation system put into place to support it. From the producers' perspective, there are currently three scenarios for hydrocarbon development in the region (E. Birchard, pers. comm.):

1. "**Small Oil Development**" - This would involve the construction of a small diameter (8-10") pipeline to transport oil from the Delta to Norman Wells, where it would tie into the existing Interprovincial Pipe Line (IPL) system. This would involve the transport of 15,000-25,000 barrels/day of oil and would see small onshore fields such as Atkinson brought into production. This scenario is not considered to be economically feasible at the present time, given the high tariffs on this type of pipeline.

2. "**Big Oil Development**" - This would involve the construction of a large diameter (20-24") pipeline that would transport oil (about 100,000 bbls/day) from proven oil reserves in the Delta and nearshore Beaufort Sea. The lead field would be Amauligak. This pipeline would tie into other lines in Alberta. A "Big Oil Development" would involve its own pipeline and would require that Amauligak come into production, as well as other significant onshore and offshore fields.

3. "**Big Gas Development**" - This would initially involve production of Delta natural gas reserves from three fields: Taglu, Parsons Lake and Niglintgak. Production from these fields would keep a large diameter (30-36") pipeline filled to capacity for 8-10 years. Because project financing would require that the line be operated at capacity for 20 to 25 years, other fields would have to be brought into production. If an oil pipeline was already in place, the liquid condensate from processing of the natural gas would be fed into the existing line. If there is no infrastructure in place, then a small-diameter liquids pipeline could be constructed.

"Small gas development" is not considered an option because it would require a large throughput to be economically feasible.

3.2.3 Production of Gas Reserves

The following description of most probable scenarios for production of natural gas reserves in the Mackenzie Delta/Beaufort region has been taken largely from discussions with industry representatives and CPA (1989).

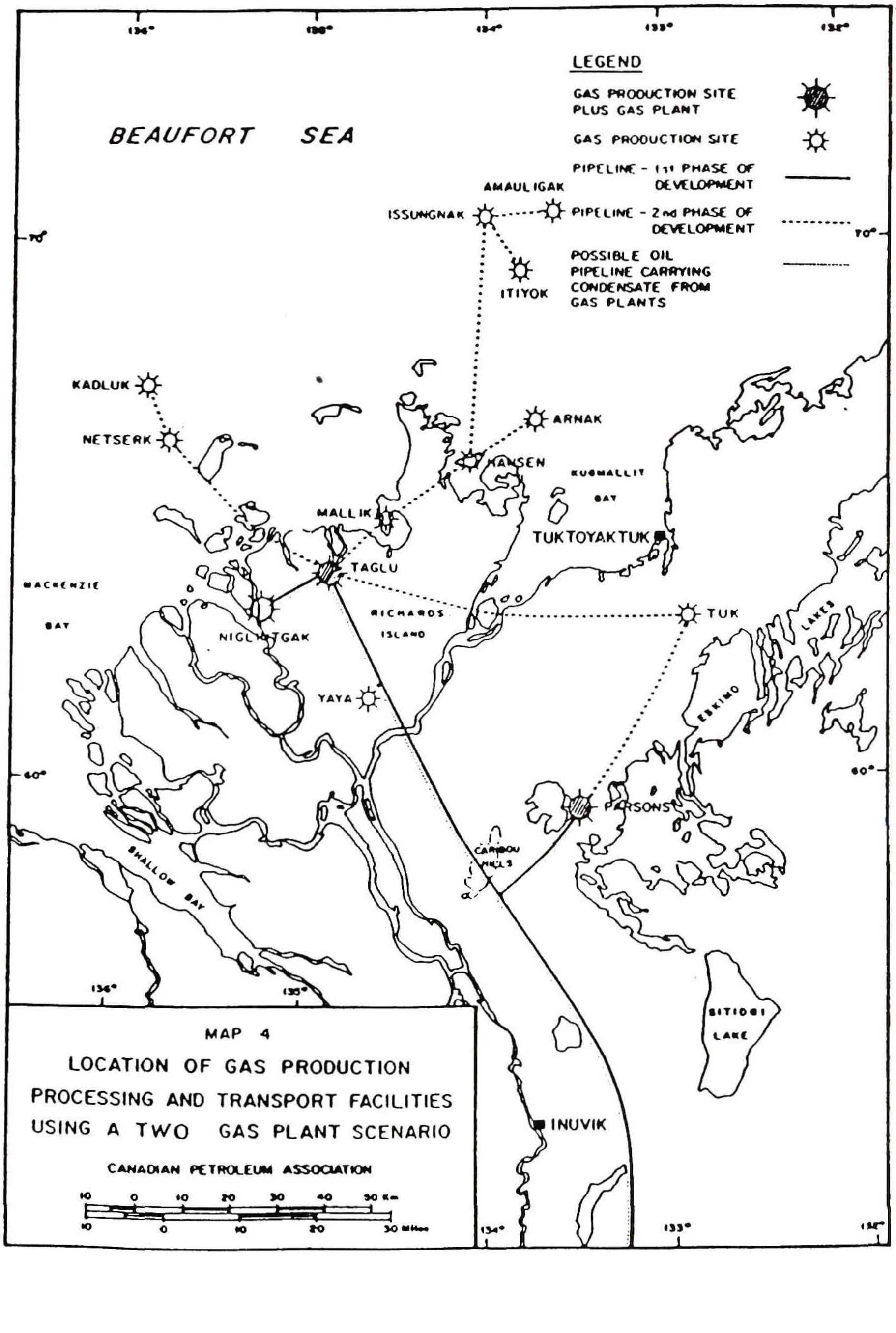
3.2.3.1 Two Plant Option

The likely scenario for the first phase of gas development in the region would be the construction of a gas processing plant at Taglu on Richards Island and one at Parsons Lake on the mainland. Gas reserves at Niglintgak on Richards Island would be processed at Taglu. Taglu, Parsons Lake and Niglintgak are the largest gas reserves located to date in the Delta. Figure 3-1 shows the location of gas production, processing and transportation facilities in a development scenario involving two gas plants. Drilling operations and construction of gathering systems at the three fields, as well as construction of the two gas plants, would be sequenced over a four-year period. However, it is conceivable that the gas could initially be produced only from the two major fields on Richards Island (Taglu and Niglintgak), with gas from the mainland (Parsons Lake) coming onstream a few years later.

Based on well and geological data, it is estimated that the Taglu field would require approximately 22 production wells and 2 water disposal wells to achieve maximum production efficiency. The production wells would be aligned in a group cluster, and directional drilling techniques using oil-based mud formulations would be employed to reach the optimal reservoir points. The gas produced from each wellhead would be transported to the Taglu plant via an insulated, above-ground pipeline. The plant would have a raw gas capacity of 890 MMSCFD (millions of standard cubic feet per day) in order to process both Taglu and Niglintgak gas reserves, and would process 13,000 barrels of condensates per day.

FIGURE 3-1

LOCATION OF GAS PRODUCTION PROCESSING AND TRANSPORT FACILITIES USING A TWO GAS PLANT SCENARIO (Adapted from CPA 1989)



Gas from the Niglintgak field would be moved to Taglu by an above-ground insulated pipeline. Development of this field would involve approximately 10 production wells drilled vertically or from common drilling pads. Production from these wells would be gathered at a small onsite processing facility, which would separate free water and prepare the gas for shipment to Taglu.

Under the two plant scenario, a separate plant would be required at Parsons Lake. This facility would be capable of processing 470 MMSCFD of gas and 6,500 barrels/day of condensates. Development of this field would involve 13 production wells drilled from two drilling pads. Above-ground gathering lines would move gas to the plant. Processed gas would be moved through below-ground pipelines to the main gas line, which would be located about 25 km to the west of the plant. Liquid hydrocarbons would be transported from both the Parsons and Taglu plants via a small liquids line, which would either parallel the natural gas pipeline route or tie in with the existing line at Norman Wells.

As these three primary gas reserves begin to deplete, a number of smaller onshore and, eventually, offshore gas fields would be developed to meet long-term gas sales requirements. These would likely include Kadluk, Netserk, Issungnak, Amauligak, Itiyok, Arnak, Hansen, Tuk and Mallik. However, more delineation drilling of these reserves would be required. Over a 25-year period, there would likely be overlapping phases of development (possibly 4-5 phases) in order to keep the pipeline operating at full capacity. Onshore reserves would likely be connected first because this would be the less expensive alternative. Gas would be transported by refrigerated, buried pipelines. Production from offshore gas fields would likely require the construction of production islands to provide a central base for the dehydration and liquid separation facilities. Gas and liquid condensates would be moved to shore via buried lines.

3.2.3.2 "Industry" Plant Option

An alternative plan for development of natural gas reserves is also under consideration. This would involve construction of a centrally-located gas plant that would serve the three major gas fields and eventually other smaller reserves in onshore and offshore areas. Swimming Point on the east channel of the Mackenzie River seems the most likely site for the plant, although other locations may be considered in the future. A central plant would require extensive above-ground gathering systems, which would have both economic and environmental implications. This scenario is illustrated in Figure 3-2.

3.2.4 Production of Oil Reserves

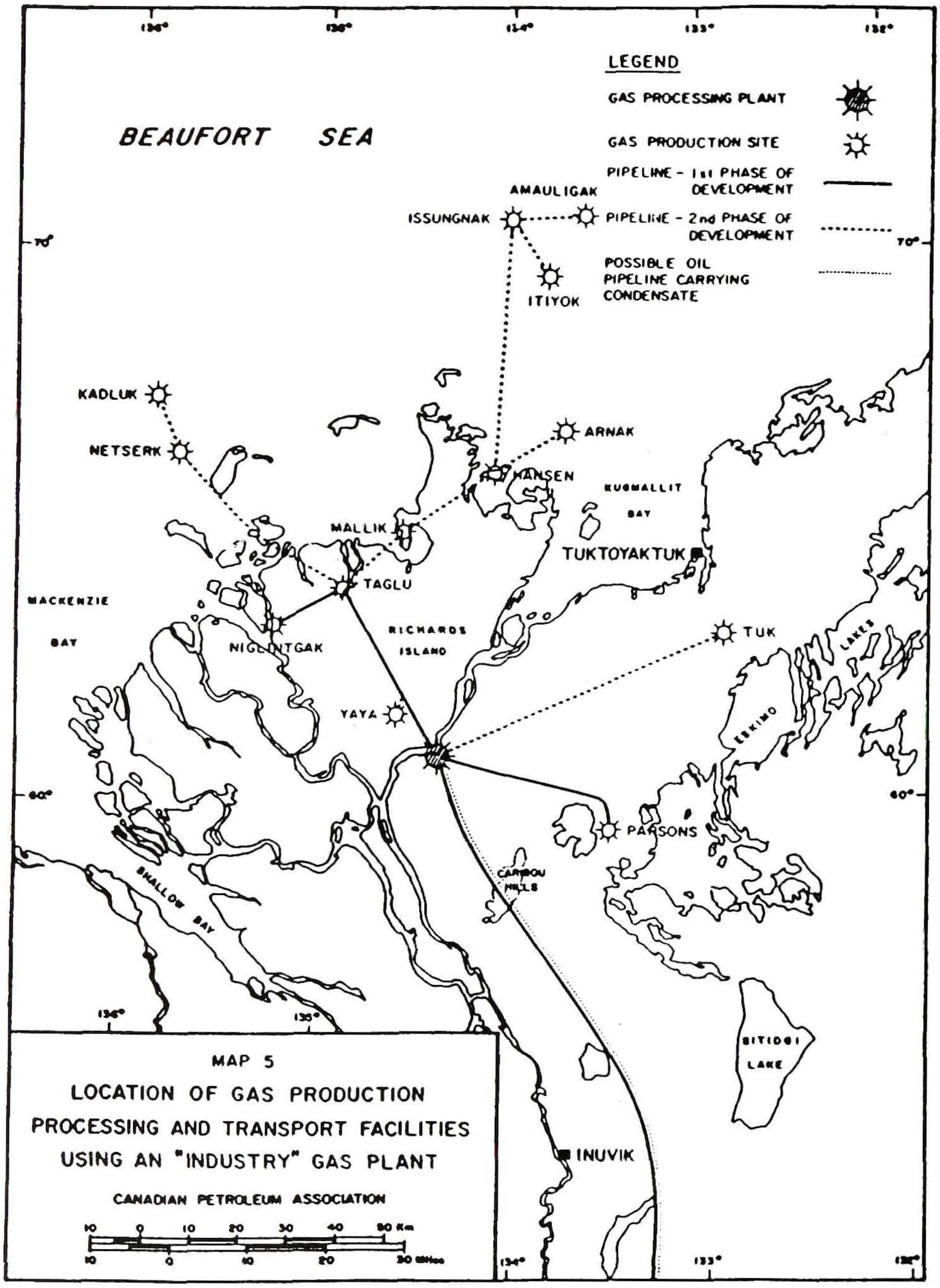
As stated previously, additional large proven oil reserves will likely have to be discovered before production of oil in the Mackenzie/Beaufort region is viewed as being economically feasible. While exploration of oil reserves will likely continue onshore and in the nearshore in support of future production from the region, activity in deep offshore waters of the Beaufort Sea is very unlikely in the immediate future due to high costs associated with such drilling programs.

Development of oil reserves in the region would initially involve production from small onshore fields such as Atkinson, Adgo, Niglintak, Kumak and Kugpik. Under this development scenario, oil would be transported south by a small diameter pipeline along the Mackenzie Valley where it would tie into the existing IPL system. Production of new reserves at Norman Wells brought onstream in the mid 1980s is now declining, and it is estimated that the IPL pipeline will be operating only at partial capacity by the mid 1990s (E. Birchard, Esso, pers. comm.). Use of tankers to transport oil out of the north is not considered an option by the petroleum industry at the present time. However, there is the potential for smaller-scale shuttle of oil from prospective offshore fields to onshore harbour complexes.

Large-scale development in the region would not likely occur until well into the next century (E. Birchard, pers. comm.). "Big Oil Development" would involve production from the major oil discovery at Amauligak. Offshore production facilities would be put into place at

FIGURE 3-2

LOCATION OF GAS PRODUCTION PROCESSING AND TRANSPORT FACILITIES USING A SINGLE GAS PLANT SCENARIO (Source: CPA 1989)



Amauligak, and a sub-sea pipeline would be constructed to carry oil to shore. The most likely location for the landfall would be North Point on Richards Island, which would require the construction of onshore facilities to receive, condition, store and pump the produced oil. Under this development scenario, oil would be carried south via a large diameter pipeline extending from North Point along the Mackenzie Valley, where it would follow the existing ROW of the small diameter line and eventually the IPL line. Once transportation systems are in place and production of Amauligak oil is onstream, production of smaller offshore discoveries would then follow. These reserves would be connected either through separate offshore gathering lines or existing lines (i.e. Issungak) to North Point. The locations of oil production sites and transport facilities described in this development scenario are illustrated in Figure 3-3.

If oil reserves in the region are developed within a similar time frame or after natural gas, gas produced at oil production sites would be moved to gas processing facilities, or to a nearby gas pipeline.

3.3 Transportation Systems

The following material was taken largely from Polar Gas (1991) and has been supplemented to reflect discussions with other representatives of the pipeline industry.

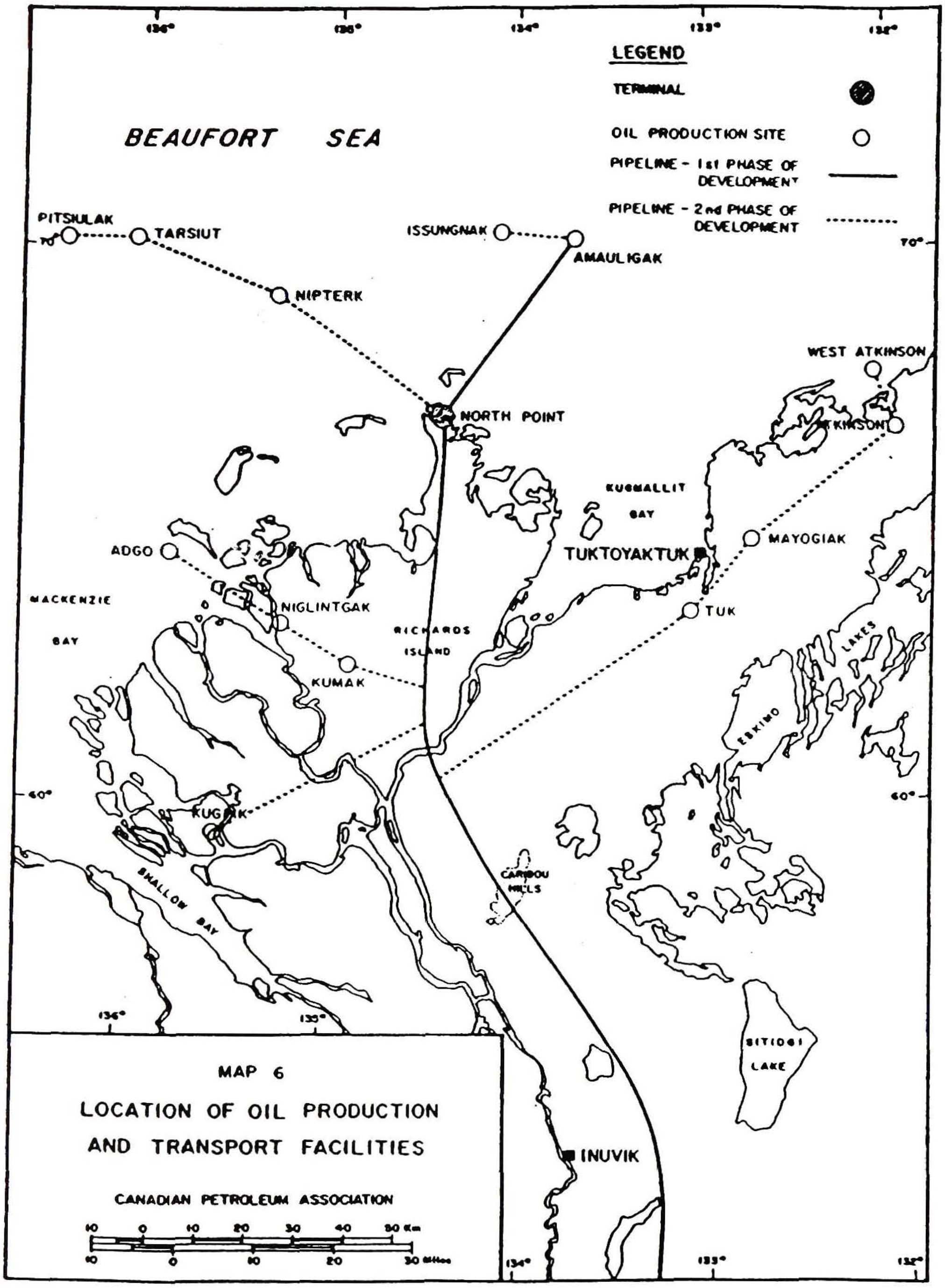
3.3.1 Background

Based on the likely scenarios for development of oil and natural gas reserves in the Mackenzie/Beaufort region, up to three separate transmission pipelines may eventually be constructed to transport petroleum to southern markets. These include a natural gas pipeline, an oil pipeline and/or a condensate pipeline.

The feasibility of an oil pipeline to carry both onshore and offshore oil from the Mackenzie Delta and southern Beaufort Sea south along the Mackenzie Valley has been discussed for several decades. Although such a facility is considered an essential element in

FIGURE 3-3

LOCATION OF OIL PRODUCTION AND TRANSPORT FACILITIES
(Source: CPA 1989)



the development of the region's petroleum reserves, there are currently no proposals for an oil pipeline.

As part of the plan put forward for the Alaska Highway Gas Pipeline system, Foothills Pipe Line proposed a Dempster Lateral Gas Pipeline to carry Mackenzie/Beaufort natural gas to the mainline system in the Yukon. While Foothills has a Certificate of Public Convenience and Necessity for the Alaska pipeline, there are no current initiatives to proceed with either system. Any plans for construction of the Dempster Lateral would be contingent on whether the Alaska Highway Gas Pipeline goes ahead. Transportation of Alaskan gas to southern markets via the Alaska Highway Pipeline, however, remains one of the long-term goals of Foothills. If Alaskan gas flows before Mackenzie Delta gas, then the company's interest in the Dempster line would be renewed and it could be seen as a viable development option. Alternatively, other industry representatives have indicated the potential for an east-west pipeline tying the North Slope or adjacent and subsequent feeder lines to a Mackenzie Valley pipeline. Such a pipeline would likely be located within the land-fast ice and be constructed during winter.

At the present time, the NEB has before it two incomplete applications to build a Mackenzie Valley gas pipeline. The first was filed by Polar Gas in 1984 and was intended for the construction of a large diameter (36") pipeline from Richards Island in the Mackenzie Delta to Edson, Alberta, where it would connect with existing pipeline systems. The second application, filed by Foothills Pipelines in 1989, was for a 34" diameter pipeline extending from Richards Island to Caroline, Alberta, via Boundary Lake on the British Columbia-Alberta border. As mentioned previously, the three major producers (Esso, Shell and Gulf) and the three main pipeline companies (Polar Gas, Foothills and Interprovincial) have signed a Statement of Principles to establish a new Joint Venture to transport Mackenzie Delta natural gas to southern markets. Through such a venture, it would be the intent to prepare a new pipeline application to replace the present ones. Only one joint application would proceed through the necessary public review processes, eventually leading to an NEB Certificate of Public Convenience and Necessity.

Eventual timing for development of a natural gas pipeline will ultimately be determined by the North American gas market demands and associated price. A joint pipeline application will not likely be pursued until the demand and price of natural gas increase.

3.3.2 Natural Gas Pipeline System

The following provides a brief description of how a joint Mackenzie Valley gas pipeline project might proceed. The description is of a general nature, with ranges being provided where differences between companies and their philosophies exist. It should also be emphasized that the proponents of this project expect and will promote input from all interested parties, particularly from the people and communities along the proposed route. The objective will be to ensure that the final routing and nature of the project will be both environmentally and socially acceptable in addition to satisfying the mandatory technical and economic criteria.

A natural gas pipeline along the Mackenzie Valley will be a buried pipeline approximately 1,450 miles (2,330 km) long, extending from Taglu, on Richards Island to connect to existing systems in Alberta. The pipeline will have an outside diameter of 34" -36" (864 - 914 mm) and will be designed to initially transport 1.2 billion ft^3/day (34 million m^3/day).

The natural gas will be transported at a maximum operating pressure in the range of 1140 to 2160 psig, with a related nominal pipe wall thickness of 0.46 to 0.51 inch (11.68 - 12.95 mm). Heavier-walled pipe will be used in regions where there is potential for pipe movement (i.e. discontinuous permafrost areas, unstable slopes, river crossings). The gas will be chilled to 32°F (0°C) or lower from Taglu through to the southerly limit of widespread permafrost between Fort Good Hope and Norman Wells, NWT. Beyond this point, the temperature of the gas will be maintained between 32° to 50°F (0°C to 10°C) to minimize thermal effects on terrain.

The pipeline system will be powered initially by 3-10 compressor stations, equipped with refrigeration and/or heating facilities to maintain a thermal balance between the pipeline and adjacent permafrost or seasonally-frozen soils. Future expansion of the system to increase gas throughput can be accommodated by adding additional compression facilities as required.

3.3.2.1 Compressor Stations

Assuming a 1440 psi-pressure pipeline, 10 compressor stations would be required to initially power the pipeline system. Each of the stations will require up to 12 acres (5 hectares) for site development. The compressor stations will be designed to meet the requirements of the northern environment. To protect any underlying permafrost, the northern stations will be constructed on gravel pads and critical foundations within each station will be insulated. In addition, all of the station equipment will be enclosed in fully-insulated buildings. All emissions from the compressor stations will meet or exceed existing regulatory standards.

3.3.2.2 Pipeline Route

The past pipeline proposals have indicated a route that extends southerly from the Mackenzie Delta gas production facilities passing approximately 15 miles (24 km) east of Inuvik and continuing southeasterly past Travaillant Lake. Beyond this point, the route generally parallels the Mackenzie River to the vicinity of Fort Good Hope and then proceeds southerly to enter the Franklin Mountains west of Chick Lake. After crossing the mountains at Gibson Gap, the route continues generally parallel to the Mackenzie River and the Interprovincial Pipe Line (NW) Ltd. oil pipeline to a point approximately 40 miles (64 km) west of Fort Simpson. At this location, two primary routing options of identical length have been considered.

1. The "Polar Gas option" continues to follow the IPL oil pipeline right-of-way, passing to the east of Fort Simpson, where it crosses the Mackenzie River. The route then proceeds southward past Zama en route to Caroline.

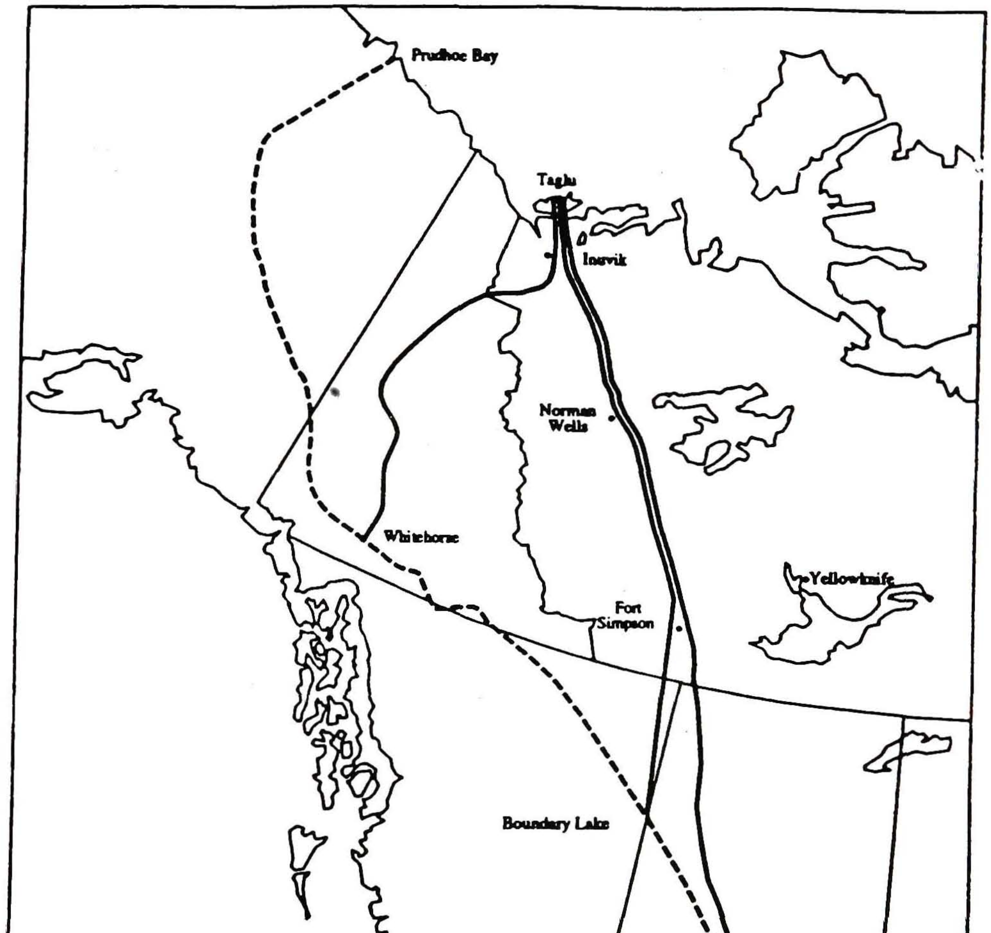
2. The "Foothills option" crosses the Mackenzie River 40 miles (64 km) west of Fort Simpson. It then crosses the Liard River heading in a southerly direction to interconnect with the facilities of Foothills Alta. on the British Columbia border near Boundary Lake. From there, the route heads southeasterly into Alberta.

Final route selection for a joint pipeline proposal will be the subject of further discussion. Decisions regarding route selection will be made by the proponents in consultation with government regulatory agencies and the communities along the proposed routes. Figure 3-4 shows the proposed routing alternatives to transport Mackenzie Delta gas to Alberta.

It is possible that small feeder/distribution lines would eventually be constructed off the main pipeline to transport natural gas to northern communities. It is expected that the GNWT would undertake economic analyses to determine those communities located adjacent to the pipeline route where such distribution systems may be viable over the long term.

FIGURE 3-4

ROUTING ALTERNATIVES TO TRANSPORT MACKENZIE DELTA GAS



4. EFFECTS OF ROUTINE ASPECTS OF HYDROCARBON DEVELOPMENT AND TRANSPORTATION

4.1 Introduction

The primary focus of the 1991/1992 BREAM program was placed on reviewing existing BEMP and MEMP impact hypotheses related to routine aspects of hydrocarbon development and transportation to determine research and monitoring priorities for BREAM and NOGAP over the next two years. An interdisciplinary workshop, attended by 40 representatives from government, industry and northern communities, was held in Richmond, B.C. on May 5-7, 1992. During the workshop, the Impact Hypothesis Working Group was charged with the responsibility of: (1) reviewing the hypotheses in terms of the adequacy of existing information; (2) conducting a preliminary assessment of each hypothesis; and (3) identifying future research and monitoring requirements.

4.2 Assessment Procedures used in BREAM

During the Project Initiation Meeting (Section 2.2.1), it was concluded that the assessment procedure described in Duval and Vonk (1991) should be used to make a preliminary determination of the significance of potential impacts evaluated in each of the BREAM hypotheses. However, because the workshop facilitators from ESSA Ltd. were unfamiliar with this method, it was agreed in a pre-workshop planning meeting that they could use a procedure with which they were more familiar. This procedure was explained to workshop participants in the opening Plenary Session and was followed by two of the four sub-groups. One group found the ESSA procedure to be too time-consuming and, therefore, followed the Duval and Vonk method, while the fourth group refused to undertake any assessment activities during the workshop, stating [incorrectly] that BREAM was not the appropriate forum for environmental assessment. The concern of some members of this group was that any conclusions regarding impact significance would be taken out of their intended context as a preliminary screening tool to help focus research priorities. Specifically, it was feared that assessment conclusions of "significant" or "insignificant" by this group might be construed by some individuals or organizations as pre-empting the need for other (more detailed) assessment procedures in the future. Attempts to convince this group that this was not the intent of BREAM were unsuccessful.

The use of two methods, while unfortunate and something that will have to be addressed by the BREAM sponsors to avoid this problem in the future, is unlikely to have any serious consequences to the outcome of the workshop. Both procedures lead assessors to a conclusion of whether a potential impact would be: (1) significant, (2) insignificant, or (3) unknown. It is also emphasized that the preliminary assessment conducted as part of BREAM is not intended to circumvent the need for other assessment activities that may be appropriate as part of project review processes, particularly when a more precisely-defined development scenario is presented by industry. The fact that one of the four groups did not comply with the workshop charge to undertake the preliminary assessment is also unfortunate. In the future, facilitators will have to be prepared to comply with the requirements of the BREAM workshop organizers and sponsors, regardless of the views of a few participants.

The remainder of this section briefly describes both assessment procedures used during the workshop.

4.2.1 Method A - ESSA Procedure

There were six steps in the first of the two assessment procedures used during the workshop. These were:

1. Define all project activities
2. Define all environmental components (VECs) in the project area

and for each project activity/VEC interaction,

3. Define the spatial scale of the potential impact
4. Define the temporal scale of the potential impact
5. Determine the magnitude of the perturbation (change)
6. Determine potential environmental effects of the project based on Steps 1 to 5 and assign significance to the impact.

In definition of the **Spatial Scale**, the following four categories were used:

Site Impact: The effect/impact is on a portion of a single, relatively independent and unconnected resource or value.

Local Impact: The effect/impact is on a large proportion of a single, relatively independent and unconnected resource or value. Other, similar resources or values may or may not exist in the region, but these are unaffected if they do exist.

Regional Impact: The effect/impact is on a group of similar resources or value. Other similar resources or values may exist in the region, but these are unaffected. Alternately, the effect is on a single resource which has a regional distribution.

National Impact: Anything larger than a regional impact.

Three categories of impacts were then used to define **Temporal Scale:**

Short term: The effect/impact can/will occur over a time period less than one generation of the resource or value being considered. For resources or values that are defined with the word "quality" such as "water quality" or "sediment quality", it is appropriate to use the generation time of the medium, in this case the water or the sediment turnover.

Medium term: The effect/impact can/will occur over a time period approximately equivalent to one generation of the resource or value being affected. The "quality" issue described above applies equally here.

Alternatively, recovery of the resource or value after removing the influence of the project activity(ies) will take approximately one generation of the resource or value. The "quality" issue described above applies equally here.

Long term: The effect/impact can/will occur over a time period greater than one generation of the resource or value being affected. The "quality" issue described above applies equally here.

Alternatively, recovery of the resource or value after removing the influence of the project activity(ies) will take more than one generation of the resource or value. The "quality" issue described above applies equally here.

The scale of impact was also examined in the context of the **Perturbation Magnitude** through the use of the following definitions:

Small Perturbation:	The effect/impact cannot be statistically detected (under normal assessment budgets; given enough resources, any perturbation can be detected).
Mod. Perturbation:	The effect/impact can be statistically detected and ascribed to the influence of the project.
Large Perturbation:	Statistics are not required to observe the effect/impact.

The ESSA procedure then uses the above three scale parameters as guidelines to determine if the effect/impact is "low", "medium" or "high". However, for the purpose of the BREAM workshop, these categories were expressed as either "insignificant" or "significant" by equating low and medium impacts to insignificant impacts, and high impacts to significant impacts. Table 4-1 shows the relationship between the time scale, spatial scale and perturbation categories and the potential environmental significance derived using this method.

TABLE 4-1

ASSESSMENT CONCLUSIONS FOR DIFFERENT TEMPORAL AND SPATIAL OVERLAP PERTURBATION CATEGORIES (based on ESSA procedure)

TIME SCALE	SPATIAL SCALE	PERTURBATION TYPE	SIGNIFICANCE
Short term	Site	Small	Low-Insignificant
Short term	Site	Moderate	Medium-Insignificant
Short term	**Site**	**Large**	**High-Significant**
Short term	Local	Small	Low-Insignificant
Short term	Local	Moderate	Medium-Insignificant
Short term	**Local**	**Large**	**High-Significant**
Short term	Regional	Small	Medium-Insignificant
Short term	**Regional**	**Moderate**	**High-Significant**
Short term	**Regional**	**Large**	**High-Significant**
Short term	**National/Internat.**	**Small**	**High-Significant**
Short term	**National/Internat.**	**Moderate**	**High-Significant**
Short term	**National/Internat.**	**Large**	**High-Significant**
Medium term	Site	Small	Low-Insignificant
Medium term	Site	Moderate	Medium-Insignificant
Medium term	**Site**	**Large**	**High-Significant**
Medium term	Local	Small	Medium-Insignificant
Medium term	Local	Moderate	Medium-Insignificant
Medium term	**Local**	**Large**	**High-Significant**
Medium term	Regional	Small	Medium-Insignificant
Medium term	**Regional**	**Moderate**	**High-Significant**
Medium term	**Regional**	**Large**	**High-Significant**
Medium term	**National/Internat.**	**Small**	**High-Significant**
Medium term	**National/Internat.**	**Moderate**	**High-Significant**
Medium term	**National/Internat.**	**Large**	**High-Significant**
Long term	Site	Small	Medium-Insignificant
Long term	**Site**	**Moderate**	**High-Significant**
Long term	**Site**	**Large**	**High-Significant**
Long term	Local	Small	Medium-Insignificant
Long term	**Local**	**Moderate**	**High-Significant**
Long term	**Local**	**Large**	**High-Significant**
Long term	Regional	Small	Medium-Insignificant
Long term	**Regional**	**Moderate**	**High-Significant**
Long term	**Regional**	**Large**	**High-Significant**
Long term	**National/Internat.**	**Small**	**High-Significant**
Long term	**National/Internat.**	**Moderate**	**High-Significant**
Long term	**National/Internat.**	**Large**	**High-Significant**

4.2.2 Method B - Duval and Vonk Procedure

The assessment procedure described in Duval and Vonk (1991) involves the use of a series of standard forms that assist in:

(1) identifying the activities and disturbance sources associated with the proposed project that may cause impacts, planned mitigative measures, and their anticipated success in preventing or minimizing impacts;

(2) identifying the environmental components that would be considered VECs or VSCs;

(3) preparing matrices that delineate all potential interactions between selected VECs and VSCs with project-related disturbances and activities;

(4) predicting in a semi-quantitative manner, the degree of spatial and temporal overlap between each VEC in relation to each project disturbance/activity, as well as assessing potential conflicts involving each of the VSCs;

(5) evaluating the environmental significance of any potential and/or residual impact that may result from the project;

(6) recording the rationale for all decisions and conclusions through the completion of an Audit Trail; and

(7) considering the potential for cumulative impacts within a given year and in subsequent years both in terms of defining spatial and temporal overlap between the project and VECs and VSCs and in evaluation of potential impact significance.

To adapt this assessment procedure for use in BREAM, some minor modifications were necessary. The first three steps in this procedure were accomplished through the Adaptive Environmental Assessment and Management (AEAM) approach utilized in BREAM. Through formulation of impact hypotheses, the VECs/VSCs and project disturbances/activities were already defined and the potential interactions between these were identified in the set of hypothesis linkages. Both BREAM and this assessment procedure follow the Valued Ecosystem Component (VEC) concept to aid in defining impact significance.

Although the standard forms (mentioned above) for estimating the spatial and temporal overlap of each project interaction were not used during the workshop, the working group was required to define the spatial and temporal scales of the potential impact in order to determine impact significance. In this assessment procedure, the determination of environmental significance builds on semi-quantitative estimates of the extent of spatial and temporal overlap between project impacts and VECs and VSCs.

The environmental significance of each project/VEC or project/VSC interaction is evaluated through the use of three questions shown in Figures 4-1 and 4-2. This process leads to a conclusion on impact significance ranging from CLASS 1 and CLASS 2 (**SIGNIFICANT**) to CLASS 3 and CLASS 4 (**INSIGNIFICANT**). In some cases, lack of information precludes the assessment of impact significance and forces the assessor to conclude that the impact significance is **UNKNOWN** and that additional research may be required. If it is believed that additional research will not provide information with which to assess the environmental significance of the effect, then it is concluded that the significance **CAN'T BE KNOWN**. In the Duval and Vonk assessment procedure, one generation for species VECs (the time required for an organism to reach sexual maturity) and one year for VSCs was selected as the appropriate length of time to distinguish short- and long-term impacts. However, the assessor should establish its own definition of long-term and short-term recovery/restoration as these periods could vary among VECs and VSCs.

4.3 Review of Impact Hypotheses

During the Impact Hypothesis Working Group Meeting (Section 2.2.2), it was concluded that 32 impact hypotheses would be reviewed as part of BREAM this year. Of these, 8 hypotheses were identified for a detailed evaluation due to new information, re-interpretation of existing information, changes to the development scenario and/or the increased scope of BREAM. For each of the hypotheses, the workshop participants were charged with: (1) evaluating the validity of the hypothesis and its associated linkages; (2) determining the adequacy of existing information; and (3) identifying areas where further information gained through research and monitoring is needed. The remainder of the 32 impact hypotheses were

FIGURE 4-1
SPECIES VALUED ECOSYSTEM COMPONENTS
QUESTIONS OF SIGNIFICANCE

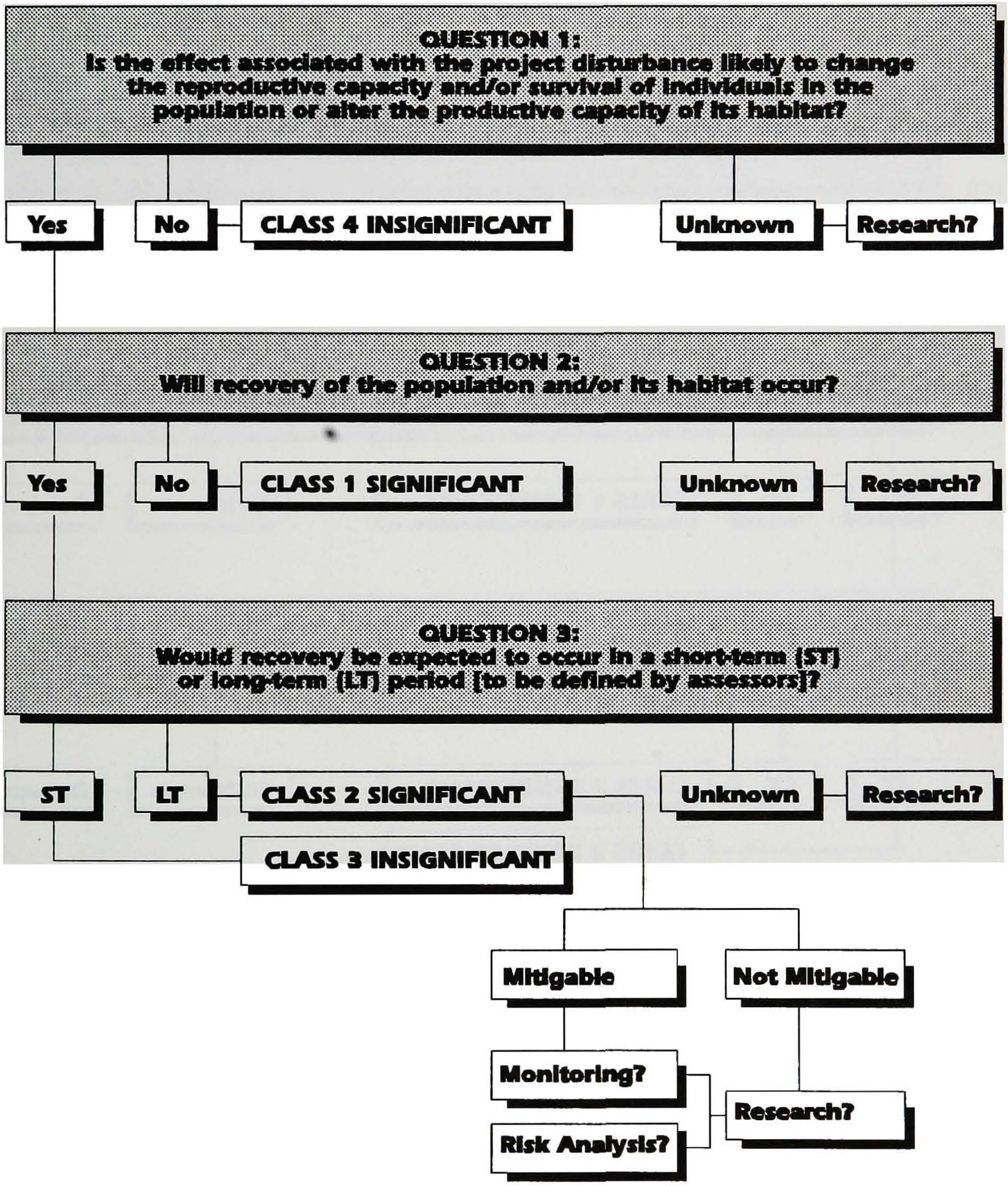
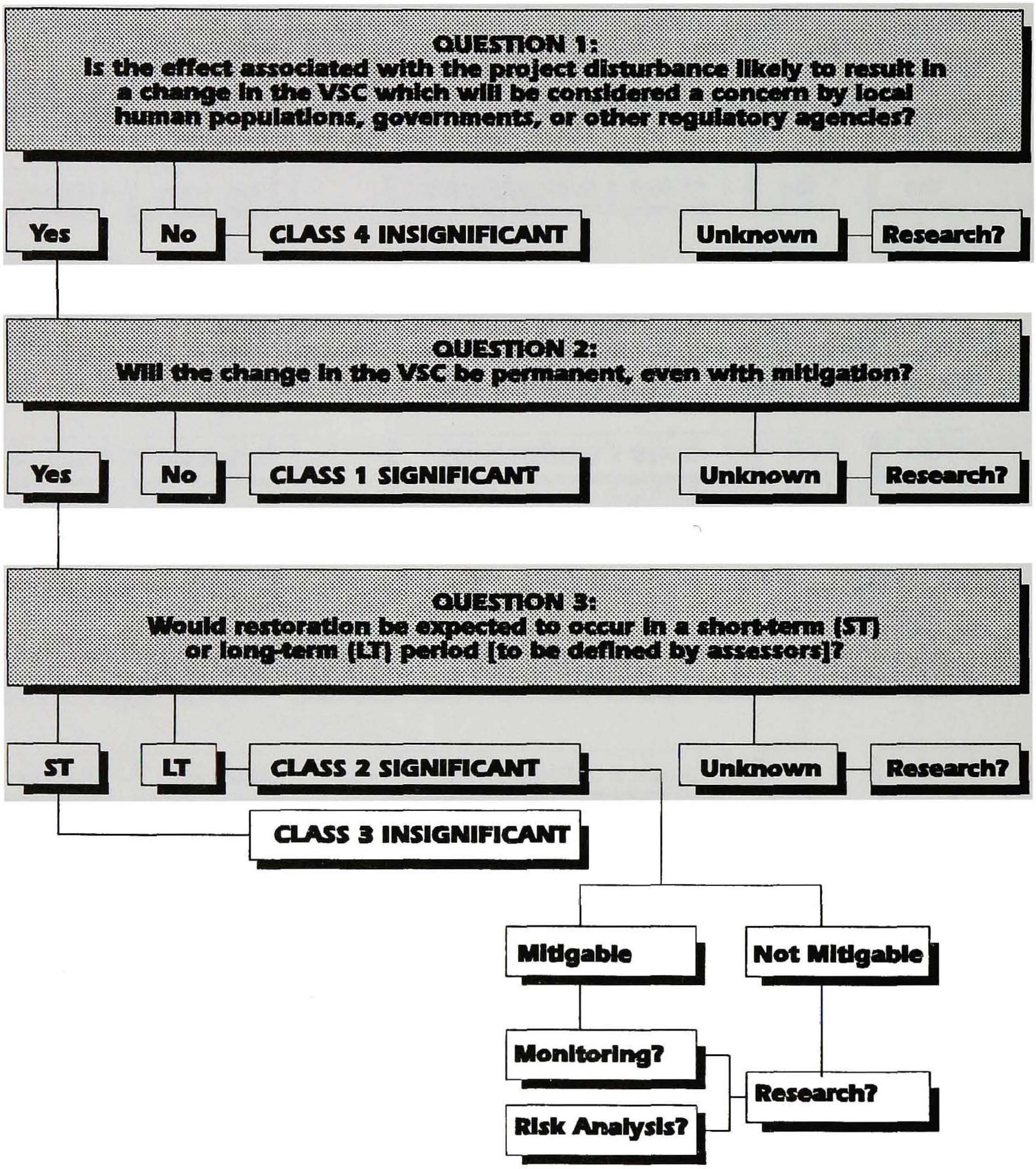


FIGURE 4-2
VALUED SOCIAL COMPONENTS
QUESTIONS OF SIGNIFICANCE



considered valid but not necessary to evaluate at this time. For these hypotheses, the working group was responsible for reviewing the structure and wording of the hypothesis and recommending changes, where necessary. It is for this reason that the present wording of some hypotheses differ from that shown earlier in Table 2-1.

As mentioned in Section 2.0, it was also the objective of the workshop to include environmental assessment into the BREAM process. Although a preliminary assessment was not completed for all of the 32 BREAM impact hypotheses, each of the hypotheses are presented in the following section for completeness.

BREAM HYPOTHESIS R-1

SHIP TRAFFIC, SEISMIC EXPLORATION AND ACTIVE OFFSHORE STRUCTURES WILL CAUSE A REDUCTION IN THE WESTERN ARCTIC POPULATION OF BOWHEAD WHALES

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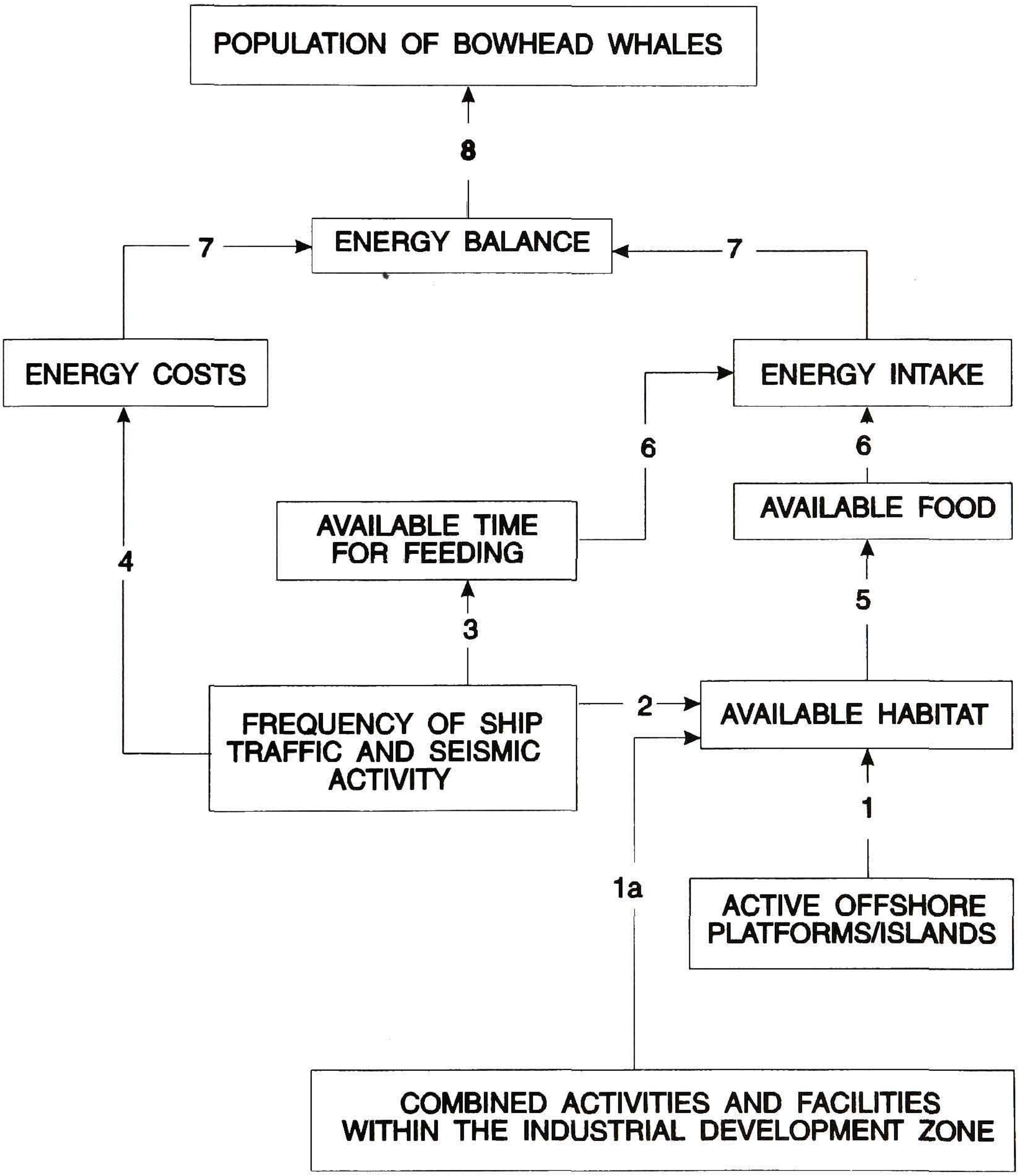
INTRODUCTION

In the BREAM Planning Meeting, it was concluded that this hypothesis (originally BEMP 1) should be re-evaluated at the workshop due to new information and re-interpretations of existing information. This has been the most controversial and repeatedly examined hypothesis in the BEMP process and has been the focus of sub-group discussions in four previous workshops. The last of these workshops was held in March 1987. Since that time, there have been several new research findings that have changed and clarified the basis of this hypothesis.

Many of the new findings were relevant to several links in the hypothesis and to the overall significance of the hypothesis. Thus, the findings were discussed by subject matter, rather than link-by-link, at the present workshop. At the end of the discussions, the relevance of the new findings to the overall hypothesis were determined.

FIGURE 1-1

EFFECTS OF SHIP TRAFFIC, SEISMIC PROGRAMS, AND ACTIVE OFFSHORE PLATFORMS/ARTIFICIAL ISLANDS ON THE WESTERN ARCTIC POPULATION OF BOWHEAD WHALES



Linkages

1. Each active offshore island or platform will exclude bowheads from a zone around the island/platform.

1a. The cumulative effect of all offshore industrial activities will be to create a large-scale zone of bowhead whale exclusion encompassing the entire industrial zone.

2. Ship traffic will exclude bowheads from a zone around the ship track.

3. Each passage of a ship will reduce the feeding time available to bowheads.

4. Each passage of a ship will increase the energy expenditure of whales due to avoidance behaviour.

5. The available aquatic habitat determines the level of available food.

6. The amount of available food and the time available for feeding determine the energy intake.

7. Energy intake and expenditures determine the energy balance of a bowhead whale.

8. The energy balance of a bowhead whale determines its survival and its ability to reproduce.

EVALUATION OF LINKAGES

Before discussing the new research findings, it is instructive to review the basis of the present hypothesis and the assumptions that underlie it. Without this information it is not possible to grasp the significance of the recent research. When this hypothesis was first formulated in 1983, it was assumed that bowhead whales were typical of other baleen whales that migrated to high latitudes to feed during the summer. This assumption was supported by the limited evidence from the stomachs of whales harvested during spring and fall in Alaska. It was assumed that bowheads did virtually all of their significant feeding while on the summering grounds in the Canadian Beaufort Sea and Amundsen Gulf.

An energetics model was developed using information on the known sizes of bowheads, the energetic requirements of other baleen whales, and knowledge of zooplankton distribution and densities in the Beaufort Sea area. Based on information on bowhead migrations to and from the Bering Sea wintering grounds, it was determined that bowheads spent about 120 days per year in summering areas.

Combining this information with data on zooplankton densities and the fact that bowheads have uniquely small digestion systems, the model indicated that bowheads could just barely obtain their annual energy requirements during 120 days in summer.

The close match between energy available and energy required suggested that the success of the summer feeding was critical to the reproductive welfare of the population. Information available at the time indicated that bowheads reacted to offshore industrial activities and that these activities could reduce the amount of time available for feeding by bowheads and reduce the sizes of bowhead feeding areas. This in turn could reduce energy intake by the whales, thereby negatively affecting reproductive success. These relationships are embodied in Links 1 to 8 of the hypothesis. The subgroup discussed some new information related to some of these links.

Link 1: **Each active offshore island or platform will exclude bowheads from a zone around the island/platform.**

Link 2: **Ship traffic will exclude bowheads from a zone around the ship track.**

Link 3: **Each passage of a ship will reduce the feeding time available to bowheads.**

Link 4: **Each passage of a ship will increase the energy expenditure of whales due to avoidance behaviour.**

The results of studies of the responses of fall-migrating bowheads to an offshore drilling operation in the Alaskan Beaufort Sea in 1986 were not available to the previous bowhead workshop in March 1987. These studies demonstrate that bowheads responded at distances of up to 25 km from the drilling operation and that no bowheads occurred closer than 10 km to the operation (Davis 1987). These results indicated that bowhead evasive responses occurred at greater distances from offshore activity than previously considered by BEMP.

More recent studies in the Canadian Beaufort Sea indicate that bowhead responses to ships depend upon the behaviour of the whales at the time of approach by the vessel. Wartzok *et al.* (1990) found that feeding whales were difficult to approach by ship but that whales involved in intense sexual and social activity generally ignored the close approach of a vessel. To date, this type of intense social behaviour has not been observed in the areas of interest to the oil industry.

The studies cited above confirm the validity of Links 1 to 4 of the hypothesis and indicate that the zones of effect are greater than previously thought, except for socializing adult animals.

During the early years of BEMP, observations of the distribution of bowhead whales indicated that there was a decline in the numbers that occurred in the area used by the oil industry. These observations led to the concern that the combination of the many potential disturbance sources in the industrial zone was creating a large zone from which the bowheads were being excluded. This led to the formulation of Link 1a.

Link 1a: The cumulative effect of all offshore industrial activities will be to create a large-scale zone of bowhead whale exclusion encompassing the entire industrial zone.

The empirical data indicated that bowheads did not occur in the industrial area in the years of maximum industrial activity. It is not known whether the absence of the whales was due to cumulative disturbance effects in the industrial area or to poor feeding conditions in the industrial area. The last BEMP workshop went to great lengths to determine whether it was possible to statistically demonstrate whether feeding conditions in the industrial area were inferior to conditions in other areas. These discussions centred on the difficulty of finding and evaluating distinct patches of high densities of zooplankton suitable for feeding by bowheads. The costs of these types of ship-based studies precluded the approach from being used to attempt to distinguish between the disturbance-effects and food availability explanations.

However, participants in this meeting did not consider the study by Thomson *et al.* (1985), who hypothesized that bowhead distribution must be governed by large scale factors, since the absence of bowheads occurred over such large areas of the Beaufort Shelf. If food availability was determining the large scale distribution of bowheads, then the distribution of the food itself must be determined on a broad-scale by large oceanographic features. The micro-distribution of small food patches seemed inadequate to explain the observed changes in bowhead distribution.

Thomson *et al.* (1985) concluded that the distribution of brackish Mackenzie estuary water over the shelf determined the distribution of bowhead food. The Mackenzie waters were low in zooplankton and were not used by bowheads. In some years, the estuarine waters covered most of the industrial area and few bowheads occurred in the area. In years when west and north winds compressed the Mackenzie plume into coastal waters, then bowheads entered the shelf area to feed in the marine waters that had displaced the plume. In these latter conditions, bowheads would be expected in the industrial area. In the four years studied, these authors found that the presence of the Mackenzie plume was a good predictor of whale distribution in three years. In the fourth year, marine water was present in the industrial area but bowheads were not. This suggested that other factors, such as industrial disturbance, could have been keeping bowheads out of good feeding areas.

New Information

There have been several recent studies of the accumulated data on bowhead whales that bring into question some of the basic assumptions underlying the significance of this hypothesis. The assumption that the bowhead whale is a typical baleen whale turns out to be erroneous. The bowhead is unique.

The main sources of new data and interpretations are the carbon isotope studies by Don Schell at the University of Alaska and the large amounts of data from photographic and distribution studies that have recently been synthesized by Bill Koski and his co-workers at LGL Limited. The new information is reviewed in the following paragraphs.

The bowhead whale is a very slow-growing animal. It does not become sexually mature until it is about 18 to 20 years of age. The calving interval is thought to be between 4 and 7 years with a single calf per pregnancy. In spite of these very low reproductive rates, the number of bowheads in the population is now thought to be about 7500 whales. This is about twice as large as the estimate of the population that was available in the early 1980s. Improved census techniques are responsible for the increased population estimate. However, analyses by Judy Zeh at the University of Washington suggest that the bowhead population has been slowly increasing in the past few years.

Growth Data

The carbon isotope studies indicate that the baleen of young bowheads can be used to determine their age. Thus, it is possible to relate baleen length and age to body length and size in bowheads that are taken in the spring and fall harvests in Alaska. The results show that bowhead calves grow rapidly during the first year of life when they are dependent on their mother's milk. However, the calves essentially stop growing after they are weaned. There is virtually no growth for the next 4 or 5 years. During this period, the baleen is not fully developed and the animals obviously have difficulty feeding. They apparently have trouble obtaining enough energy to maintain themselves and are unable to take on enough surplus energy to allow them to grow. It is clear that young bowheads are under energetic stress for several years after weaning.

The remarkable early growth patterns were determined primarily from the baleen ageing technique which is difficult to independently verify. Support for the above conclusions comes from the photographic studies. Photographic measurements of small bowheads that have been identified in more than one year confirm that the small bowheads do, in fact, grow very slowly.

Feeding Data

The isotopic studies of bowheads and their prey conducted by Schell have indicated that adult bowheads feed very little in the Canadian Beaufort Sea. The subadult whales do feed there, obtaining from a quarter to a third of their energy on the summering grounds.

The original BEMP concern about the energy balance of summering adult whales seems not to have been valid. The conclusion that adult whales feed little on the Beaufort Shelf means that disturbance of these whales would have minimal energetic consequences. On the other hand, about a third of the food intake of the energetically stressed young whales is obtained on the summering grounds.

Distribution Data

Photogrammetric studies by several workers have shown that there is a marked differential distribution of the various age classes of bowheads on the summering grounds. In these studies, whale length is used as an indicator of whale age. One of the most striking distributional features is the concentration of small subadult whales on the shallow Beaufort Shelf. In fact, data from some years indicate that virtually the entire population of small, one to 5 or 6 year-old bowheads may be concentrated in these shallow waters.

CONCLUSIONS

The original hypothesis was concerned with the energetic consequences of disturbance on an unknown fraction of the overall population of bowheads. The new data suggest that the emphasis on the energetics of the overall population in summer was misplaced. The energetic consequences, on adults and old subadults, of disturbance and exclusion during summer seem to be of relatively minor importance to the population. However, the new data indicate that virtually the entire population of four or five age cohorts may be affected by industrial activity. These young whales only take on about a third of their energy on the summering grounds but it is obvious that these whales are under intense energetic stress (e.g. virtually no growth in the first 4 or 5 post-weaning years). It is not known what the effects of exclusion of these age classes from summer feeding areas would be.

The new data on the low reproductive rates and high age of sexual maturity indicate that the population would have a slower recovery rate than originally anticipated.

The working group concluded that the logic of the hypothesis is still applicable and the links are valid. The hypothesis remains valid. If industrial activity affected the entire population of 4 or 5 age cohorts, then the results would be considered significant.

RECOMMENDED RESEARCH AND MONITORING

One of the major difficulties in the interpretation of the several years of bowhead distribution data gathered during the period of offshore industrial activity is that there are no control data collected before industrial activities began. In fact, the first systematic bowhead surveys did not occur until 1980, the fifth year of offshore drilling in the Canadian Beaufort Sea. After 1980, industrial activity levels increased markedly until about 1985-86. Subsequently, activity levels declined steadily, until there was no offshore drilling in 1991 and 1992.

The working group concluded that the present situation provides a good opportunity to collect data on bowhead distribution during a period when there was no industrial activity. Thus, the required control data would be obtained after the experimental data, rather than before. Collection of these data would provide a test of the critical Link 1a which underpins the exclusion hypothesis. Also, the data would provide undisturbed control data for the resumption of offshore activity. This is important since the resumption of offshore exploration will not be delayed for a year, or two, while control data are collected.

Satellite data can be used to determine the position of the Mackenzie plume over the shelf, in and around the former industrial zone. These data can be used to evaluate whether bowheads should be expected to occur in particular parts of the zone. If plume conditions (=feeding conditions) are appropriate in the industrial zone and bowheads do not occur there, then it is likely that the industrial zone is not an area that is regularly used by bowheads. Thus, the situation in 1982, when plume conditions were suitable but bowheads were not present in the industrial zone, was probably not a result of exclusion of bowheads from the zone by industrial activities. On the other hand, if plume conditions are suitable and bowheads do occur in the former industrial zone during future surveys, then it indicates that their absence in 1982 probably was a function of the high levels of industrial activity at that time.

The group recommended that Link 1a be tested with aerial surveys of bowhead distribution in conjunction with analyses of satellite data to determine plume conditions. It is recommended that the program be conducted in at least one year, and preferably two years.

LITERATURE CITED

Davis, R.A. 1987. Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea; autumn 1986: Integration and summary report. Rep. by LGL Ltd., King City, Ontario, for Shell Western E & P Inc., Anchorage, AK. 51 p.

Thomson, D.H., D.B. Fissel, J.R. Marko, R.A. Davis and G.A. Borstad. 1985. Distribution of bowhead whales in relation to hydrometeorological events in the southeastern Beaufort Sea, 1980-83. Rep. by LGL Ltd., Arctic Sciences Ltd., and G.A. Borstad Ltd. to Environmental Studies Revolving Funds, Ottawa. 119 p.

Wartzok, D., W.A. Watkins, B. Wursig, J. Guerrero and J. Schoenherr. 1990. Movements and behaviors of bowhead whales. Rep. from Purdue University, Fort Wayne, IN to Amoco Production Company, Anchorage, AK. 197 p.

BREAM HYPOTHESIS R-2

VARIOUS FACILITIES AND ACTIVITIES ASSOCIATED WITH OFFSHORE HYDROCARBON DEVELOPMENT WILL AFFECT THE HARVEST OF BELUGA WHALES

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Rolph Davis	Don Schell
Dave Fissel	Gary Wagner
Lois Harwood	

INTRODUCTION

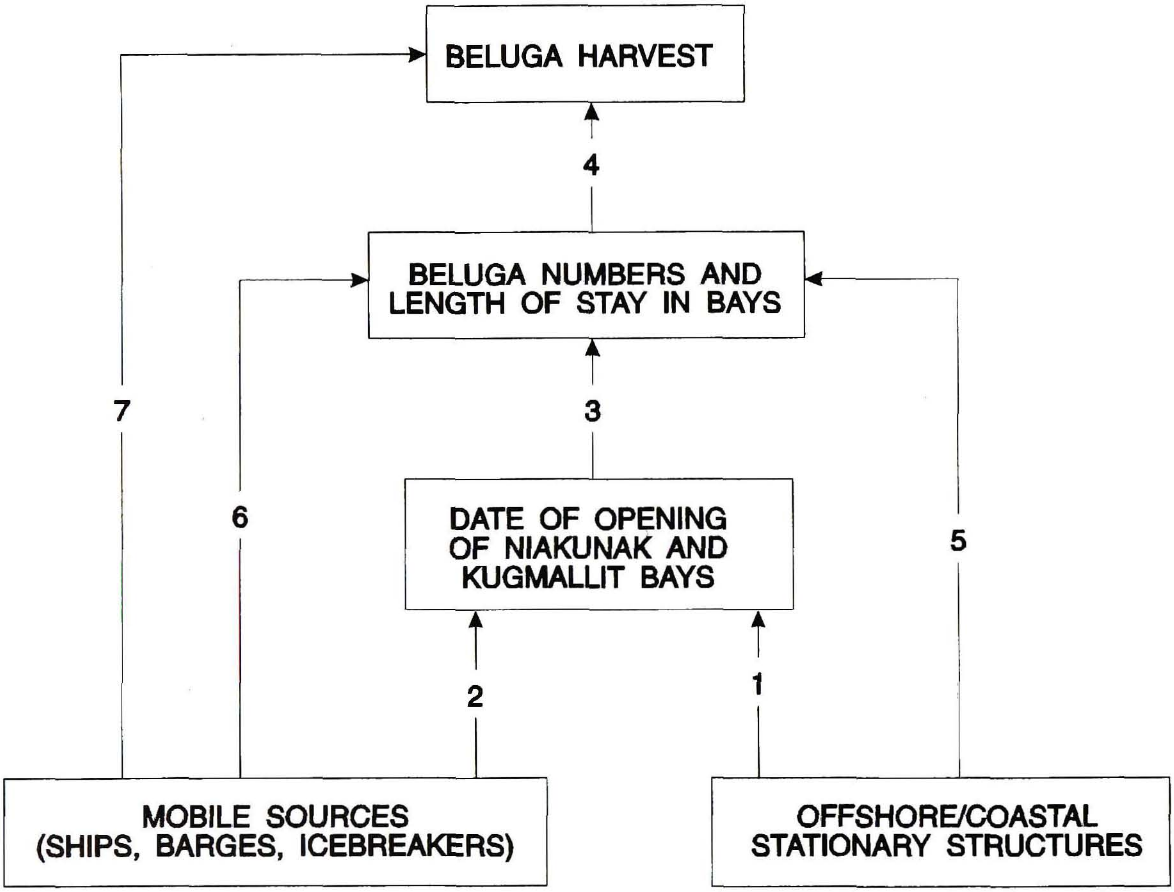
This is a complex, high profile hypothesis that focuses on issues of significant concern within the Inuvialuit Settlement Region. The earlier Planning Meeting charged the Working Group with the following tasks with regard to this hypothesis.

1. Combine BEMP Hypothesis 2 with MEMP Hypothesis 19 since they both deal with beluga harvests in the Mackenzie estuary.
2. Add linkages related to barge traffic.
3. Evaluate the structure of the hypothesis with respect to the potential effects of global climate change.
4. Evaluate the restructured hypothesis.

The Working Group discussed the above items and several others. Additional changes to the linkages were made and they are reflected in the following diagram.

FIGURE 2-1

EFFECTS OF VARIOUS FACILITIES AND OFFSHORE HYDROCARBON DEVELOPMENT ACTIVITIES ON THE HARVEST OF BELUGA WHALES



Linkages

1. Artificial structures/islands off the Mackenzie Delta will delay the regional break-up of the landfast ice.

2. Icebreaker traffic in the landfast ice in spring will advance the break-up of ice barriers across Kugmallit and Niakunak bays.

3. The timing of break-up of the landfast ice influences the timing of entry, and the numbers and the duration of residence of beluga whales in Niakunak and Kugmallit bays.

4. The numbers and the duration of residence of beluga whales in Niakunak and Kugmallit bays will influence the beluga harvest.

5. The presence of offshore or coastal facilities will disturb belugas and reduce the numbers present and the amount of time that they spend in hunting areas.

6. Vessel traffic through estuarine summering areas will disturb belugas and this will reduce the number of whales that frequent these areas or the length of time that they spend in the areas.

7. Ship traffic in and near beluga hunting areas will lead to changes in the distribution of whales that will lead to changes (probably reductions) in the harvest levels. In addition, vessel traffic could directly interfere with hunting activities by frightening whales that are being hunted.

The recently completed Beaufort Sea Beluga Management Plan was prepared through the cooperation and participation of both the Inuvialuit (Hunters and Trappers Committees and Inuvialuit Game Council), the Fisheries Joint Management Committee, and the Department of Fisheries and Oceans (DFO). The Management Plan identifies and describes the issues of concern related to beluga harvests, particularly with regard to site-specific oil and gas industry activities. To protect the harvest, the Plan defines management zones and provides guidelines on the time of year, by individual zones, when industrial activities are to be eliminated or curtailed. The Plan calls for the prohibition of oil and gas exploration and production, including development of facilities, in Zone 1. This zone includes those parts of the Mackenzie estuary [Kugmallit Bay, Mackenzie Bay (=Niakunak Bay), and the Kendall Island area] that are used by belugas and by beluga hunters.

The Working Group reviewed the Beluga Management Plan, new information that was summarized in the BREAM Final Report for 1990/1991 (ESL 1991), and the most recent oil and gas development scenarios.

EVALUATION OF LINKAGES

BEMP and MEMP used the name white whale to describe this species. However, since beluga whale is the preferred name used by the Inuvialuit and other northern hunters, the Working Group decided to adopt this name.

MEMP Hypothesis 19 and part of BEMP Hypothesis 2 stated that Inuit employment in industry would affect hunter effort, which in turn would affect the harvest of belugas. These links were incorporated into BREAM Hypothesis 2 as defined in the 1990-91 Report (ESL 1991). Without discussing the validity of these linkages, the Working Group decided not to consider them since they seem to form the basis of BREAM Hypothesis R-28. The latter hypothesis was transferred to the Community-based Concerns Group for consideration. As a result, the linkages relating to Inuit employment in industry and its effects on hunter effort and harvest success were removed from BREAM Hypothesis R-2.

The original hypothesis explicitly considered Niakunak Bay and Kugmallit Bay separately. This was because changes in the spring break-up of the ice bridges across the mouths of the bays could affect beluga harvests in different ways depending upon the bay involved and ice conditions in the other bay. Although, these factors remain important, the Working Group decided to combine the two bays in order to simplify the hypothesis and its linkages. The group recognized, however, that during evaluations of these linkages, the two bays would have to be considered separately.

The Working Group considered the question of climate change, specifically global warming. It was decided that it was inappropriate to include a specific linkage for global warming since it is completely independent of the oil and gas industry in the Beaufort-Mackenzie area. This is not to say that the effects of global warming will not be significant but rather that it is not an action that will be precipitated by development in the Mackenzie estuary. Global warming will certainly affect the break-up of the ice bridges across Niakunak and Kugmallit bays and these effects will have to be accounted for when evaluating the effects of industry activities.

Link 1: Artificial structures/islands off the Mackenzie Delta will delay the regional break-up of the landfast ice.

Artificial islands and other structures may act as anchor points for the landfast ice resulting in increased stability of the ice and delaying the onset of its breakup and dispersal. The numbers and spacing of structures required to have any substantial effect on breakup of the landfast is not clear. However, it is clear that the small amount of offshore development currently envisioned (see Section 3 of this report) will probably not be sufficient to affect breakup patterns. Therefore, this link is considered valid in large development scenarios but not significant in presently predicted circumstances.

Ongoing research into Beaufort Sea ice morphology and dynamics is being conducted (BREAM Project Overview B2-1; ESL 1991), but the recent work has been directed at offshore ice in the pack and transition ice zones rather than the landfast ice areas.

The potential impacts of climatic change, due to greenhouse gases, on the Beaufort Sea ice regime is relevant to the hypothesis over longer-time scales. A recent study (BREAM Project Overview B2-2; ESL 1991) suggests that winter air temperatures may increase significantly (10°C) resulting in reduced ice thickness. While many uncertainties remain in assessing this effect (including possible changes in precipitation, river runoff, wind patterns and storm tracks), the possibility of advancing the breakup and dispersal of landfast ice is evident. Unfortunately, modelling conducted to date has not addressed the landfast ice regime specifically.

Link 2: Icebreaker traffic in the landfast ice in spring will advance the break-up of ice barriers across Kugmallit and Niakunak bays.

There has been no recent research on the effects of icebreaker traffic on the integrity of landfast ice. The Working Group concluded that this link was theoretically valid but not a concern given the present development scenarios which have limited icebreaker traffic and do not include icebreaker traffic into Kugmallit and Niakunak bays.

Link 3: The timing of break-up of the landfast ice influences the timing of entry, and the numbers and the duration of residence of beluga whales in Niakunak and Kugmallit bays.

This link was demonstrated to be valid in earlier BEMP workshops. There is no new information on this topic and the Working Group concluded that the link was still valid but was of little concern with the present development scenarios, which involve few offshore structures and little icebreaker traffic.

Link 4: The numbers and the duration of residence of beluga whales in Niakunak and Kugmallit bays will influence the beluga harvest.

Previous BEMP Workshops have established that the size of the annual beluga harvest is influenced by the numbers of belugas that enter the bays and the length of time that the belugas remain in these estuarine bays. The numbers and duration of stay are correlated with the date of opening of the landfast ice bridges across the bays. The numbers of belugas and the duration of their stays in the estuary can also be affected by disturbance from industrial and other activities. If either the numbers or the length of stay are reduced by disturbance then it is likely that the harvest will also be reduced. The workshop considered that this link was valid. No new information was available regarding this link.

Link 5: **The presence of offshore or coastal facilities will disturb belugas and reduce the numbers present and the amount of time that they spend in hunting areas.**

This new link was added to reflect the possibility that belugas could be exposed to permanent offshore and/or coastal facilities in or near to the beluga hunting areas. This had not been explicitly considered in earlier workshops. Belugas may avoid these facilities, particularly during hunting season, thereby reducing the length of time that they remain in the hunting area.

There is little information on the responses of beluga whales to stationary disturbance sources. Responses are expected to be less than to moving sources, such as vessels. Marine mammals typically habituate more quickly to fixed sources of noise than to moving sources (Richardson *et al.* 1989).

The Working Group considered this new link to be valid. The extent to which these facilities would create problems is a function of their specific location with respect to beluga use areas and hunting areas. The effects can be mitigated by appropriate siting.

Link 6: **Vessel traffic through estuarine summering areas will disturb belugas and this will reduce the number of whales that frequent these areas or the length of time that they spend in the areas.**

This link originally referred only to Niakunak and Kugmallit bays. However, due to concerns raised by Inuvialuit hunters, the Kendall Island hunting area on the north side of the Mackenzie Delta was added. The term "ship traffic" was replaced by the more general term, "vessel traffic", to make it clear to readers that barge traffic was also included in this link, and in link 7.

The Working Group considered this link to be valid but there is no quantitative information on the numbers of vessel passages that are required to cause belugas to reduce the length of time that they spend in the Mackenzie estuary.

Link 7: **Ship traffic in and near beluga hunting areas will lead to changes in the distribution of whales that will lead to changes (probably reductions) in the harvest levels. In addition, vessel traffic could directly interfere with hunting activities by frightening whales that are being hunted.**

This link was considered valid by the Working Group. Disturbance in beluga hunting areas is a matter of great concern to the Inuvialuit hunters. Belugas are known to swim away from approaching ships although the distances at which the whales react, and the distances that they travel in response to a ship, are radically different in various parts of the arctic. These differences seem to depend on habitat, activities of the whales, experience of the whales, and type of vessel (Davis *et al.* 1990). There has been no relevant research on responses of belugas in the Canadian Beaufort Sea since the last consideration of this hypothesis in 1985. Ongoing research on the responses of spring migrating belugas in leads off Alaska (W. J. Richardson, LGL Ltd., for U.S. MMS) and new research off Banks Island (S. E. Cosens, DFO, for NOGAP) may provide some further insight into reaction distances of belugas in the Beaufort Sea.

CONCLUSIONS

The Working Group confirmed the validity of the revised hypothesis, BREAM R-2. The group also concluded that less emphasis should be placed on the linkages dealing with changes in the timing of ice breakup since the present development scenarios have few offshore structures to anchor the landfast ice and little icebreaker traffic to enhance breakup. The principal concerns relate to disturbance caused by vessel traffic and by offshore and coastal facilities in and near the beluga hunting grounds in Kugmallit Bay, Niakunak Bay and the Kendall Island area. It was concluded that a reduction in the beluga harvest would be of significant concern to the Inuvialuit. It is clear that appropriate controls on the timing of vessel traffic and the locations of permanent facilities could prevent these disturbance-induced reductions in the harvest of belugas. The existing Beaufort Sea Beluga Management Plan addresses these issues.

RESEARCH AND MONITORING

The Working Group reviewed several planned research projects on beluga whales and identified some additional initiatives. The two types of projects are discussed below.

Planned Research

Several studies of belugas in the Canadian Beaufort Sea have been funded for 1992 and 1993. These are identified here and their relevance to the hypothesis is discussed.

1. **Responses of Belugas to Industrial Noise**: Under NOGAP, DFO (Dr. S. Cosens) plans to test the reactions of belugas to playbacks of various ship noises. The studies planned for the Banks Island area will also attempt to address the question of habituation. The study should provide information on the distance at which belugas respond to various ship noises. The results of this study will be directly relevant to links 6 and 7 of Hypothesis R.2 although it is not clear whether the results from the relatively deep water off Banks Island will be directly transferable to the very shallow (<2m) water of the Mackenzie estuary.

2. **Studies of the Beluga Harvest**: The Fisheries Joint Management Committee (FJMC) is providing funding to analyze the biological samples which have been taken from harvested whales over the past few years. In addition, a study will tap the traditional knowledge of the Inuvialuit beluga hunters to determine what is known about numbers and movement patterns of belugas in the delta. The results of this study will be of general relevance to this hypothesis by improving our knowledge of how belugas use the Mackenzie estuary.

3. **Use of Satellite Tags on Belugas**: This is a two-year study beginning in 1992. The first year involves community consultations and manufacture of the satellite tags to be applied in 1993. The first phase is funded by the Environmental Studies Research Fund. In the second year, 20 tags will be applied under the direction of Dr. Tom Smith of DFO. The tagging results will supply information on local movements of belugas between shallow estuaries and offshore feeding areas and movements between the two main summering areas in Kugmallit Bay and Niakunak Bay. This

information is of general relevance to the entire hypothesis.

4. **Population Estimate:** FJMC is funding a major three aircraft survey of the beluga population in July 1992. The objective is to obtain a relatively precise estimate of the size of the Beaufort Sea beluga population. The relevance of this study to Hypothesis R.2 is that it will allow determination of the proportion of the population that uses the main bays at any one time.

Recommended Research

The above studies have all been designed and funded independently of BREAM. The Working Group identified three research efforts that would provide useful information regarding this hypothesis.

1. **Climate Change:** Since global warming is expected to have significant effects on ice breakup, it will affect links 1 and 2 of the hypothesis. The Working Group recommends that the BREAM Steering Committee approach Environment Canada and ask them to expand their ongoing research on the regional climatic effects of global warming to include the effects on the fast ice zone, as well as the pack ice zone.

2. **Monitoring of Harvest Effort:** The annual beluga harvest is monitored on an ongoing basis as part of the Harvest Study conducted by the Inuvialuit Game Council. It is recommended that a measure of hunter effort be obtained so that changes in the availability of whales can be quantified. This would provide an early warning that industrial activity was affecting the beluga hunt. The group did not reach conclusions on the methodology for collecting the 'Catch Per Unit Effort' (CPUE) data, the period during which the data should be collected, or the group or agency that should conduct this research.

3. **Integrate FJMC Study Results:** The Working Group felt that the major beluga research initiatives sponsored by the FJMC would probably provide a great deal of information that is relevant to BREAM Hypothesis R-2. This information should be synthesized and the information integrated into the hypothesis. Obviously, this integration cannot occur until 1994 when the results should be available.

The Working Group did not assign priorities among these three studies.

LITERATURE CITED

Davis, R.A., W.J. Richardson, L. Thiele, R. Dietz and P. Johansen. 1990. State of the arctic environment: Report on underwater noise. Finnish initiative on the protection of the arctic environment. Rep. by Greenland Environmental Research Institute, Copenhagen. 151p.

ESL Environmental Sciences Limited. 1991. Beaufort region environmental assessment and monitoring program (BREAM). Final report for 1990/1991. Dept. Indian Affairs and North. Develop., Environmental Studies No. 67, Ottawa. 416 p.

Richardson, W.J., C.R. Greene, J.P. Hickie, R.A. Davis and D.H. Thomson. 1989. Effects of offshore petroleum operations on cold water marine mammals: a literature review. 2nd Edition. Rep. by LGL Limited to Amer. Petrol. Inst., Washington, D.C. 385 p.

BREAM HYPOTHESIS R-3

MARINE VESSEL TRAFFIC, SEISMIC ACTIVITIES, DREDGING OPERATIONS AIRCRAFT OVERFLIGHTS AND ACTIVE OFFSHORE PLATFORMS/ISLANDS WILL REDUCE THE SIZE OF POPULATIONS OF RINGED AND BEARDED SEALS IN THE BEAUFORT SEA

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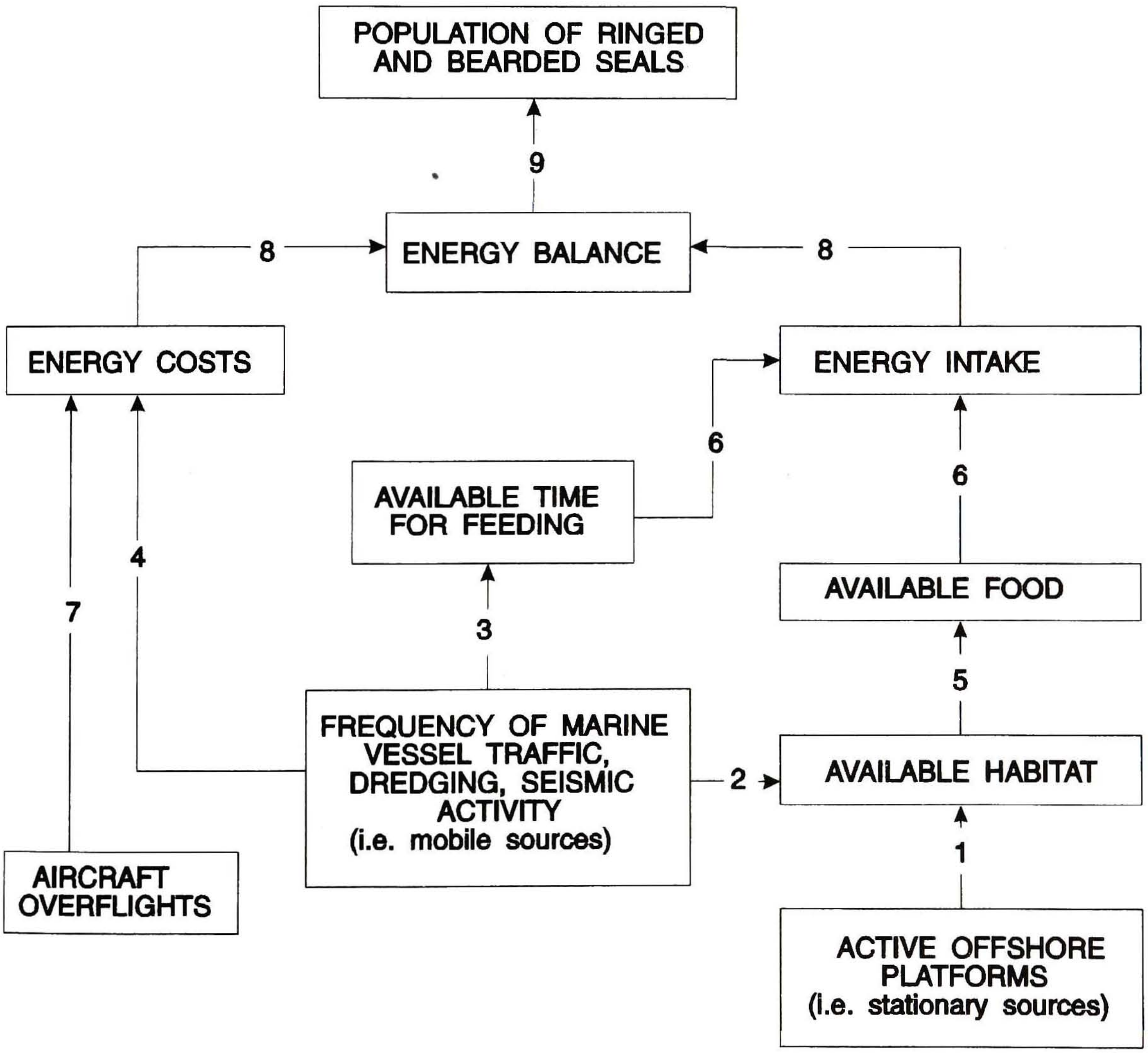
During the planning meeting of the Impact Hypothesis Working Group, it was agreed that re-evaluation of Hypothesis R-3 was not necessary at the present time. This hypothesis remains valid but is untestable. The workshop subgroup was charged with the responsibility of reviewing the structure and wording of the linkages and undertaking a preliminary assessment of the hypothesis. No changes to the wording of the hypothesis or its associated linkages were recommended by the group.

A preliminary assessment of the potential impacts described in this hypothesis was not completed by the subgroup. Rationale for this decision is described earlier in Section 4.2.

FIGURE 3-1

EFFECTS OF MARINE VESSEL TRAFFIC, SEISMIC ACTIVITIES, DREDGING OPERATIONS, AIRCRAFT OVERFLIGHTS AND ACTIVE OFFSHORE PLATFORMS/ISLANDS ON THE SIZE OF THE BEAUFORT SEA POPULATIONS OF RINGED SEALS AND BEARDED SEALS



Linkages

1. Each active offshore platform will result in the exclusion of ringed and bearded seals from some habitat.

2. Marine traffic (ships, dredges, seismic vessels) will exclude ringed and bearded seals from available habitat.

3. Each passage of a ship or other marine vessel will reduce the feeding time available to ringed and bearded seals.

4. Each passage of a vessel will increase the energy expenditure of seals because of avoidance behaviour.

5. The available aquatic habitat can influence the level of available food.

6. The amount and quality of available food and the time available for feeding determine energy intake.

7. Noise from aircraft overflights will disturb hauled-out seals and lead to increased energy costs.

8. Energy intake and costs determine energy balance.

9. The energy balance of a seal determines its survival and its ability to reproduce. The energy balance of the individuals in the population influences the reproductive capacity and health of the population.

BREAM HYPOTHESIS R-4

INCREASED FREQUENCY OF ICEBREAKER TRAFFIC THROUGH THE LANDFAST ICE WILL REDUCE RINGED SEAL PUP PRODUCTION AND POPULATION LEVELS

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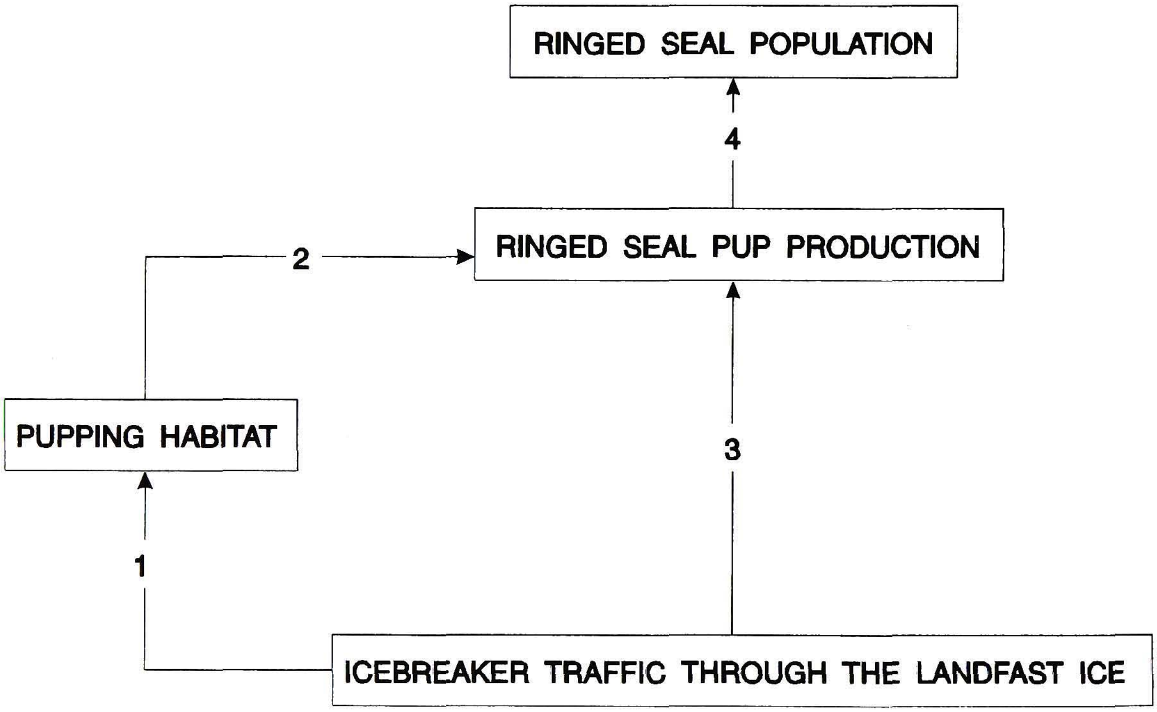
During the planning meeting of the Impact Hypothesis Working Group, it was concluded that re-evaluation of Hypothesis R-4 was not necessary at the present time. This hypothesis was considered valid but untestable and the potential impacts likely to be insignificant. The wording of the hypothesis was changed to remove all references to Amundsen Gulf.

No further changes to the hypothesis or its linkages were recommended by the workshop subgroup. A preliminary assessment of the hypothesis was not completed by the subgroup for reasons described earlier in Section 4.2.

FIGURE 4-1

EFFECTS OF INCREASED FREQUENCY OF ICEBREAKER TRAFFIC THROUGH THE LANDFAST ICE ON RINGED SEAL PUP PRODUCTION



Linkages

1. Icebreaking vessels operating in the landfast ice will decrease the amount of pupping habitat available to ringed seals.

2. Adequate pupping habitat is necessary for the production of ringed seal pups.

3. Icebreaker traffic in late March, April and May will kill ringed seal pups.

4. Reduced ringed seal pup production will result in lower population levels.

BREAM HYPOTHESIS R-5

ICEBREAKER TRAFFIC IN THE TRANSITION (SHEAR) ZONE WILL REDUCE BEARDED SEAL PUP PRODUCTION

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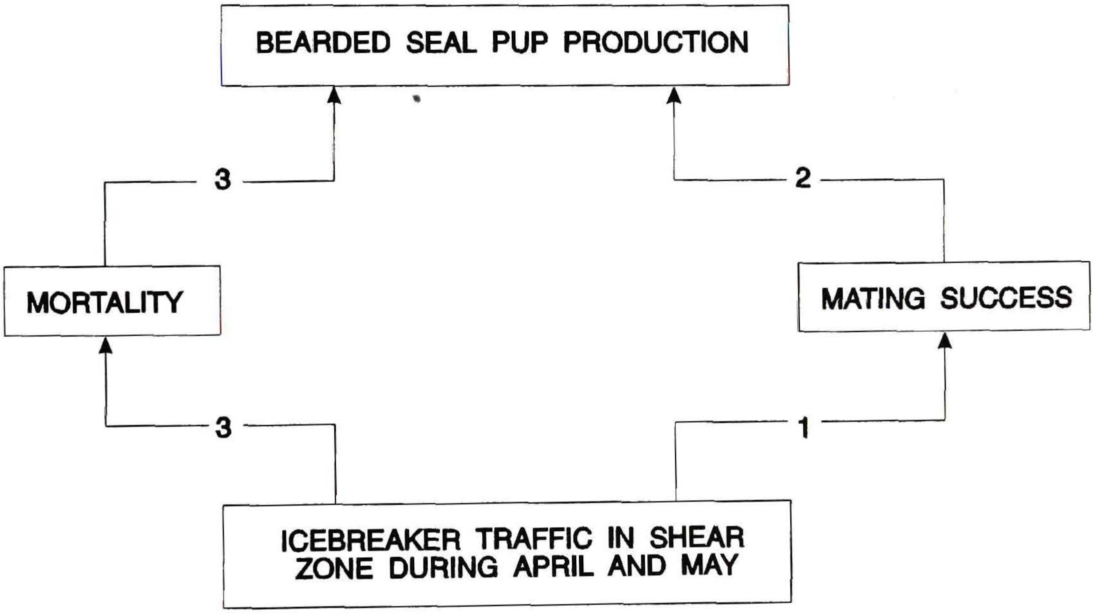
The Impact Hypothesis Working Group agreed that it was unnecessary to re-evaluate Hypothesis R-5 at this year's workshop. This hypothesis is considered valid but untestable.

During the workshop, the subgroup did not recommend any changes to the wording or structure of the hypothesis. For reasons discussed in Section 4.2, a preliminary assessment was not completed by the group.

FIGURE 5-1

EFFECTS OF ICEBREAKER TRAFFIC IN THE TRANSITION (SHEAR) ZONE ON BEARDED SEAL PUP PRODUCTION



Linkages

1. Icebreaker traffic in the shear zone during April and May will interfere with vocalizations of male bearded seals, and this will result in reduced mating success.

2. Successful mating is necessary for production of bearded seal pups.

3. Icebreaker traffic in the shear zone during April and May will result in mortality of bearded seal pups.

BREAM HYPOTHESIS R-6

THE PRESENCE OF ACTIVE FACILITIES WILL RESULT IN INCREASED POLAR BEAR MORTALITY AND REDUCED HARVEST LEVELS

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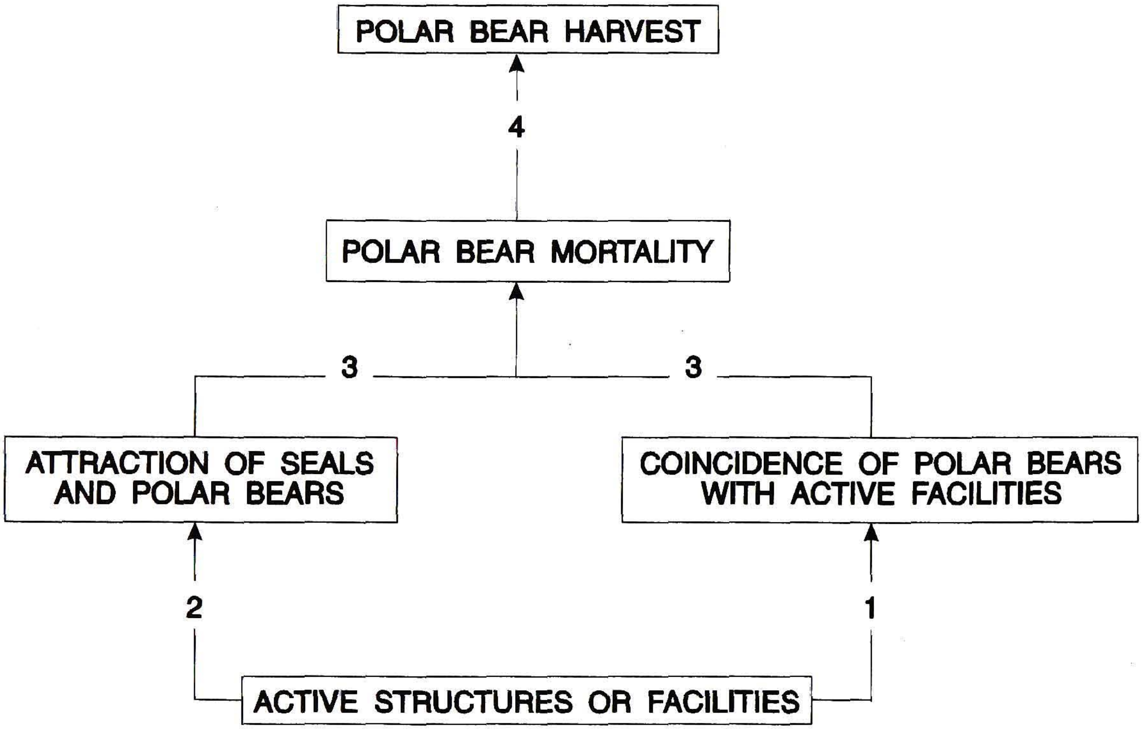
During the planning meeting of the Impact Hypothesis Working Group, the wording and structure of Hypothesis R-6 was changed to include a linkage related to the attraction of seals and bears to open water in the lee of offshore structures and subsequent reduction in harvest levels. Some new information relevant to this hypothesis is available, however because it supports earlier conclusions regarding its validity, re-evaluation of the hypothesis at this year's workshop was not considered necessary.

The workshop subgroup reviewed the hypothesis, and agreed that it was acceptable in its present form. A preliminary assessment was not completed by the group for reasons discussed in Section 4.2.

FIGURE 6-1

EFFECTS OF ACTIVE FACILITIES ON POLAR BEARS



Linkages

1. Polar bears will encounter active structures or facilities.

2. Seals and polar bears will be attracted to open water in the lee of offshore structures.

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

4. Mortality of polar bears will lead to a reduction in the harvest of polar bears.

BREAM HYPOTHESIS R-7

OFFSHORE DEVELOPMENT ACTIVITIES WILL REDUCE THE HARVEST OF POLAR BEARS

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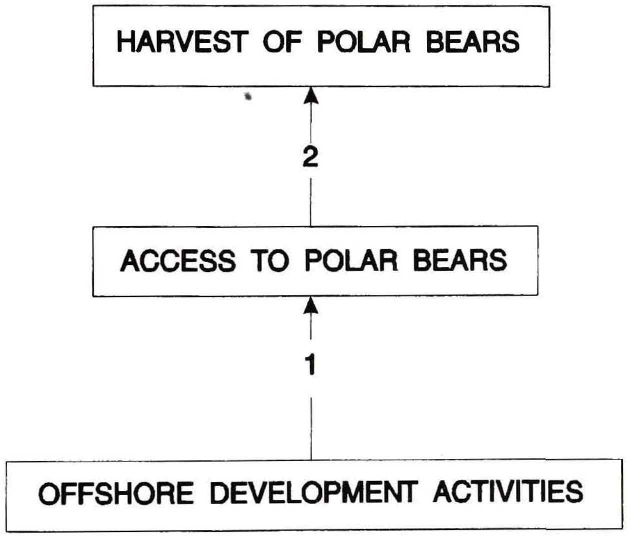
Given the current development scenario, re-evaluation of the validity of Hypothesis R-7 was not considered necessary. However, the workshop subgroup was charged with the responsibility of reviewing the wording of the hypothesis and conducting a preliminary assessment of the potential impacts described in this hypothesis. No changes to the wording or structure of the hypothesis was recommended by the group.

An assessment of the hypothesis was not completed by the subgroup for reasons discussed earlier in Section 4.2.

FIGURE 7-1

EFFECTS OF OFFSHORE HYDROCARBON DEVELOPMENT ACTIVITIES ON POLAR BEAR HARVEST



Linkages

1. Hunter access to polar bears will be reduced because offshore development will cause bears to move farther offshore and/or create physical barriers to Inuit travel on the ice.

2. Reduced access to polar bears will lead to reductions in the Inuit harvest of polar bears.

BREAM HYPOTHESIS R-8

CHRONIC/EPISODIC OIL SPILLS RESULTING FROM NORMAL PETROLEUM HYDROCARBON DEVELOPMENT ACTIVITIES WITHIN AND ADJACENT TO THE MARINE ENVIRONMENT WILL RESULT IN LOCALIZED MORTALITY OF POLAR BEARS AND REDUCED HARVEST LEVELS

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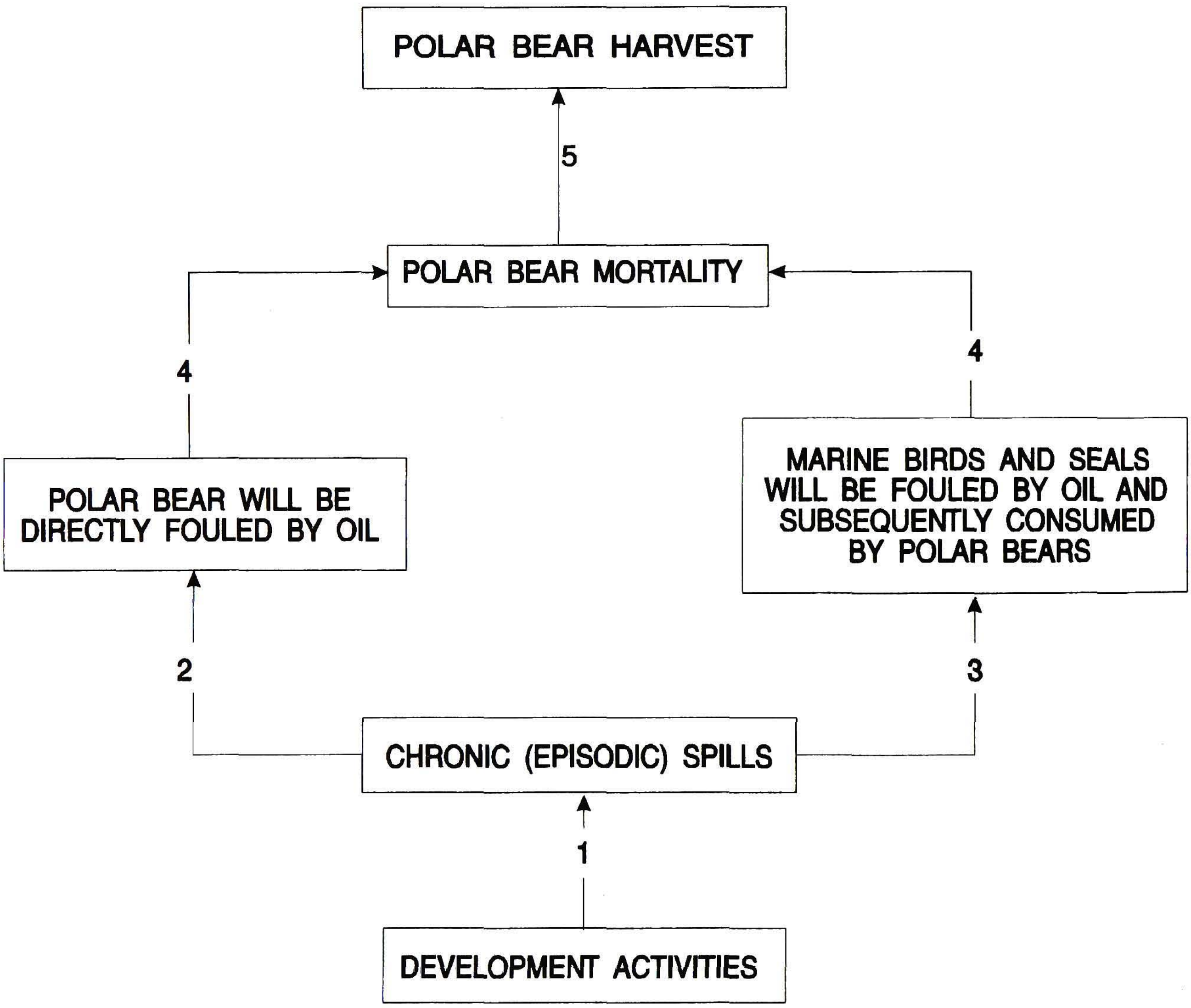
The Impact Hypothesis Working Group recommended that an additional linkage related to reduced harvest levels be added to Hypothesis R-8. It was noted that adequate information with which to evaluate the hypothesis currently exists and that further work related to R-8 is not required. For this reason, the group agreed that it was not necessary to evaluate the hypothesis at this year's workshop.

During the workshop, the hypothesis was reviewed and no further changes to its linkages were considered necessary. A preliminary assessment was not completed by the subgroup for reasons discussed in Section 4.2 of this report.

FIGURE 8-1

EFFECTS OF CHRONIC (EPISODIC) OIL SPILLS RESULTING FROM NORMAL PETROLEUM HYDROCARBON DEVELOPMENT ACTIVITIES WITHIN AND ADJACENT TO THE MARINE ENVIRONMENT ON POLAR BEARS



Linkages

1. Development activities will result in chronic/episodic spills.
2. Chronic spills will result in the direct fouling of polar bears.
3. Chronic spills will result in the direct fouling of marine birds and seals that are consumed by bears.
4. Mortality of bears will occur if oil is contacted or ingested.
5. Mortality of bears will lead to a reduction in the harvest of polar bears.

BREAM HYPOTHESIS R-9

CHRONIC (EPISODIC) OIL SPILLS RESULTING FROM NORMAL PETROLEUM HYDROCARBON DEVELOPMENT ACTIVITIES WITHIN AND ADJACENT TO THE AQUATIC ENVIRONMENT WILL RESULT IN MORTALITY AND DECREASED PRODUCTIVITY OF CERTAIN SPECIES OF WATERBIRDS

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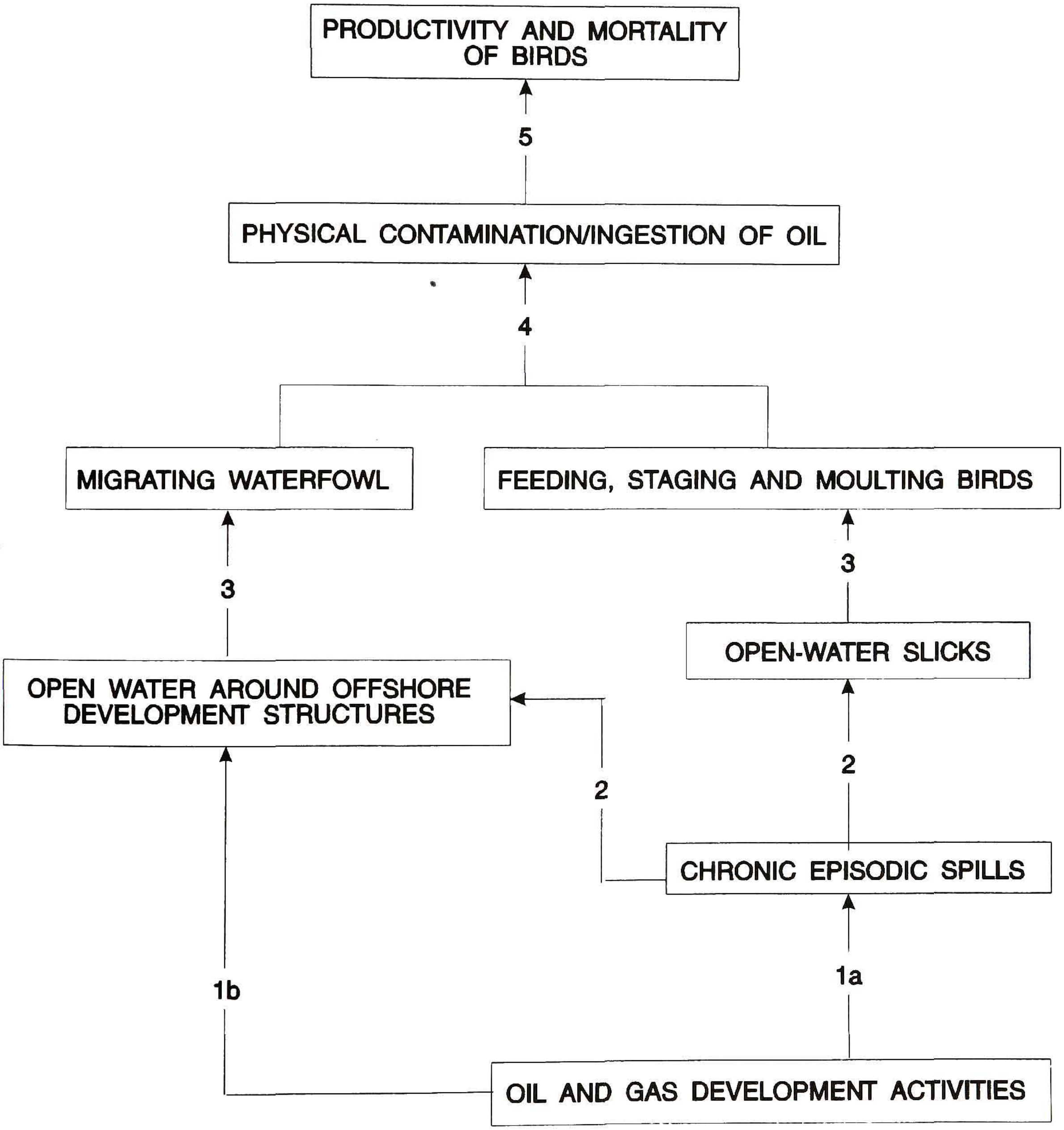
INTRODUCTION

New BREAM Hypothesis R-9 is the result of merging BEMP and MEMP hypotheses 10, both of which dealt with chronic oil spills, contamination of birds and bird mortality. MEMP 10 addressed specific causes of waterbird mortality (physical contamination and ingestion of oil). In this latter hypothesis, the linkages dealing with physical contamination with oil (Link 1a) and ingestion of oil (Link 2) were treated separately but were combined in the new restructured BREAM hypothesis because these effects are so closely associated with one another. Link 4 of MEMP 10, which dealt with the reduction in quality of waterfowl flesh as a result of oil ingestion, was deleted from the new hypothesis since this linkage was considered to be outside the scope of the original hypothesis and is already addressed in various other harvest-related BREAM hypotheses.

A review of existing BEMP and MEMP hypotheses conducted during Phase I of BREAM found both hypotheses to be valid and identified a substantial body of new information concerning these hypotheses. However, because this information supports earlier conclusions regarding the validity of BEMP and MEMP hypotheses 10, evaluation of BREAM R-9 in this year's workshop was not considered necessary. During the planning meeting of the Impact Hypothesis Working, it was recommended that the wording and structure of the hypothesis be

FIGURE 9-1

EFFECTS OF CHRONIC (EPISODIC) OIL SPILLS ON WATERFOWL AND FEEDING, STAGING AND MOULTING BIRDS



Linkages

1a. Development activities will result in chronic (episodic) spills of petroleum hydrocarbons. (BEMP 10 and MEMP 10)

1b. Thermal discharges under and onto the ice from offshore production facilities will enhance melting and formation of open water around the structures. (BEMP 10)

2. Where chronic spills occur, slicks with the capacity to foul birds will be present under certain conditions. (BEMP 10 and MEMP 10)

3. Susceptible bird species will co-occur in space and time with the presence of a slick.

4. Physical contamination of birds will occur and they will consume oil through ingestion of contaminated food sources and preening of fouled plumage. (MEMP 10)

5. Mortality and decreased productivity of birds will occur through physical contamination and ingestion of oil. (BEMP 10 and MEMP 10)

clarified and the significance of potential impacts be assessed.

EVALUATION OF LINKAGES

The workshop subgroup reviewed the wording of the hypothesis statement and its associated linkages and agreed on the following changes:

(1) The VECs considered in this hypotheses are waterfowl and feeding, staging and moulting birds.

(2) The statement of the hypothesis should be changed from "marine environment" to "aquatic environment" to reflect the expanded spatial scope of BREAM relative to BEMP or MEMP.

(3) The statement of the hypothesis should be changed from "local mortality" to "mortality and decreased productivity".

(4) The structure of the hypothesis should be changed so that linkages 1 (creation of open-water areas around offshore structures) and 1a (episodic spills) are shown as two separate effects of oil and gas activities rather than link 1a resulting from link 1. This revised structure is similar to that used in BEMP 10.

(4) Links 2 and 3 should be divided into two separate pathways: one dealing with open-water slicks and its effect on feeding, staging and moulting birds; and the other with episodic spills in open-water areas around offshore development structures and its effect on migrating waterfowl.

(5) Link 5 should be re-worded to include decreased productivity of birds as well as mortality as a result of physical contamination and ingestion of oil.

ASSESSMENT OF IMPACTS

Using the assessment procedure developed by ESSA Ltd., the workshop subgroup conducted a preliminary assessment of the significance of potential impacts of chronic (episodic) oil spills on waterfowl and birds. Separate assessments were completed for waterfowl in open-water areas around offshore structures, and feeding/staging/moulting birds in areas of open-water slicks.

(1) OIL ON OPEN WATER IN ICE VS. MIGRATING WATERFOWL

A number of assumptions regarding a worst-case scenario for chronic (episodic) oil spills from offshore production platforms were made by the subgroup. These assumptions were based on extrapolating information on the frequency and size of spills in the Gulf of Mexico (Gulf 1981; cited in Dome *et al.* 1982, Volume 6) to the Beaufort Sea.

- In most cases, spills at offshore production facilities would involve diesel spills.
- The zone of influence of a spill would be 0.5 km^2.
- It was assumed that there would be 7 offshore platforms from which a total of 3-4 spills could occur in any given year. These spills could last up to 1-2 hours in duration and could involve the release of 1 - 10 bbls oil/day.
- The frequency and duration of episodic spills would be such that there would be a continuous presence of some slick around the offshore platforms.

Based on this worst-case scenario, potential impacts of chronic (episodic) oil spills on migrating waterfowl are expected to be **insignificant** in years of normal ice breakup but could be **significant** in extreme ice years (1 in 10).

Extreme Ice Years

Spatial: Assuming that 10 percent of nesting habitat in open water could be affected by chronic spills of oil at offshore production platforms, and 5 percent of migrating waterfowl attempt to use this habitat, as much as 100,000 of the 2 million migrating birds could potentially be affected (L. Dickson, pers. comm.) In extreme ice years when 10 percent of migrating birds could die of starvation, the effects could be significant from a **regional** perspective.

Temporal: Given that the generation time of some species of waterfowl such as eiders and oldsquaw is 2-3 years, the effect would likely be **long term**.

Magnitude: It was suggested that given the number of waterfowl that could be potentially affected by chronic spills during extreme ice years, the effect may be detectable the following spring at Point Barrow (L. Dickson, pers. comm.). The magnitude of the effect was, therefore, considered to be **medium**.

While the effects of chronic oil spills on migrating waterfowl could be significant based on this worst-case scenario, an industry representative (E. Birchard) noted that more realistic assumptions in terms of the number of spills and frequency at which they would occur at offshore production platforms would likely include the following.

- The probability of a spill would be highest when diesel is transferred from a marine vessel to a storage tank.
- While one operator has experienced a spill involving 50 - 100 bbl of oil, episodic spills would typically involve 50 - 100 L oil.
- On-site equipment would be available to contain and recover most of the spilled oil. It is typical to have vessels boomed during marine transfer operations.
- The frequency of episodic spills at offshore production facilities would not likely be high. In 1984, during the peak of offshore exploration in the Beaufort Sea, a total of 38 spills occurred, of which 12 occurred in open water. The majority of these involved 45 L of oil or less (LGL *et al.* 1986). It was noted that the probability and risk of a spill would be less during production than during exploration.
- In situations involving a diesel spill in open water around offshore platforms, it is likely that 50% of the product would evaporate in 3 to 4 hours.
- It was assumed that, in any given year, there would likely be one spill that would co-occur in time with spring migrations of birds.

Based on this scenario, the effects of chronic oil spills on migrating waterfowl during extreme ice years would likely be **insignificant**.

Spatial Scale: Assuming that only one spill would occur in any given year, a **site-specific** effect would be expected due to the fact that only a small portion of the total population would likely be affected. Although the availability of open-water habitat would be limited in extreme ice years, the presence of a slick would be very localized and temporary.

Temporal Scale: Assuming that the spill would be contained and recovered within hours of the event, the effects are expected to be **short term**.

Magnitude: Any effects of chronic oil spills on waterfowl would likely be masked by natural fluctuations in population numbers. Given the wide distribution of nesting eiders over the entire Arctic, it would be very difficult to measure the effects on this species. The magnitude of the effect would likely be **small**.

(2) OPEN WATER SLICK VS. FEEDING/STAGING/MOULTING BIRDS

The subgroup agreed that in the absence of project information, assessing the significance of the effects of chronic oil spills on feeding/staging/moulting birds using ESSA's procedure was difficult and inappropriate. Therefore, the assessment was completed using the methodology developed by Duval and Vonk (1991). The assessment was based on a worst-case scenario involving the release of 10 bbls of diesel from the Atkinson platform at a time when a large number (15,000 - 20,000) of moulting birds are in Hutchinson Bay.

Given these assumptions, it was estimated that a spill of this nature could potentially cause the oiling of as many as 10,000 birds. Because this represents less than 1 percent of the population, and recovery would likely occur within one generation, the subgroup concluded that the impact would be **insignificant**.

RECOMMENDED RESEARCH AND MONITORING

No research or monitoring specifically related to the effects of chronic oil spills on waterbirds was recommended by the subgroup.

LITERATURE CITED

Dome Petroleum Limited, ESSO Resources Canada Limited, Gulf Canada Resources Inc. 1982. Beaufort Sea-Mackenzie Delta Environmental Impact Statement - Volume 6. Accidental Spills.

Duval, W. and P. Vonk. 1991. A semi-quantitative procedure for preparation of initial environmental evaluations and assessment of potential impact significance. Seakem Group Ltd., Vancouver, B.C.

LGL Limited, ESL Environmental Sciences Limited, ESSA Environmental and Social Systems Analysts Limited and P.J. Usher Consulting Services Limited. 1986. Mackenzie Environmental Monitoring Project. 1985-1986 Final Report. Prep. for Indian and Northern Affairs Canada. 308 pp. + appendices.

BREAM HYPOTHESIS R-10

ACTIVITIES ASSOCIATED WITH HYDROCARBON DEVELOPMENT WILL AFFECT THE ABUNDANCE AND DISTRIBUTION OF AGGREGATIONS OF STAGING, MOULTING AND NESTING BIRDS

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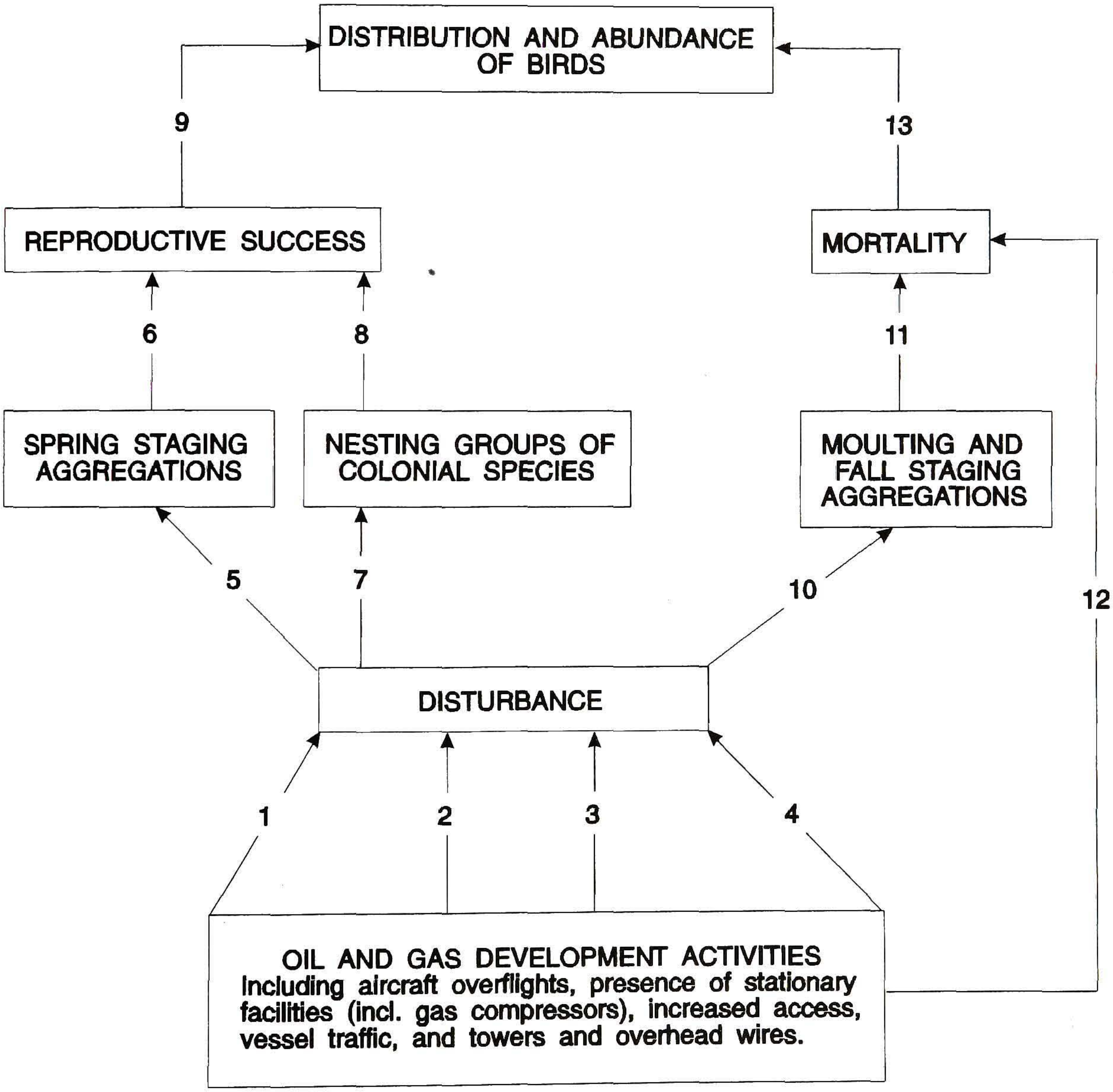
INTRODUCTION

BREAM Hypothesis 10 is the result of merging MEMP 7 and BEMP 12. The structure and linkages of this new hypothesis are the same as MEMP 7, which is the more comprehensive of the two hypotheses. The rationale for merging the hypotheses is that specific issues dealing with energy expenditure, fat loss and increased winter mortality of brant due to aircraft disturbance (BEMP 12) is already addressed by MEMP 7 within the broader context of increased energy costs to birds caused by aircraft disturbance. In addition to consolidating MEMP 7 and BEMP 12, the Impact Hypothesis Working Group also recommended that linkages of the hypothesis be reworded to include the effects of gas compressor noise on aggregations of birds.

Since the last BEMP workshop, the results of several new studies of relevance to BREAM Hypothesis 10 have become available (Johnson 1991, 1992; Wiggins and Johnson 1992; TERA 1991; Troy 1991; Troy and Carpenter 1990; Troy and Wickliffe 1990; Truett and Kertell 1990). All of these studies address the impacts of gravel roads, pads, causeways and other permanent structures associated with oil and gas development in the Prudhoe Bay area on waterbirds, particularly waterfowl and shorebirds. A multi-year study on the effects of noise associated with gas processing facilities on waterfowl (Johnson *et al.* 1990; Anderson *et al.*

FIGURE 10-1

EFFECTS OF DISTURBANCES ASSOCIATED WITH HYDROCARBON DEVELOPMENT ACTIVITIES ON STAGING, MOULTING AND NESTING BIRDS



Linkages

1. Increases in aircraft overflights will increase disturbance to aggregations of moulting, staging and/or nesting birds.

2. The presence of exploratory, processing and distribution facilities, including gas compressors and associated noise, will increase disturbance to aggregations of birds.

3. Increased access by humans will increase disturbance to aggregations of birds.

4. Increases in vessel traffic on the Mackenzie River will increase disturbance to aggregations of staging, moulting or nesting birds.

5. Increased disturbance will displace aggregations of birds in spring staging areas, and interfere with feeding, courtship and breeding activities.

6. Increased energy costs due to disturbance and displacement during spring staging will decrease reproductive success.

7. Increased disturbance will cause an increase in nest desertion and brood loss, particularly for colonial nesting species.

8. Increased nest desertion and brood loss will decrease reproductive success, particularly in colonial nesting species.

9. A decrease in reproductive success will reduce the abundance and alter the distribution of birds.

10. Increased levels of disturbance will increase energy costs of aggregations of birds during moulting and/or fall staging.

11. Increased energy costs during moulting and/or fall staging will ultimately affect the energy balance of the birds and cause an increase in mortality.

12. The presence of towers and overhead wires associated with development will result in collisions by birds that will ultimately increase mortality of all birds.

13. Increased mortality will reduce local abundance and alter the distribution of birds.

1990, 1991) has also been completed and the results are now available.

EVALUATION OF LINKAGES

During the planning meeting of the Impact Hypothesis Working Group, it was concluded that both MEMP 7 and BEMP 12 remain valid. Consequently, the new BREAM hypothesis is also valid. The hypothesis was not re-evaluated during this years workshop because adequate information exists to support the conclusion regarding the validity of the hypothesis. The potential impacts of industry disturbances on staging, moulting and nesting birds are well documented in the literature, and further research was not considered necessary.

During the workshop, the subgroup reviewed the structure and wording of the hypothesis and agreed that all references to waterfowl should be changed to birds, and this should include all bird VECs with the exception of raptors. Based on VECs selected for BEMP and MEMP, this list includes common eiders, diving ducks, king eiders, brant, thick-billed murre, snow geese and loons. It was noted that while this hypothesis is valid for staging and moulting birds, it may not necessarily be valid for all nesting birds, such as nesting loons (L. Dickson, pers. comm.).

ASSESSMENT OF IMPACTS

Using the assessment methodology developed by Duval and Vonk (1991), the subgroup concluded that the impacts of disturbances on staging, moulting and some nesting birds would likely be significant. The effects of disturbances from aircraft overflights, vessel traffic and stationary facilities would occur for the duration of the project and, therefore, recovery of the affected populations would be long term.

RECOMMENDED RESEARCH AND MONITORING

No research or monitoring specifically related to the effects of hydrocarbon development activities on staging, nesting and moulting birds was recommended by the subgroup.

LITERATURE CITED

Anderson, B.A., S.M. Murphy, M.T. Jorgenson, J.A. Ciarletta, and B.A. Kugler. 1990. GHX-1 Waterbird and noise monitoring program. Unpub. rep. by Alaska Biological Research, Inc. and ACENTECH, Inc., for ARCO Alaska, Inc., Anchorage, Alaska. 84 p.

Anderson, B.A., S.M. Murphy, C.L. Cranor, M.T. Jorgenson, and B.A. Kugler. 1991. GHX Waterbird and noise monitoring program. Unpub. rep. by Alaska Biological Research, Inc. and ACENTECH, Inc., for ARCO Alaska, Inc., Anchorage, Alaska. 109 p.

Duval, W. and P. Vonk. 1991. A semi-quantitative procedure for preparation of initial environmental evaluations and assessment of potential impact significance. Seakem Group Ltd., Vancouver, B.C.

Johnson, C.B., S.M.Murphy, C.L. Cranor, M.T. Jorgenson, and B.A. Kugler. 1990. Point McIntyre waterbird and noise monitoring program. Unpub. rep. by Alaska Biological Research, Inc. and ACENTECH, Inc., for ARCO Alaska, Inc., Anchorage, Alaska. 132 p.

Johnson, S.R. 1991. The status of snow geese in the Sagavanirktok River delta area, Alaska: a 12-year summary report, 1980-1991. Unpub. rep. by LGL Alaska Research Assoc., Inc., for BP Exploration (Alaska) Inc., Anchorage, Alaska. 35 p.

Johnson, S.R. 1992. The distribution, abundance, and movements of black brant in the Sagavanirktok River delta area, Alaska, 1991. Unpub. rep. by LGL Alaska Research Assoc., Inc., for BP Exploration (Alaska) Inc., Anchorage, Alaska. 23 p.

TERA. 1991. Trends in bird use of the Pt. McIntyre reference area: 1990 update. Unpub. rep. by Troy Ecological Research Associates (TERA), for BP Exploration (Alaska) Inc., Anchorage, Alaska. 47 p.

Troy, D.M. 1991. Bird use of disturbed tundra at Prudhoe Bay, Alaska: bird and nest abundance along the abandoned peat roads, 1988-1989. Unpub. rep. by Troy Ecological Research Associates (TERA), for BP Exploration (Alaska) Inc., Anchorage, Alaska. 57 p.

Troy, D.M. and J.K. Wickliffe. 1990. Trends in bird use of the Pt. McIntyre reference area: 1989-1989. Unpub. rep. by Troy Ecological Research Associates (TERA), for BP Exploration (Alaska) Inc., Anchorage, Alaska. 47 p.

Troy, D.M. and T.A. Carpenter. 1990. The fate of birds displaced by the Prudhoe Bay oilfield: the distribution of nesting birds before and after P-Pad construction. Unpub. rep. by Troy Ecological Research Associates (TERA), for BP Exploration (Alaska) Inc., Anchorage, Alaska. 51 p.

Truett, J.C. and K. Kertell. 1990. Effects of habitat disturbance on arctic wildlife: a review and analysis. Unpub. rep. by LGL Alaska Research Assoc., Inc., for BP Exploration (Alaska) Inc., Anchorage, Alaska. 61 p.

Wiggins, D.A. and S.R. Johnson. 1992. Use of gravel causeways by nesting common eiders, Beaufort Sea, Alaska, 1991. Unpub. rep. by LGL Alaska Research Assoc., Inc., for BP Exploration (Alaska) Inc., Anchorage, Alaska. 36 p.

BREAM HYPOTHESIS R-11

SHOREBASES AND SHALLOW-WATER PRODUCTION FACILITIES WILL RELEASE HYDROCARBONS AND HEAVY METALS AT SUFFICIENT LEVELS SUCH THAT FISH HARVEST WILL BE REDUCED THROUGH TAINTING AND HEAVY METAL ACCUMULATION

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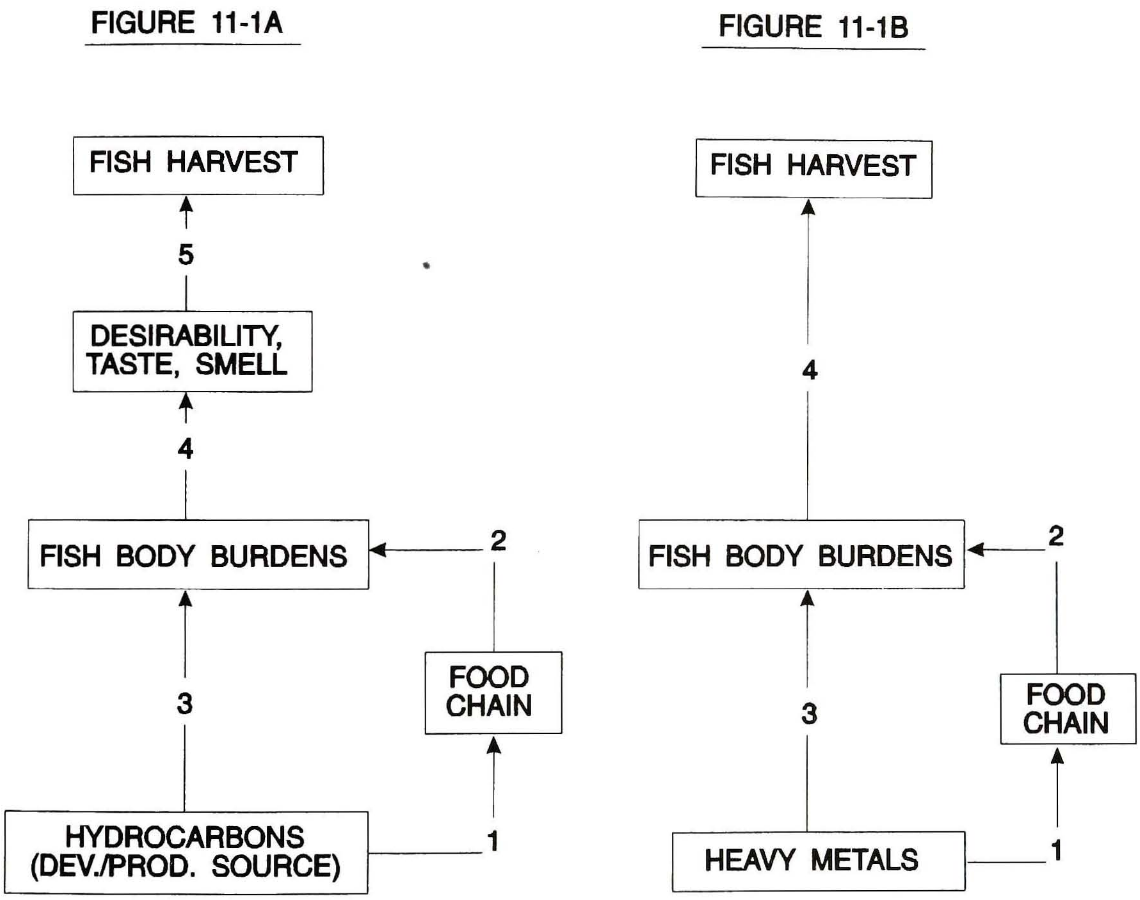
INTRODUCTION

Previous evaluations of this hypothesis considered only local sources of contaminants (metals and hydrocarbons). It is now known that metals, hydrocarbons and organochlorines from distant sources will also impact the development zone through long-range transport of atmospheric pollutants (LRTAP) mechanisms (see BREAM Impact Hypothesis R-26). At the present time, the relative contribution of contaminants from local and LRTAP sources can not be readily quantified. However, it is expected that under most circumstances for metals and hydrocarbons that local sources will predominate. As there are no significant local sources of organochlorines, LRTAP is expected to predominate as a source. An unanswered question is how organochlorines may result in, modify, or contribute to the tainting or undesirability of fish. Organochlorines are a relevant part of this hypothesis due to the perception that their presence, particularly in combination with hydrocarbons and metals, may lead to "tainting' or a decreased desirability for fish as food. The hypothesis is considered to be valid. In the time available at the workshop, only a very brief assessment was possible.

FIGURE 11-1

EFFECTS OF SHOREBASES AND SHALLOW-WATER PRODUCTION FACILITIES ON THE HARVEST OF FISH



Linkages for Hypothesis 11A

1. and 3. Hydrocarbons in water and sediments will enter fish and prey organisms of harvested fish species.

2. Hydrocarbons can be passed through food chains.

4. Desirability of fish is decreased as a result of increases in body burden of hydrocarbons.

5. Decreased desirability will decrease fish harvest.

Linkages for Hypothesis 11B

1. and 3. Heavy metals from water and sediments will enter fish and prey organisms of harvested fish species.

2. Heavy metals can be passed through food chains.

4. Human health and desirability of fish can be affected by increases in heavy metal concentrations.

5. Decreased desirability will decrease fish harvest.

ASSESSMENT OF IMPACTS

Using the assessment procedure developed by ESSA Ltd., the workshop subgroup assessed the significance of potential impacts of hydrocarbons and heavy metals on fish harvest.

Hypothesis R-11A

Spatial Scale	•	regional because of range of mobile fish species.
Temporal Scale	•	short-term for a single event such as a minor hydrocarbon spill.
	•	long-term for chronic exposures.
Effect	•	on scientific grounds probably insignificant because natural dispersion will probably be effective in diluting contaminants. Nonetheless, the effect will likely be significant simply because of perception of taint or because of fear of taint.

Hypothesis R-11B

Spatial Scale	•	same as for BREAM Impact Hypothesis R-11A.
Temporal Scale	•	short term for a single event such as a minor drilling fluid spill.
	•	potentially long-term for chronic exposures.
Effect	•	Significant because of fear of an effect on human health due to metal accumulation in fish.

RECOMMENDED RESEARCH AND MONITORING

The subgroup identified two areas where research/monitoring is required.

1. Examine metal levels in fish and marine mammals of the western Arctic.
2. Conduct a taste testing program. Testing of effluents would probably be necessary to establish the actual source of hydrocarbons that was causing the tainting.

BREAM HYPOTHESIS R-12

THE CONSTRUCTION OF SHOREBASES, PIPELINE LANDFALLS, AND DEVELOPMENT OF SHALLOW WATER PRODUCTION FIELDS WILL RESULT IN A DECREASE IN THE POPULATIONS OF ARCTIC CISCO AND BROAD WHITE FISH

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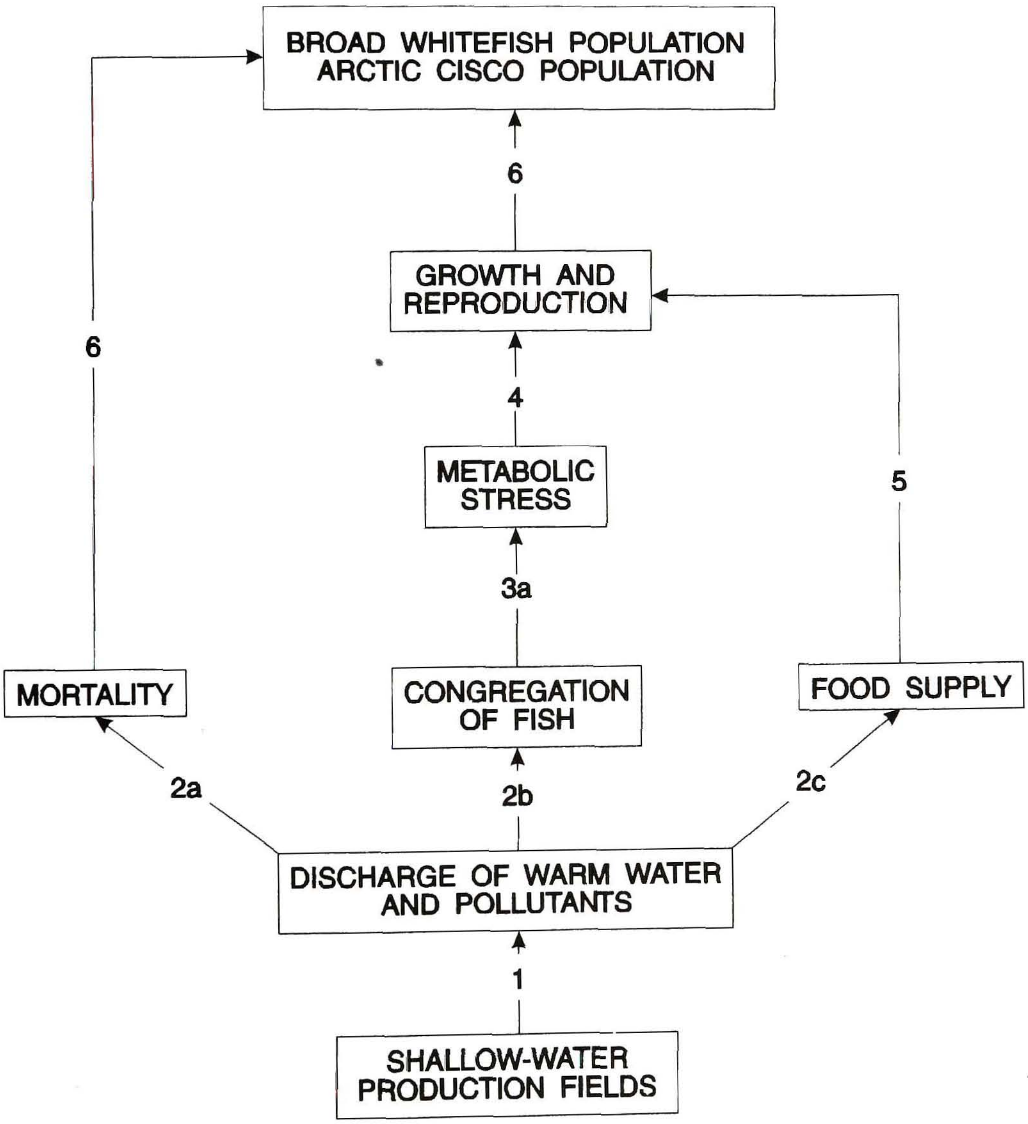
INTRODUCTION

BREAM Hypothesis R-12 was formerly BEMP Hypothesis 16. During the BREAM Planning Meeting, the hypothesis working group concluded that BEMP 16 was **valid** but too restrictive in its project activity definition. The hypothesis focused primarily on production fields and shorebases and did not consider pipeline landfalls, which are components of the latest production scenarios. In addition, BEMP 16 did not consider interference with coastal migrations of fish. Any developments in the near shore (pipeline landfalls, shorebase construction and operation, oil or gas field development) that may result in effluent discharge, accidental spills, production water disposal or physical perturbation (i.e. from dredging) have potential to interfere with the coregonids that are dependent on nearshore habitat. As a result, several new linkages were added to the hypothesis to address concerns related to pipeline landfalls and the possible interference of coastal fish migrations as a result of nearshore dredging and construction activities.

The original statement of Hypothesis R-12 (above) includes the combined effects of pollutant discharges from shallow-water field production and of nearshore dredging and trenching on the movements of fish in the nearshore area. Participants of the working group believed that the two distinct sources and pathways for effects would be better assessed if they were separated into two hypotheses: 12A (dealing with shallow-water field development) and

FIGURE 12-1A

EFFECTS OF DEVELOPMENT OF SHALLOW-WATER PRODUCTION FIELDS ON THE ABUNDANCE OF ARCTIC CISCO AND BROAD WHITEFISH



Sub-Hypothesis 12A
Linkages

1. Production drilling will result in the discharge of contaminated warm water effluent in the shallow nearshore waters.

2a. Exposure of Arctic cisco and broad whitefish to effluents will result in direct mortality.

2b. Fish will be attracted to thermal plumes.

2c. Effluent and warm water discharges will affect the abundance and distribution of invertebrate food organisms.

3. Contaminants in water in areas where fish are congregated will result in increased metabolic stress.

4. Increased metabolic stress resulting from exposure to effluents will reduce growth rate and affect reproduction.

5. Change in food supply will result in changes in growth and reproduction.

6. Increased mortality and changes in growth and reproduction as a result of exposure to the effects of effluents will affect the size of the Arctic cisco and broad whitefish populations.

12B (dealing with trenching and dredging associated with shorebase construction and pipeline landfalls).

EVALUATION OF LINKAGES

Development in the nearshore (i.e., within one-half km or at depths < 5m) impinges on seasonal coregonid habitat. Of special concern are broad whitefish, because of their importance to local fisheries and because their coastal migratory habits are particularly vulnerable to coastal developments of any kind (Reist and Bond 1990; Lawrence *et al.* 1984; Bond 1983). The nearshore areas also provide important summer feeding habitat for both Arctic cisco and broad whitefish.

Link 1: **Production drilling will result in the discharge of contaminated warm water effluent in the shallow nearshore waters.**

As described in BEMP Hypothesis 16, production drilling was assumed to result in the discharge of up to 3000 m^3/day of warm (40°C), saline (60 ppt) water in the nearshore zone (water depth < 5m). Although the water would be treated prior to disposal, contaminants in the form of dissolved metals and hydrocarbons would be present at low concentrations. The link is still valid.

Link 2a: **Exposure of Arctic cisco and broad whitefish to effluents will result in direct mortality.**

Fish kills can occur due to cold shock as a result of sudden changes in temperature. This linkage was discussed in BEMP 16 and determined to be valid but inconsequential at the population level because of the localized nature of effects.

Link 2b: Fish will be attracted to thermal plumes.

A number of studies have shown that fish are attracted to thermal plumes. This link was determined to be valid by BEMP workshop participants, and is still considered to be valid.

Link 2c: Effluent and warm water discharges will affect the abundance and distribution of invertebrate food organisms.

Changes in salinity can result in mortality of invertebrates as a result of osmoregulatory effects (M. Bergman, pers. comm.). Invertebrates that are more tolerant to changes in salinity and thermal regimes may predominate in the benthic community. The area of effect is expected to be localized under the present development scenario. Participants agreed with the assessment of BEMP that only small areas of habitat would be affected.

Link 3: Contaminants in water in areas where fish are congregated will result in increased metabolic stress.

The link was considered valid by BEMP workshop participants and is still valid, as per the discussion in BEMP 16. The link that stated that increased congregations of fish would result in a decreased abundance of food due to overcompetition was considered invalid and consequently was deleted from the hypothesis. There is no evidence that fish would remain in a warm water plume under such conditions, particularly if abundant food sources were available elsewhere.

Link 4: Increased metabolic stress resulting from exposure to effluents will reduce growth rate and affect reproduction.

This link was considered valid as per discussions for BEMP 16 during the 1985 workshop.

Link 5: Change in food supply will result in changes in growth and reproduction.

This link was considered to be implicitly valid. However, the working group considered that effects would be localized.

Link 6: Increased mortality and changes in growth and reproduction as a result of exposure to the effects of effluents will affect the size of the Arctic cisco and broad whitefish populations.

The link was considered to be conceptually valid; however, the small area affected by the discharge and the relatively small numbers of fish that are expected to be affected led to the conclusion that population effects would not be detectable. This was in concurrence with conclusions on BEMP 16 during the 1985 workshop.

ASSESSMENT OF IMPACTS

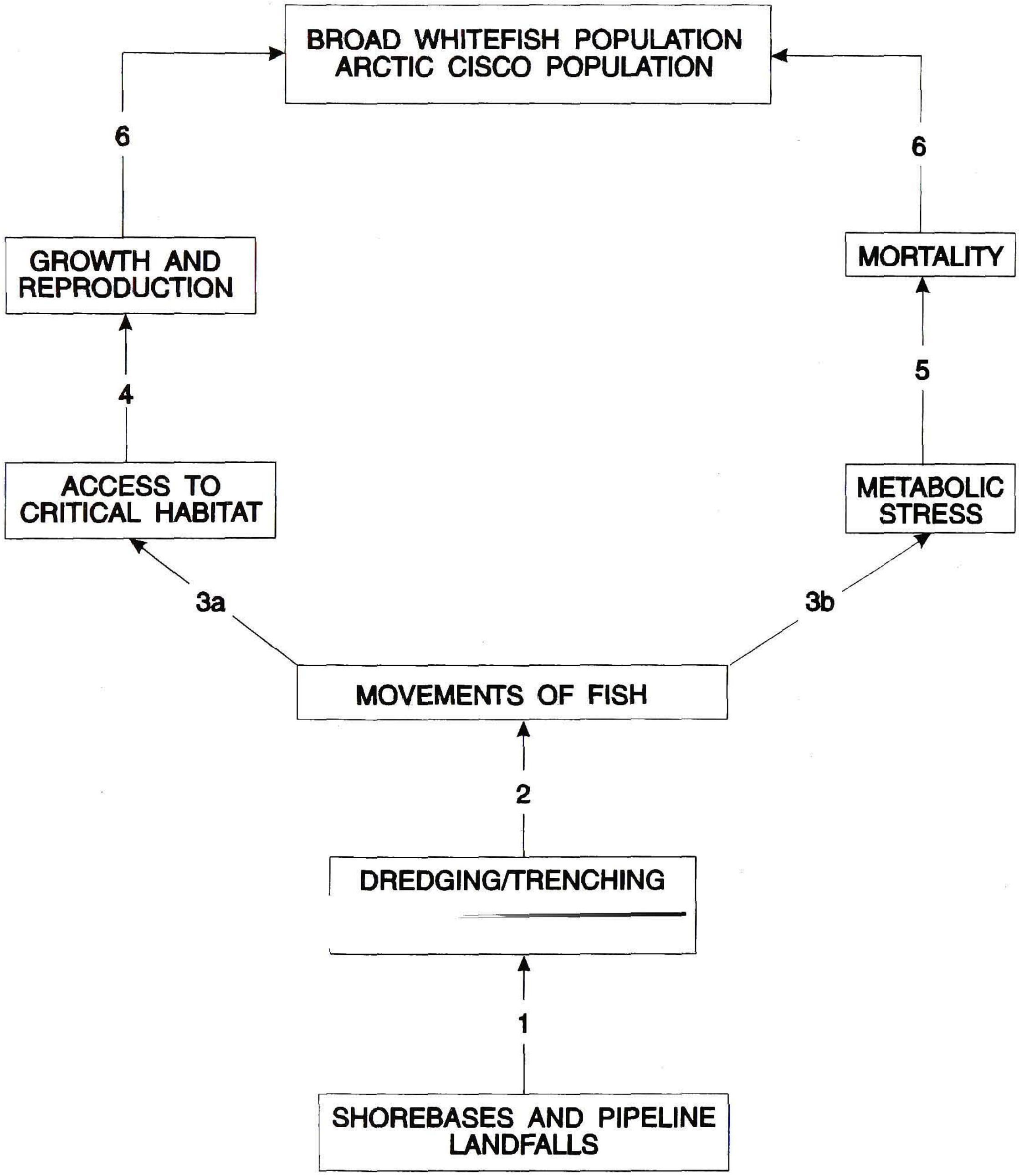
While the hypothesis is valid, the working group concluded that the effects of development of shallow-water production fields on broad whitefish and Arctic cisco populations would be insignificant due to the localized nature of effects (i.e., discharge of 3000 m^3/day warm, saline water).

RECOMMENDED RESEARCH AND MONITORING

Information needs relate only to the requirement for project-specific estimates of effluent discharges.

FIGURE 12-1B

EFFECTS OF DREDGING AND TRENCHING ACTIVITIES ASSOCIATED WITH PIPELINE LANDFALLS AND SHOREBASES ON THE ABUNDANCE OF ARCTIC CISCO AND BROAD WHITEFISH



Sub-Hypothesis 12B
Linkages

1. Shorebases and pipeline landfalls will require dredging and trenching activities to be undertaken in the nearshore littoral zone.

2. Dredging associated with shorebase development in the nearshore and in coastal embayments will affect coastal migrations of broad whitefish.

3a. Changes in the migration pattern of fish will affect access to important feeding and overwintering habitat.

3b. Movement of young-of-the-year (YOY) fish to offshore areas to avoid suspended solids from dredging will result in metabolic stress resulting from exposure to more saline, colder water.

4. Loss of access to critical feeding habitat will affect growth and reproduction.

5. Increased metabolic stress resulting from osmoregulatory effects will cause mortality amongst young-of-the-year broad whitefish.

6. Increased mortality and changes in growth and reproduction will affect the size of broad whitefish and Arctic cisco populations.

EVALUATION OF LINKAGES

Landfalls for offshore delivery of gas to coastal gas plants will result in the need for dredging and associated construction activities in nearshore areas. Activities of this nature have potential to affect the movement of fish within the narrow band of warm brackish water that, in particular, serves as a critical migration corridor for broad whitefish to access coastal streams. The streams provide access to feeding and overwintering habitat for whitefish.

Link 1: Shorebases and pipeline landfalls will require dredging and trenching activities to be undertaken in the nearshore littoral zone.

Trenching operations for the construction of the pipeline from offshore areas will be a requirement. However, the short-term nature of the operation and the opportunity to mitigate effects by conducting trenching operations during least sensitive times (e.g., winter) suggests that although this is a valid link, the effects will be inconsequential. Dredging associated with shorebases does have a history of occurring at more sensitive times, and tends to be of a scale that may be cause for concern (e.g., Tuktoyaktuk Harbour and McKinley Bay).

Link 2: Dredging associated with shorebase development in the nearshore and in coastal embayments will affect coastal migrations of broad whitefish.

It is uncertain whether short-term exposure to concentrations of dredged materials above natural levels will affect the migration of fish. Numerous studies indicate that fish can tolerate short-term exposures with little or no observable effect (Neucombe and MacDonald 1991). The link was considered to be weak and tenuous, and the working group suggested that a more appropriate link was the effect of dredging on loss of habitat and change in food supply, rather than limiting access to habitat.

Link 3a: **Changes in the migration pattern of fish will affect access to important feeding and overwintering habitat.**

Link 3b: **Movement of young-of-the-year fish to offshore areas to avoid suspended solids from dredging will result in metabolic stress resulting from exposure to more saline, colder water.**

Link 4: **Loss of access to critical feeding habitat will affect growth and reproduction.**

Link 5: **Increased metabolic stress resulting from osmoregulatory effects will cause mortality amongst young-of-the-year broad whitefish.**

Link 6: **Increased mortality and changes in growth and reproduction will affect the size of broad whitefish and Arctic cisco populations.**

Linkages 4, 5 and 6 were all considered valid; however, linkages 3a and 3b were assessed as being weak and tenuous. In the absence of any studies to support the contention, it was considered unlikely that dredging would interrupt or change the movement patterns of these species of fish. There are numerous examples related to placer mining and fish movements being relatively unaffected by short-term exposure to high levels of suspended solids. Similarly, the working group suggested that a more valid concern was related to habitat loss or alteration.

ASSESSMENT OF IMPACTS

The hypothesis was considered weak and tenuous at best. Under the present development scenario, the effects were considered to be localized, short in duration and insignificant in terms of population effects.

Effects could be mitigated by timing dredging activities to coincide with movements of YOY in the coastal waters.

RECOMMENDED RESEARCH AND MONITORING

The working group did not identify any research or monitoring needs related to this hypothesis.

LITERATURE CITED

Bond, W.A. 1982. A study of the fish resources of Tuktoyaktuk Harbour, southern Beaufort Sea coast, with special reference to life histories of anadromous coregonids. Can. Tech. Rep. Fish. Aquat. Sci. 1119: vii + 178 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.

Neucombe, C.P. and D.D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. North American Journal of Fisheries Management, Vol 11: 72-82.

Reist, J.D. and W.A. Bond. 1988. Life history characteristics of migratory coregonids of the lower Mackenzie River, Northwest Territories, Canada. Finnish Fish Res. 9: 133-144.

BREAM HYPOTHESIS R-13

WATER WITHDRAWAL FROM FRESHWATER LAKES FOR USE IN LAND-BASED PRODUCTION FACILITIES WILL RESULT IN A REDUCED POPULATION OF BROAD WHITEFISH

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Mike Lawrence	David Thomas

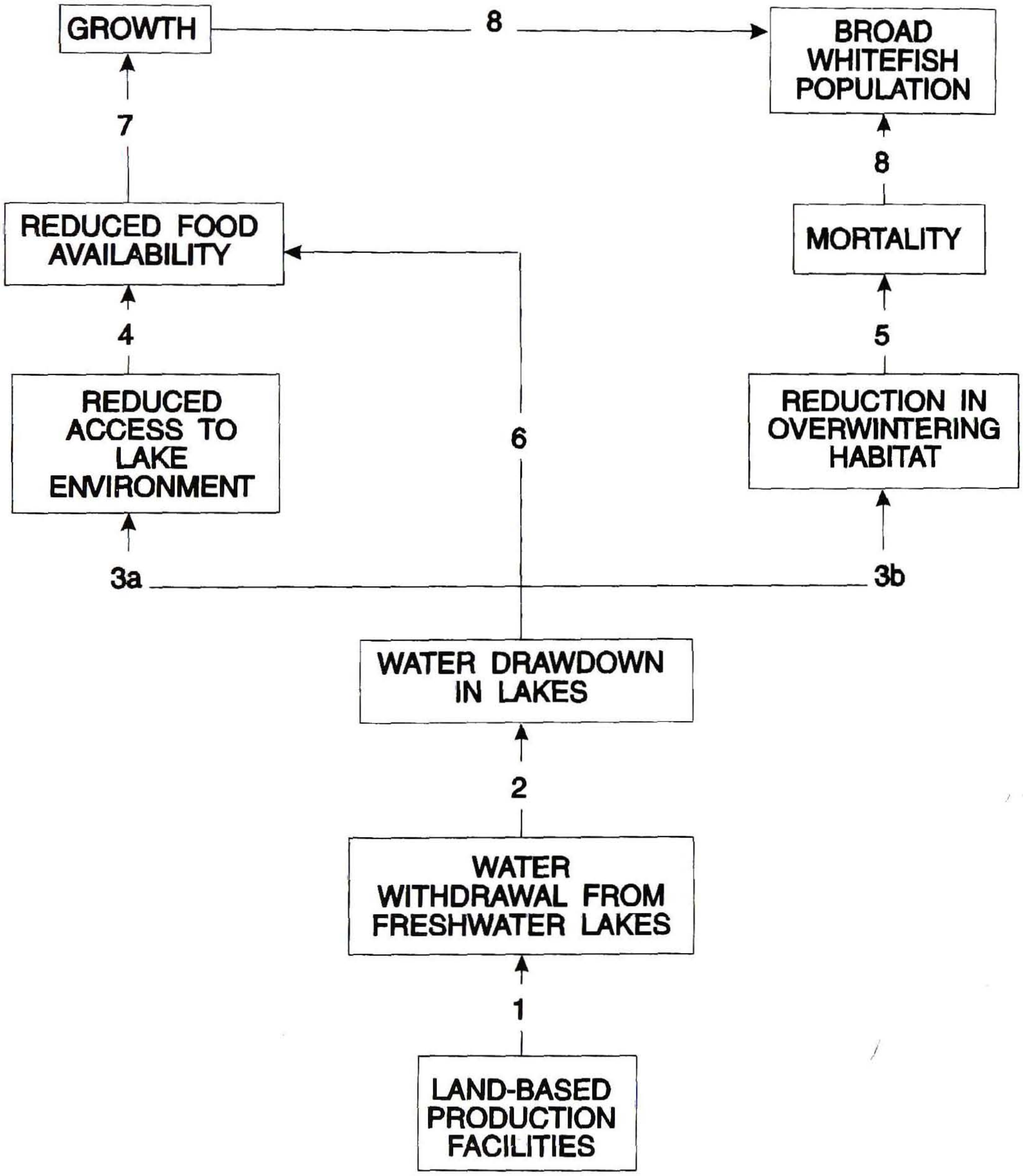
INTRODUCTION

BEMP Hypothesis 17 considered the effects of **marine** water use on populations of broad whitefish and Arctic cisco from the perspective of entrainment. The hypothesis was assessed as being inconsequential with respect to Arctic cisco and invalid with respect to broad whitefish because the latter do not utilize marine waters. In the BREAM Planning Meeting, a new hypothesis (BREAM R-13) was developed because of concerns for the protection of lakes on Tukyoyaktuk Peninsula and Richards Island that provide important broad whitefish overwintering and feeding habitat, from water withdrawal for field flooding and other uses. Arctic cisco do not make use of these freshwater habitats and so were excluded from the new BREAM hypothesis.

The development scenario for the production of oil reserves includes a potential requirement of large volumes of water for field flooding (500 - 5000 m^3/day assumed in the latter stages of production) and for small volumes (unspecified) at onshore facilities to condition and cool produced oil. Meeting the requirement for ample supply of fresh water was viewed as a project activity with potential for effects on freshwater lake environments.

FIGURE 13-1

EFFECTS OF WATER WITHDRAWAL FROM FRESHWATER LAKES ASSOCIATED WITH LAND-BASED PRODUCTION FACILITIES ON BROAD WHITEFISH POPULATION



Linkages

1. Land-based production facilities will have a requirement for a secure supply of clean, fresh water.

2. The annual requirement for fresh water will result in a decrease in water levels in lakes on Tuktoyaktuk Peninsula and Richards Island.

3a. Reduction in lake outflow discharge will reduce broad whitefish access to freshwater lakes.

3b. Drop in lake level will result in reduced quantity and quality of available overwintering habitat.

4. Reduction in access to lake environments will reduce the feeding habitat and food supply for broad whitefish.

5. Reduction in overwintering habitat will result in mortality of broad whitefish.

6. Lowering of lake levels will result in a decrease in the food production in lakes.

7. Reduction in food supply will result in reduction in growth.

8. Reduction in growth and increase in mortality will result in decreased broad whitefish population size.

EVALUATION OF LINKAGES

Freshwater lakes of the Delta region, especially many of the lakes on Tuktoyaktuk Peninsula and Richards Island, provide important nursery, summer feeding and overwintering habitat for broad whitefish for up to 6 years of their pre-spawning life (Reist and Bond 1990; Lawrence *et al.* 1984). The hydrology of Tuktoyaktuk Peninsula watersheds is not well understood, but is the subject of ongoing research activities (Phil Marsh pers. comm.; Wedel and Lawrence, in prep.). Recent problems with water supply to the hamlet of Tuktoyaktuk suggests that withdrawal of water from lakes on the Peninsula for land-based production facilities could not only cause further problems to water supply but also could potentially interrupt fish movements in streams connecting them to the sea.

Link 1: Land-based production facilities will have a requirement for a secure supply of clean, fresh water.

This linkage was considered to be conceptually valid; however, the requirement for field flooding is uncertain. Should there be a need for water for this purpose, other potential sources are available (Mackenzie River, coastal water, Husky Lakes), where water use would have inconsequential drawdown effects (entrainment effects would need to be re-evaluated in these circumstances). The smaller volume requirement for processing and cooling was considered valid.

Link 2: The annual requirement for fresh water will result in a decrease in water levels in lakes on Tuktoyaktuk Peninsula and Richards Island.

This link was also considered to be conceptually valid; however, specific information on the annual water budgets of the Tuktoyaktuk Peninsula and Richards Island lakes is lacking. This information would be necessary, prior to an assessment of the potential for water use, to result in a meaningful lowering of lake levels. Previous experience in the Hamlet of Tuktoyaktuk related to the lowering of water levels in the lakes and streams that supply the community's water requirements lends credence to the validity of this linkage.

Link 3a: Reduction in lake outflow discharge will reduce broad whitefish access to freshwater lakes.

The small streams that drain lakes of Tuktoyaktuk Peninsula and Richards Island have mid-summer flows that range from less than 0.1 to 1.5 m^3/sec. Interannual variability in flow can be large (Lawrence *et al.* 1984). The streams are relatively shallow and are frequently characterized by shallow sills at the lake outlets. As well, the mouths of the creeks are frequently clogged with coastal drift wood that originates from points upstream on the Mackenzie River. Fish passage in these streams under normal flow conditions has been recognized as a concern and remedial measures have been undertaken in the past to improve broad whitefish access to and from some of the Peninsula lake systems (DFO files, Winnipeg and Inuvik). The group had insufficient understanding of the hydrologic characteristics of these small coastal watersheds to suggest at what point water withdrawal would create an access problem, but mentioned that work being sponsored by DFO (Wedel, in prep.) and the National Hydrologic Research Institute (P. Marsh, pers. comm.) would be instructive. The link is valid.

Link 3b: Drop in lake level will result in reduced quantity and quality of available overwintering habitat.

Lakes on Tuktoyaktuk Peninsula and Richards Island are often shallow and have limited overwintering potential (Lawrence *et al.* 1984). Because of the extensive near-surface permafrost conditions and the extreme cold winter climate, flow into and out of lakes in the region ceases during the winter period (November - April). Reduction in lake volume over the winter period could result in winterkill of juvenile and large immature broad whitefish which overwinter in selected lakes. The amount of habitat loss will depend on the rate of water use in relation to the size and morphometry of the lake. The linkage is valid.

Link 4: Reduction in access to lake environments will reduce the feeding habitat and food supply for broad whitefish.

Broad whitefish are highly dependent on the forage habitat provided by the lakes on Tuktoyaktuk Peninsula and Richards Island (Bond 1983; Lawrence *et al.* 1984). This link is valid.

Link 5: Reduction in overwintering habitat will result in mortality of broad whitefish.

Based on reported instances of what appear to be fairly common occurrences of natural winterkills (M. Lawrence, pers. comm.), lowering of lake water levels over the winter period will exacerbate the problem. The link is valid.

Link 6: Lowering of lake levels will result in a decrease in the food production in lakes.

Lowering of lake levels will reduce the area of the euphotic zone and of bottom substrate, thereby reducing the overall capacity of the affected lakes to produce food for broad whitefish. This link is valid.

Link 7: Reduction in food supply will result in reduction in growth.

Link 8: Reduction in growth and increase in mortality will result in decreased broad whitefish population size.

Links 7 and 8 are implicitly valid.

ASSESSMENT OF IMPACTS

In the absence of a project description that specifies a volume and flow requirement for water for field flooding and processing, the hypothesis was considered by the group to be conceptually valid. In evaluating the significance of the effect of water withdrawal from lakes on Tuktoyaktuk Peninsula and Richards Island, a scenario requiring 500 - 5000 m^3

was assumed. Spatially, the effects on broad whitefish could have both local and regional implications because of the migratory behaviour of the species. Temporally, the effects were considered to be long-term in nature, dependent upon the life of the production activity. The magnitude of impacts were assessed as being small on a regional scale, limited to effects on that portion of the regional population utilizing the affected lake(s). Broad whitefish do not exhibit a high degree of fidelity to their summer feeding habitat (K. Chang-Kue, pers. comm.), and therefore recovery potential was considered to be good based on re-invasion of the lake(s) by broad whitefish from other numerous coastal watersheds that they currently use.

Mitigation

The obvious mitigation is to use other, larger sources of water supply (coast, large lakes, Mackenzie River) such that the removal for field flooding and/or processing would have inconsequential effects on broad whitefish habitat. Water use could also be regulated such that withdrawal does not cause unacceptable impacts to fish habitat.

RECOMMENDED RESEARCH AND MONITORING

Ongoing studies of Tuktoyaktuk Peninsula watershed hydrology (Wedel, in prep.) as it relates to fish utilization should be completed as well as efforts to model the hydrometeorology of selected watersheds (P. Marsh, pers. comm.). This information is essential to scoping the magnitude and importance of this potential source of impact. If and when specific development scenarios indicate a requirement for water withdrawal from lakes on Tuktoyaktuk Peninsula and Richards Island, hydrologic/fish utilization monitoring studies should be implemented.

The requirement for experimental manipulation of lake water supply and output was discussed. However, the working group agreed that it would be inappropriate given that it may pose greater risk than necessary to local populations, and because there was no development scenario that identified a requirement for water from lakes.

LITERATURE CITED

Bond W.A. 1983. A study of the fish resources of Tuktoyaktuk Harbour, southern Beaufort Sea coast, with special reference to life histories of anadromous coregonids. Can Tech. Rep. Fish. Aquat. Sci. 1119: vii + 90 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.

Reist, J.D. and W.A. Bond. 1988. Life history characteristics of migratory coregonids of the lower Mackenzie River, Northwest Territories, Canada. Finnish Fish. Res. 9: 133-144.

BREAM HYPOTHESIS R-14

DREDGING AND DEPOSITION OF SPOILS WILL REDUCE THE BEARDED SEAL POPULATION

PARTICIPANTS

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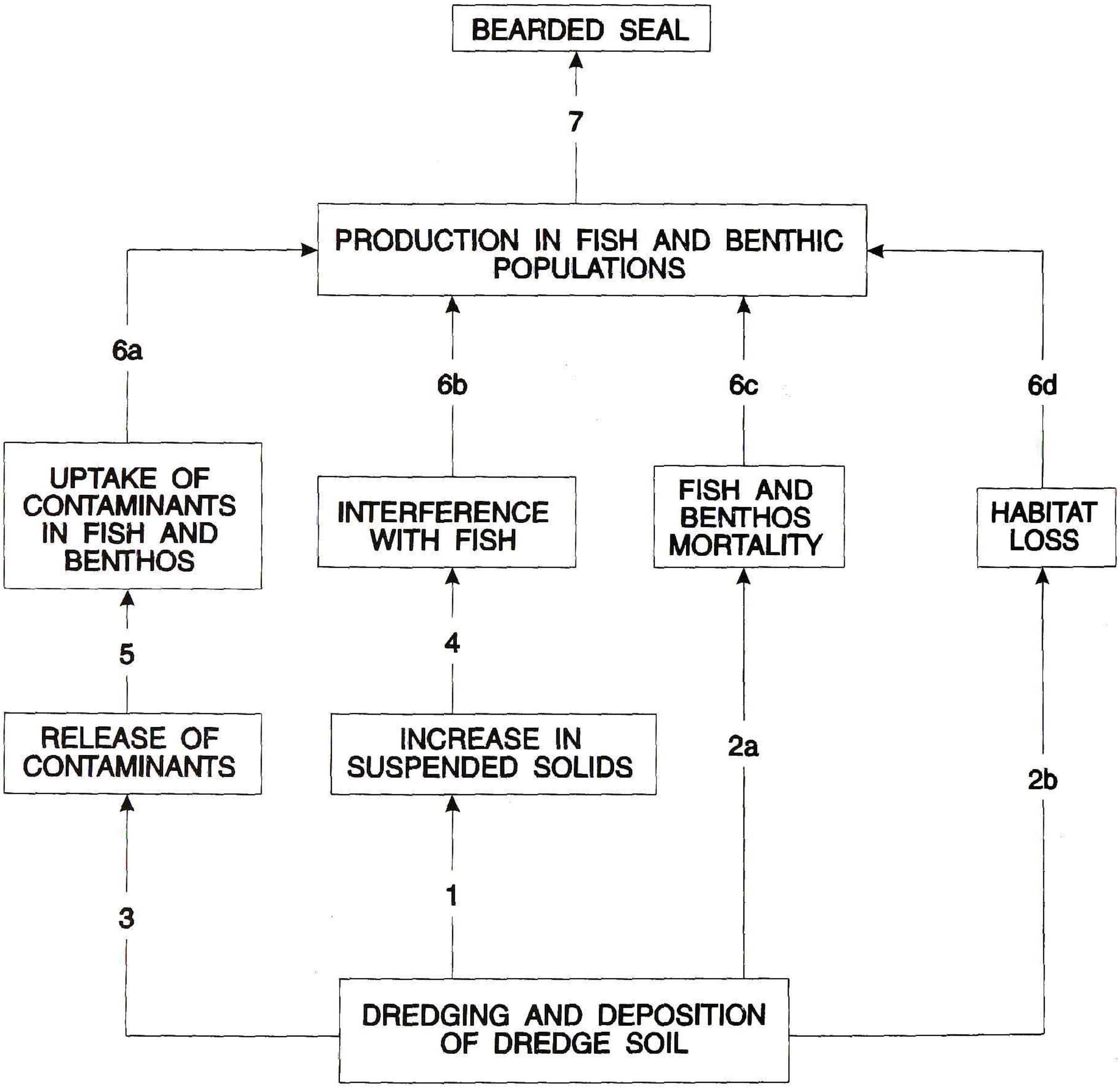
Susan Cosens	Don Robinson
Rolph Davis	Don Schell
Dave Fissel	Gary Wagner
Lois Harwood	

BREAM Hypothesis R-14 is considered valid but untestable. During the workshop, the subgroup agreed that no changes to the wording or structure of the hypothesis were necessary. A preliminary assessment of the significance of the potential impacts described in this hypothesis was not completed by the group for reasons discussed earlier in Section 4.2.

FIGURE 14-1

EFFECTS OF DREDGING ON BEARDED SEALS



Linkages

1. Dredging and deposition of dredge spoils will increase concentrations of suspended solids in the water column.

2. Removal of seafloor material and its deposition in other areas will result in mortality of benthic invertebrates and fish and habitat loss.

3. Dredging will release contaminants from the sediments.

4. Increased suspended solids will interfere with fish migration.

5. Contaminants released during dredging will be taken up by fish and benthos.

6. Habitat loss, mortality, interference with migratory routes and uptake of contaminants will reduce fish and benthic invertebrate populations.

7. Reduced populations of prey (fish and benthos) will reduce the number of bearded seals.

BREAM HYPOTHESIS R-15

THE DISCHARGE OF DRILL CUTTINGS CONTAMINATED WITH OIL-BASED DRILLING MUDS DURING HYDROCARBON EXPLORATION OR PRODUCTION WILL REDUCE POPULATIONS OF FISH, BIRDS OR MAMMALS, OR WILL DECREASE THE HARVEST OF THESE RESOURCES DUE TO HYDROCARBON ACCUMULATION IN TISSUES

PARTICIPANTS

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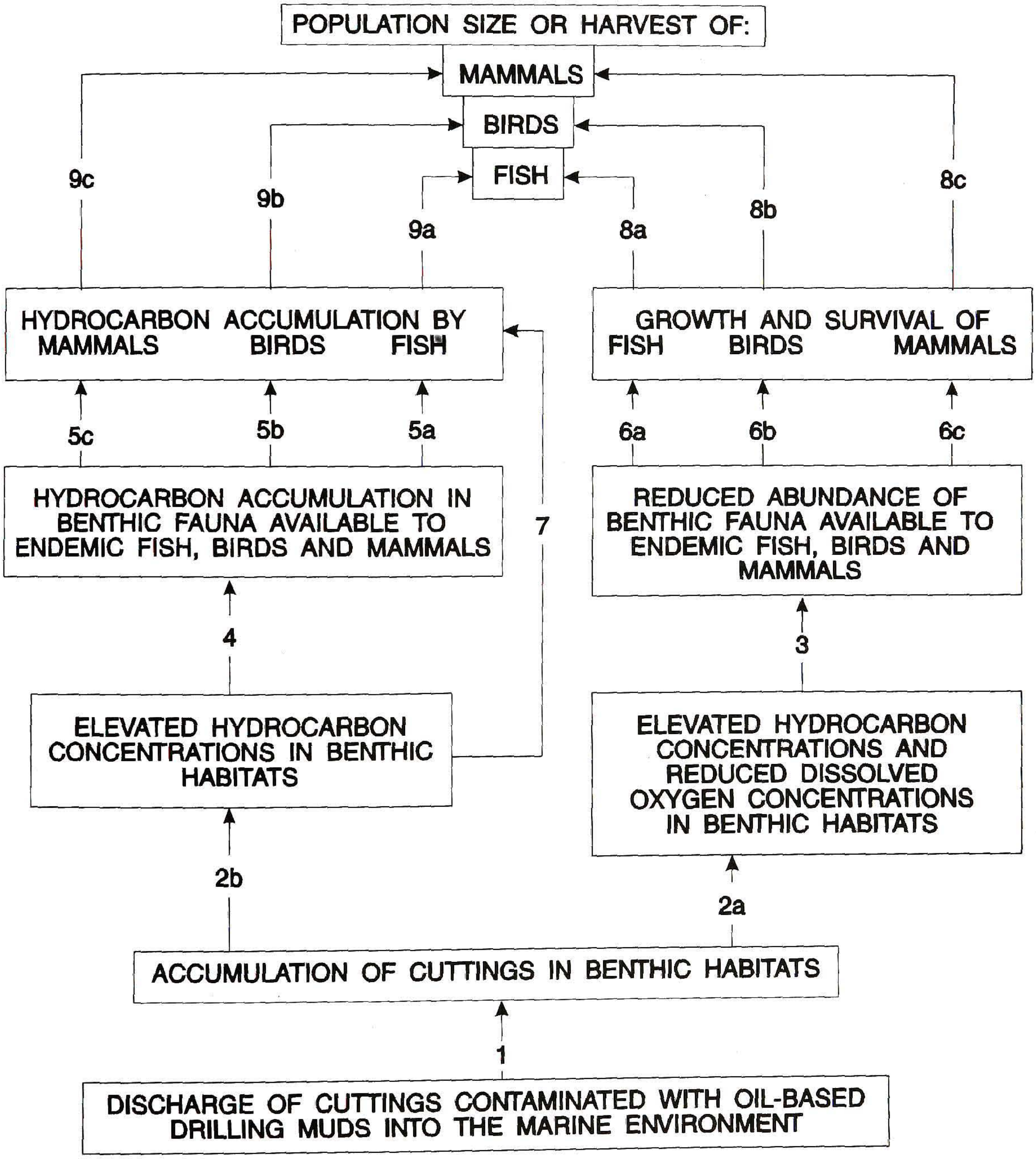
A preliminary assessment of this hypothesis was initiated but was not completed because the participants believed that there was insufficient expertise in the group related to the toxicity of oil-based drilling muds and the effects of these muds on specific wildlife groups.

FIGURE 15-1

EFFECTS OF THE DISCHARGE OF DRILL CUTTINGS CONTAMINATED WITH OIL-BASED DRILLING MUDS DURING HYDROCARBON EXPLORATION OR PRODUCTION ON THE POPULATIONS OF FISH, BIRDS OR MAMMALS OR ON THE HARVEST OF THESE RESOURCES



Linkages

1. Cuttings contaminated with oil-base drilling muds and discharged during exploration and development drilling will settle rapidly to the seafloor, and resist subsequent widespread dispersion due to the cohesiveness of oil-based mud/cuttings mixtures.

2a. In areas of cuttings accumulation, elevated hydrocarbon concentrations will occur in benthic habitats.

2b. In areas of cuttings accumulation, elevated hydrocarbon concentrations and reduced dissolved oxygen concentrations will occur in benthic habitats during the slow degradation of oil-based muds adhering to drill cuttings.

3. The abundance of benthic fauna available to endemic fish, birds and mammals will be reduced in areas of mud/cuttings accumulation due to smothering, oxygen depletion and toxicity of petroleum hydrocarbons in drilling muds or the products resulting from their degradation.

4. Benthic fauna available to endemic fish, birds and mammals in habitats containing mud/cuttings mixtures will accumulate petroleum hydrocarbons.

5a. Decreased abundance of benthic fauna will affect the growth and survival of marine and anadromous fish.

5b. Decreased abundance of benthic fauna will affect the growth and survival of birds that feed on benthic prey organisms.

5c. Decreased abundance of benthic fauna will affect the growth and survival of marine mammals that feed on benthic prey organisms.

6a. Marine and anadromous fish will accumulate petroleum hydrocarbons from ingestion of contaminated prey.

6b. Birds will accumulate petroleum hydrocarbons from ingestion of contaminated prey.

6c. Marine mammals will accumulate petroleum hydrocarbons from ingestion of contaminated prey.

7. Marine and anadromous fish remaining in areas containing oil-contaminated cuttings will accumulate petroleum hydrocarbons directly.

8a. The size of marine and anadromous fish populations will be reduced due to local effects of reduced prey availability on growth and survival.

8b. The size of waterbird populations will be reduced due to local effects of reduced prey availability on growth and survival.

8c. The size of marine mammal populations will be reduced due to local effects of reduced prey availability on growth and survival.

9a. The harvest of fish will be reduced due to the presence of petroleum hydrocarbons in tissues or to the perception that fish are of lower quality.

9b. The harvest of birds will be reduced due to the presence of petroleum hydrocarbons in tissues or to the perception that birds are of lower quality.

9c. The harvest of marine mammals will be reduced due to the presence of petroleum hydrocarbons in tissues or to the perception that marine mammals are of lower quality.

BREAM HYPOTHESIS R-16

THE PRESENCE OF OFFSHORE DRILLING PLATFORMS, CONSTRUCTION CAMPS (AND ASSOCIATED GARBAGE) AND GRAVEL EXTRACTION WILL RESULT IN A CHANGE IN THE NUMBERS OF ARCTIC AND RED FOXES

PARTICIPANTS

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Don Russel

INTRODUCTION

Based on discussions during MEMP (LGL *et al.* 1986) and the 1992 BREAM workshop, it was concluded that it was possible for future hydrocarbon development in the Canadian Beaufort to result in impacts to arctic and red foxes (*Aloplex lagopus* and *Vulpes vulpes*, respectively). Three major impact pathways were identified:

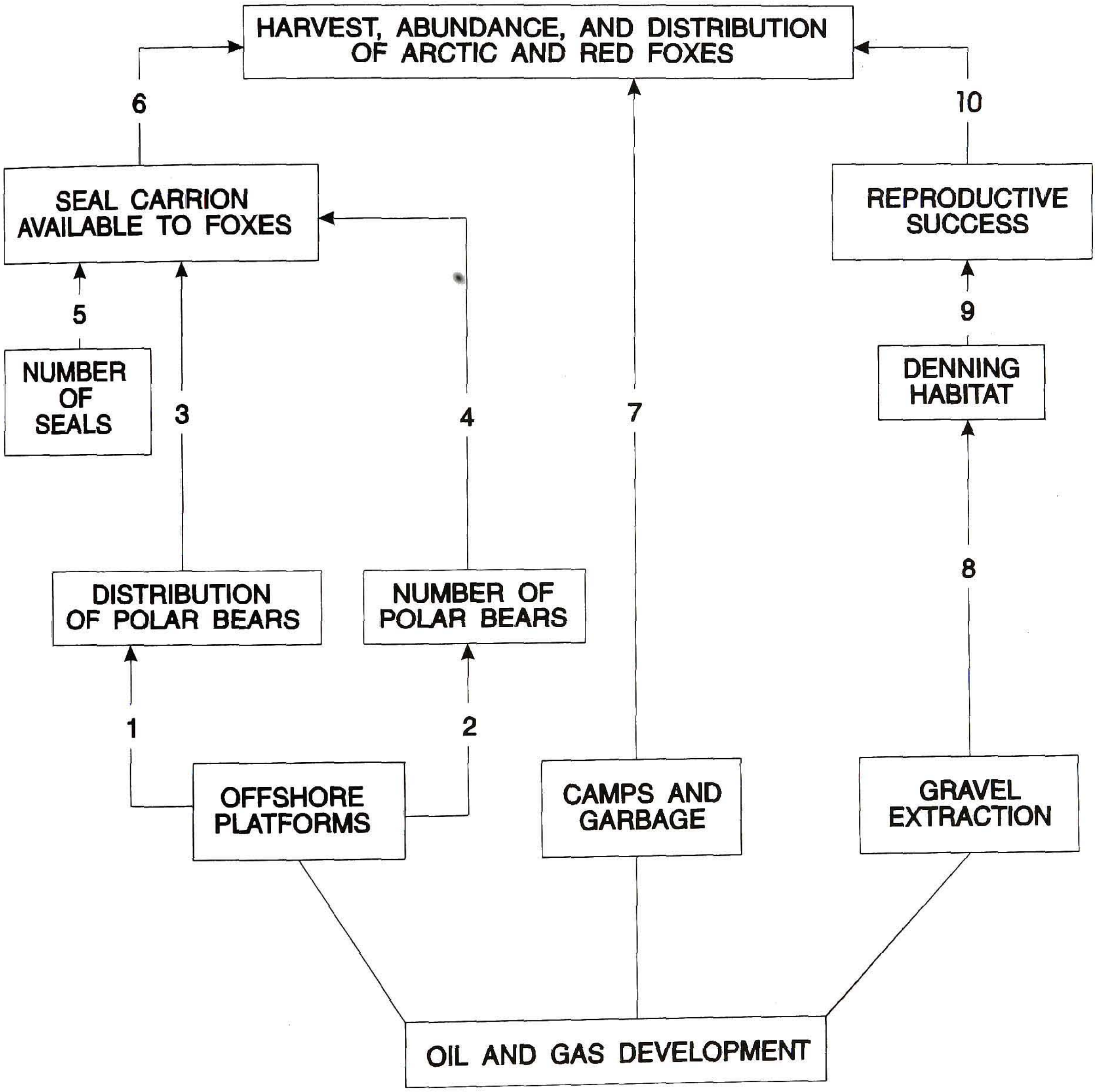
1. Hydrocarbon development in the Beaufort region will require offshore platforms and coastal facilities which may attract polar bears, and ultimately result in a change in polar bear distributions (e.g., avoidance of platforms and human activities) or destruction of problem bears. In turn, resulting changes in polar bear distributions may affect the distribution and numbers of seal kills and the availability of seal carrion to arctic foxes.

2. The presence of camps in coastal areas and associated camp refuse will result in attraction of arctic foxes and red foxes and ensuing problems with problem animals.

3. Developments will require sand and gravel for construction of transportation corridors, extraction facilities and other operational facilities. Because arctic fox and red fox dens are normally associated with fluvial landforms, concern was expressed that gravel extraction will result in loss of denning habitat.

FIGURE 16-1

EFFECTS OF THE PRESENCE OF OFFSHORE DRILLING PLATFORMS, CONSTRUCTION CAMPS (AND ASSOCIATED GARBAGE) AND GRAVEL EXTRACTION ON THE ABUNDANCE OF ARCTIC AND RED FOXES



Linkages

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

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

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

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

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

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

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

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

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

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

MEMP concluded that impacts associated with offshore platforms and camp refuse were possible, but were of low significance given that effects of offshore platforms on polar bears (and seal carrion) would be minimal, and that operational guidelines for camps and field crews had eliminated most problems associated with refuse and feeding of wildlife, respectively.

Since the completion of MEMP and the 1990/1991 BREAM Program (ESL 1991), a number of studies of the physical characteristics of arctic fox dens and den distribution have been conducted along the Yukon coastal plain (e.g., Smits and Jessup 1985; Smits *et al.* 1988; Smits *et al.* 1989a; Smits *et al.* 1989b; Smits and Slough 1991; Smits *et al.* in prep.). Definition of preferred denning characteristics and development of remote-sensing techniques for assessment of denning potential has permitted regional assessment of den availability for arctic fox along the Yukon coastline. A similar approach could be used to assess and identify important denning areas in the eastern Beaufort region. Within the western Beaufort region, Herschel Island was found to have the highest densities of arctic fox dens, whereas the Yukon Coastal Plain had one of the lowest densities.

A recent study by Prestrud (1991) provides additional information on the importance of den availability to overwinter survival of arctic foxes. The study concluded that arctic foxes reduce heat loss and energy needs during winter through several mechanisms, including extended use of snow lairs and permanent dens, particularly during periods of low food availability. This suggests that availability of denning habitat and snow lairs is increasingly important as food availability declines.

Although losses of arctic fox dens are of concern, destruction of a large proportion of the dens within a local or regional area was concluded to be unlikely since careful planning of extraction sites and activities could minimize losses of den sites. However, it was noted during the BREAM workshop that due to the limited availability of gravel in the Mackenzie Delta that economic considerations may limit the planning options to consistently avoid arctic fox dens. The local loss of den sites may be reduced through the ability of arctic foxes to utilize abandoned gravel extraction sites and small artificial gravel sources for den sites (LGL *et al.* 1986). This led to a recommendation that wildlife use of undisturbed and disturbed gravel sites in the Beaufort region be undertaken, and that guidelines for reclamation of gravel sites for wildlife be developed.

EVALUATION OF LINKAGES

Although new information on den characteristics and distributions will allow us to better predict the effects of specific gravel extraction activities on arctic and red foxes, this information will not alter the impact conclusions of MEMP. However, it was suggested that if dens were not destroyed by hydrocarbon activities, that changes in food supplies may result in small, local increases in numbers of arctic fox. Therefore the hypothesis wording was changed to read "will result in a change", rather than a "decrease" in arctic and red fox numbers.

It was also suggested that the relationship between the importance of den availability and food abundance be considered in the hypothesis through refinement of current linkages (i.e. see Linkage 9 above), rather than the development of new linkages or pathways.

ASSESSMENT OF IMPACTS

The wildlife working group during the BREAM workshop concurred with the conclusion of MEMP that impacts of oil and gas development on arctic and red foxes are likely to be insignificant (i.e. local, short-term and mitigable).

RECOMMENDED RESEARCH

The working group recommended that an assessment of wildlife use of abandoned gravel extraction sites, artificial gravel sources and undisturbed fluvial landforms be undertaken to compare the extent and types of wildlife uses of these sites, with the end objective being the development of guidelines to maximize wildlife use of reclaimed gravel extraction sites for wildlife. Guidelines should include preferred specifications for re-contouring, spacing, drainage and re-vegetation.

LITERATURE CITED

ESL Environmental Sciences Limited. 1991. Beaufort region environmental assessment and monitoring program (BREAM). Final report for 1990/1991. Dept. Indian Affairs and North. Develop., Environmental Studies No. 67, Ottawa. 416 p.

LGL Limited, ESL Environmental Sciences Limited, ESSA Environmental and Social Systems Analysts Limited and P.J. Usher Consulting Services Limited. 1986. Mackenzie Environmental Monitoring Project. 1985-1986 Final Report. Prep. for Indian and Northern Affairs Canada. 308 pp. + appendices.

Prestrud, P. 1991. Adaptations by the arctic fox to the polar winter. Arctic 44: 132-138.

Smits, C.C., B.G. Slough, and C.A. Yasui. 1989a. Summer food habitats of sympatric arctic foxes, *Aloplex lagopus*, and red foxes, *Vulpes vulpes*, in the northern Yukon Territory. Can. Field-Nat. 103: 363-367.

Smits, C.C. and C.A.S. Smith and B.G. Slough. 1988. Physical characteristics of arctic fox dens in northern Yukon Territory. Fish and Wildlife Branch, Yukon Department of Renewable resources, Whitehorse, Yukon. 27 pp.

Smits, C.M.M. and R.H. Jessup. 1985. Den distribution, harvest and management of arctic fox in northern Yukon Territory. Prep. for the Northern Oil and Gas Action Program (Project G-15) by Fish and Wildlife Branch, Yukon Department of Renewable Resources, Whitehorse, Yukon. 44 pp.

Smits, C.M.M., B.G. Slough and A. Angerbjorn. 1989b. Abundance and summer occupancy of arctic fox dens in the northern Yukon Territory, 1984-1988. Fish and Wildlife Branch, Yukon Department of Renewable Resources, Whitehorse, Yukon. 37 pp.

BREAM HYPOTHESIS R-17

HYDROCARBON DEVELOPMENT IN THE BEAUFORT REGION AND ROADWAY DEVELOPMENT TO THE YUKON NORTH SLOPE WILL ALTER THE NUMBER OF BARREN GROUND CARIBOU AND THEIR DISTRIBUTION.

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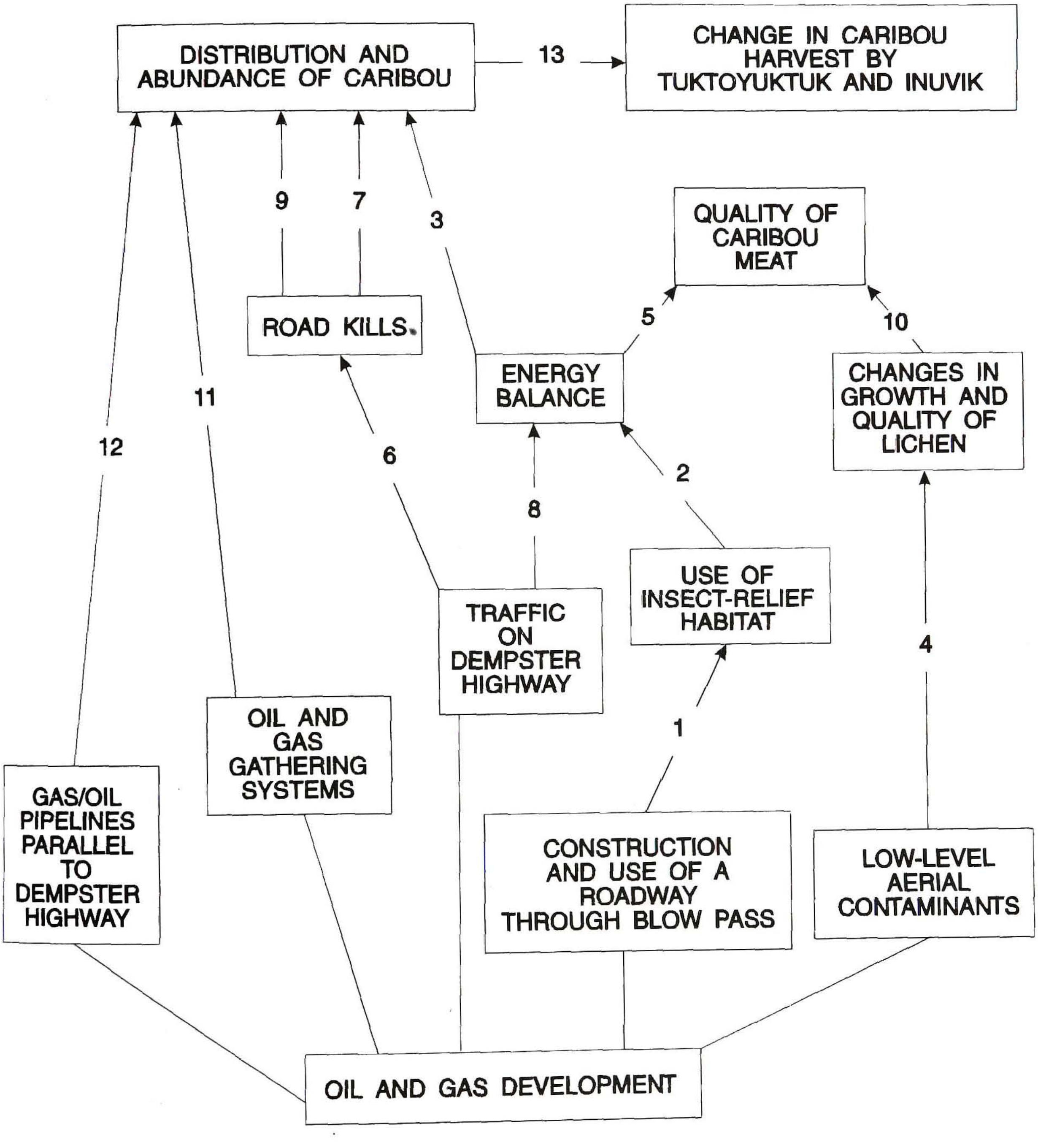
INTRODUCTION

The hypothesis working group concluded that there was a need to re-evaluate MEMP Hypothesis 2 during BREAM as (1) a substantial body of new and relevant information is available on the Porcupine caribou herd, and (2) the scenario for hydrocarbon development as discussed in MEMP has been modified as construction of a roadway to Mount Fitton and King Point is unlikely. However, it was noted that the Yukon Government or other industrial interests may still consider the construction of a roadway through the Richardson Mountains (e.g., Blow Pass) to the Yukon coast to stimulate tourism and industrial developments along the Yukon North Slope. Workshop participants also noted that oil- and gas-gathering systems on the Tuktoyaktuk peninsula, as well as a pipeline along the eastern side of the Mackenzie River, could obstruct some movements of the Bluenose caribou herd during the fall.

Following the completion of MEMP, a substantial amount of research was completed on the summer ecology of the Porcupine caribou herd (Russell and Nixon, in prep.). In addition, computer simulation models of (1) the energy relationships of the Porcupine herd (Kremsater *et al.* 1989), (2) the growth of individual animals (Hovey *et al.* 1989a), and (3) the demographics of the populations (Hovey *et al.* 1989b) provide the capability to better quantify the impacts of hydrocarbon development on caribou. Additional information is available on behaviour and group dynamics of caribou during the insect relief period (Nixon 1991), the

FIGURE 17-1

EFFECTS OF INCREASED TRAFFIC ON THE DEMPSTER HIGHWAY AND ROADS ON THE NORTH SLOPE ON THE ABUNDANCE AND DISTRIBUTION OF CARIBOU



Linkages

1. Construction and use of a roadway through the Blow Pass region to the Yukon North Slope will prevent animals in the Porcupine caribou herd from reaching insect-relief areas in the northern Richardson Mountains in late July and early August.

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.

3. Lower energy levels will result in poorer body condition in adults, decreased calving success, lower calf survival, and therefore lower numbers of caribou.

4. Air emissions associated with local hydrocarbon facilities, as well as external industrial sources, will result in long-term, low-level contamination of vegetation and soil which may result in changes in the growth, distribution and quality of caribou forage, particularly lichens.

5. Decreased animal fat levels will reduce the quality of caribou meat.

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

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

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

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

10. Changes in the quality, growth and distribution of vegetation, particularly lichens, will alter the quality of caribou meat.

11. Gathering systems for gas and oil on the Tuktoyaktuk peninsula and along the east side of the Mackenzie River will obstruct movements of the Bluenose caribou herd to parts of the late fall range.

12. Construction and operation of an above-ground gas pipeline parallel to the Dempster Highway will obstruct movements of the Porcupine caribou herd and prevent access to portions of the winter range.

13. Changes in distribution of the Bluenose caribou herd will affect the caribou harvest from Tuktoyaktuk and Inuvik.

influence of weather on caribou movements (Eastland 1991), range ecology (Russell *et al.* 1991), nutrient partitioning (Allaye-Chan 1991), and the relationship between body condition and reproductive success (Gerhart *et al.* 1992). A comprehensive literature review of impacts of human developments and land use on caribou has also been completed (Shideler 1986a and 1986b).

A number of changes to the MEMP Hypothesis No. 2 were suggested by the workshop participants to reflect the current state of knowledge of the most likely development scenarios and recent advances in caribou research. Important changes are noted below:

- As noted above, project development scenarios for future hydrocarbon development in the BREAM study area will not require the construction of a road to Mount Fitton or King Point, but there is potential for the Yukon Government and/or other tourism/industrial interests to support the construction of a roadway through the Richardson Mountains. It was therefore concluded that MEMP Link 1 should be replaced by a more generic term such as "construction and use of a roadway through the Blow Pass region".

- MEMP Link 4 was eliminated as parasites would affect the condition of spring hides, whereas fall hides are the primary source of hides for traditional use (J. Charlie, pers. comm.). As hide recovery generally appears to supercede fat deposition (D. Klein, pers. comm.), poor quality fall hides are very uncommon, even in years with apparently high insect infestation problems (J. Charlie, pers. comm.).

- Although insect harassment may affect animal fat levels and the quality of caribou meat (MEMP Link 5), hide quality is unlikely to be affected (see above). Therefore, hide quality was deleted from the linkage statement.

- As the road inland from King Point is unlikely, Link 10 was eliminated.

- Two new linkages were added linking air emissions with low-level contamination of vegetation, particularly lichens (new Link 4), and changes in the quality of caribou meat associated with changes in vegetation (new Link 10).

- A new linkage (new Link 11) was added to address the potential effects of above-ground gathering systems and pipelines along the Tuktoyaktuk peninsula and the east side of the lower Mackenzie River on fall movements and habitat use by the Bluenose caribou herd.

- Effects of an above-ground pipeline parallel to the Dempster Highway on winter movements and habitat use by the Porcupine caribou herd were addressed in a new linkage (new Link 12).
- Effects of changes in the distribution of the Bluenose caribou herd on the caribou harvest from Tuktoyaktuk and Inuvik were addressed in a new linkage (new Link 13).

EVALUATION OF LINKAGES

The Wildlife Working Group identified seven major impact pathways through which oil and gas development in the BREAM study area may affect caribou:

1. Obstruction or delays in summer movements by the Porcupine caribou herd to escape terrain from insect harassment and negative effects on their summer and fall energy balance.
2. Obstruction or delay of movements by the Porcupine caribou herd to southern portions of their winter range (south of the Dempster Highway) and negative effects on their winter energy balance.
3. Reductions in the quality of caribou meat as a result of negative effects on energy balance.
4. Reductions in the abundance of caribou as a result of increased road kills.
5. Changes in the quality and availability of caribou forage as a result of long-term, low-level contamination of vegetation and soil, and resultant changes in caribou body condition and meat quality.
6. Changes in the distribution of the Bluenose caribou herd as a result of pipeline-gathering systems on the Tuktoyaktuk peninsula and adjacent river corridor.
7. Obstruction of movements by the Porcupine caribou herd to the southern portion of their winter range as a result of the construction and operation of the Dempster lateral pipeline.

Impact linkages associated with each of these impact pathways are discussed below.

Link 1. Construction and use of a roadway through the Blow Pass region to the Yukon North Slope will prevent animals in the Porcupine caribou herd from reaching insect-relief areas in the northern Richardson Mountains in late July and early August.

If a roadway was built north through the Richardson Mountains to the Yukon North Slope, it is assumed that it will be a permanent, all-weather road. The primary concern is that a roadway through the Richardson Mountains, particularly in the Blow Pass area, would obstruct or delay caribou movements from the British Mountains to insect relief habitat in the Richardson Mountains. Insect densities and the level of harassment have been demonstrated to affect the distribution of caribou and their level of awareness (Nixon 1991). During periods of fog, when the insect problem is reduced, caribou will move inland from the coastline (where climatic conditions and the availability of water tends to reduce the level of insect harassment) to utilize better quality forage. Caribou also tend to be more alert when insect harassment is low.

Monitoring studies of the movements and distribution of the Central Arctic herd in relation to the Prudhoe Bay oil development have shown that roads can delay caribou movements to insect escape terrain (D. Klein, pers. comm.). The extent of the delay is influenced by the age and sex of the animal, the intensity of insect harassment, and the volume/frequency of traffic. Conditions which appear to inhibit movements by caribou to escape terrain from insects include (D. Klein, pers. comm.; D. Russell , pers. comm.):

- Females with young tend to not cross roads in open, flat terrain, perhaps due to the lack of hiding cover and an increased risk of exposure to natural predators (e.g., wolves, grizzly bear) and man. R. Cameron found that females with young may avoid roads by distances of up to 5.6 km (3.5 miles) (D. Klein, pers. comm.).
- Large groups of caribou tend to be less affected than smaller groups.
- If caribou have been recently hunted by man, they tend to be more reluctant to cross than unhunted animals.

- The physical movement of traffic, particularly large volumes of traffic or frequent traffic, appears to inhibit movements. If vehicles are stationary, large aggregations of caribou will often cross the roadway. Vehicle noise does not appear to be a problem, particularly if noise levels are constant.

- Road dust also inhibits movements; high dust inhibits crossing, perhaps due to a reduction in the line of sight of caribou (i.e., a visual disturbance).

It was recommended by the Wildlife Working Group that ongoing research on the effects of insect harassment on body condition, and the effects of body condition on productivity (e.g., fertility, conception and prenatal survival) be supported. A study is slated to begin on the Central Arctic herd during summer 1992 (D. Klein, pers. comm.). A similar study on the Porcupine caribou herd will also be funded through NOGAP (see Recommended Research). There is also a need to assess differences in the density of parasitizing insects in relation to seasonal variables (e.g., climate, terrain) in order to predict periods of high insect harassment. It was also recommended that studies of the ecology of parasitizing insects, other than mosquitoes, be completed in order to better understand the insect harassment problem and its effects on caribou.

Link 1 is valid.

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.

As noted above, reduced access by caribou to escape terrain from insect harassment can affect the distribution and behaviour of caribou (Nixon 1991). Effects on caribou can include (D. Klein, pers. comm.; D. Russell, pers. comm.):

- increased energy expenditures by caribou in avoiding insects;

- decreased energy intake due to the increased amount of time spent avoiding insects, as well as displacement of caribou to ranges with lower quality forage;

- if reduced energy intake results in poor condition in calves during the fall and early winter, overwinter mortality of calves (yearlings) will increase;
- with reduced energy intake during the late spring and summer, adult caribou may enter the rut in poor body condition. This may result in reduced fertility and conception, and increased overwinter mortality of adults which, in turn, will reduce caribou numbers and productivity; and
- if access to insect relief areas is prevented, it is possible that the Porcupine herd would move from the British Mountains into the South Brooks range rather than into the Richardson Range.

Changes in animal distributions or animal quality may affect the harvest by local residents. This may result in increased harvests of other species such as moose (J. Charlie, pers. comm.).

Link 2 is valid.

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

As discussed in MEMP, increased parasite loads have been documented to reduce body condition of adult animals (i.e. low fat reserves), fertility , conception, and the condition of calves entering their first winter. Overwinter survival of adult caribou and calves may therefore be reduced. Reduced fertility and conception will result in poorer calf production the following year. It was noted that quality of summer range directly affects calf condition and conception (and ultimately birth rates), whereas the quality of winter range affects overwinter survival of fetuses and young-of-the-year (D. Klein, pers. comm., D. Russell, pers. comm.).

Link 3 is valid.

Link 4. Air emissions associated with local hydrocarbon facilities, as well as external industrial sources will result in long-term, low level contamination of vegetation and soil which may result in changes in the growth, distribution and quality of caribou forage, particularly lichens.

Concern was raised that long-term, low-level contamination of vegetation and soil from local hydrocarbon facilities (e.g., compressor stations, pipelines, drill pads, producing wells), and long-range air transport of pollutants from distant industrial and urban sources would affect the quality of lichens and other vegetation. Long-term monitoring studies of vegetation quality are currently underway in the central Alaska North Slope (D. Klein, pers. comm.). Evidence from studies in Canada (e.g., Pritchard), Siberia (e.g., Lasova), and Finland (e.g., Helle) indicate that lichen growth, species abundance and distribution are affected by certain aerial pollutants such as SO_x and NO_x (D. Klein, pers. comm.). Although effects of these changes in lichen growth on the availability of caribou forage have not been quantified, Link 4 was assumed to be valid.

It was recommended that the potential for aerial contamination of vegetation and soil in the BREAM study area be assessed. In addition, long-term monitoring sites should be established and assessed on a regular basis to assess chronic, low-level contamination of vegetation and soil through long-range transport of aerial pollutants from distant industrial and urban sources (see Recommended Research).

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

Traditional hunting of caribou occurs primarily in the fall during the southward migration of caribou to wintering areas, as well as in the spring during the northward migration to the calving grounds (J. Charlie, pers. comm.). Greater numbers of caribou are harvested during years when animals are in good condition (i.e. high fat deposition) (J. Charlie, pers. comm.). Link 5 is valid.

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

As discussed in MEMP, Link 6 is valid. Observations of caribou in Canada and Alaska in relation to roadways have indicated that during periods of deep snow, caribou may utilize road corridors to move between seasonal ranges (D. Klein, pers. comm.; D. Russell, pers. comm.). High snow berms along roadways may funnel animals along roadways, as well as restrict or prevent animals from leaving the roadway. It was noted that the Porcupine herd traditionally used winter ranges to the south of the Dempster Highway, particularly during winters of high snow, but presently overwinters on ranges to the north of highway. Interactions between caribou and vehicles on the Dempster Highway have therefore been reduced.

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

Link 7 is inherently valid. However, road kills were not considered to be a significant mortality factor for caribou.

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

Studies of the Porcupine caribou herd in relation to the Dempster Highway were conducted during the mid-1970s to mid-1980s (Surrendi and deBock 1976; Horejsi 1981; Russell and Martell 1985). These studies suggest that although caribou do react to traffic by running, the overall activity patterns of caribou do not appear to be affected. However, traffic levels on the Dempster Highway at this time were light, as were hunting pressures by native and recreational hunters (D. Russell, pers. comm.). Recent observations of the Porcupine caribou herd suggests that animals are avoiding the highway more now than they did previously (D. Russell, pers. comm.). This may reflect heavier traffic volumes, as well as higher levels of hunting adjacent to the highway. It was recommended that a study of caribou-activity patterns relative to the highway and hunting pressures be conducted (see Recommended Research). Link 8 was concluded to be valid.

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

As noted above, recent observations of caribou in relation to the Dempster Highway suggest that caribou may be avoiding the highway corridor more now than during the mid 1970s to 1980s. Increased traffic volumes, as well as increased hunting pressure within the highway corridor is thought to have influenced movements by the Porcupine caribou herd to the winter ranges south of the highway (D. Russell, pers. comm.). Factors that appear to deter crossings of highways by caribou include:

- small groups sizes (large groups cross more readily than small groups),
- female-calf pairs,
- open areas as opposed to treed cover,
- higher traffic volumes and frequencies,
- hunting pressure, including snowmobile access, and
- high snow berms along highway (D. Klein, pers. comm.; D. Russell, pers. comm.).

As noted in Link 8, it was recommended that a study of caribou activity patterns in relation to the highway be conducted in areas with and without hunting pressures.

Link 9 was concluded to be valid.

Link 10. Changes in the quality, growth and distribution of vegetation, particularly lichens, will alter the quality of caribou meat.

It is reasonable to assume that changes in the quality and quantity of caribou forage will affect the body condition of caribou, and perhaps the quality of caribou meat. However, no information is available on which to quantify the significance of this impact. Link 10 was assumed to be valid.

Link 11. Gathering systems for gas and oil on the Tuktoyaktuk peninsula and along the east side of the Mackenzie River will obstruct movements of the Bluenose caribou herd to parts of the late fall range.

Under a probable development scenario for oil and gas development in the Beaufort region, it is likely that gathering pipelines would be constructed along the Tuktoyaktuk peninsula and the adjacent Mackenzie River valley to carry a mixture of gas and condensate (R. Owens, pers. comm.). Gathering pipelines are usually in clustered arrangements (i.e., several parallel pipes), are above ground and would likely operate at temperatures above freezing. Once the gas is cleaned, it would be transported in a larger pipeline that may include a combination of above-grade and below-grade sections. In new portions of the delta, the pipeline likely would be placed on low-level gravel berms or platforms, and may obstruct movements by caribou and other wildlife unless crossing sites are provided by elevated sections of pipe and earthen berms over the pipe.

Concern was raised that pipeline gathering systems on the Tuktoyaktuk peninsula and along the Mackenzie River will obstruct movements of the Bluenose caribou herd during the late fall (F. Pope, pers. comm.). Because the gathering pipelines would only affect the periphery of the fall range of this herd, obstructions of movements were concluded not to be significant to the overall survival or productivity of the herd. However, changes in the fall distribution of the herd might affect access by residents of Tuktoyaktuk and Inuvik to caribou during the fall hunt.

Link 11 is valid.

Link 12. Construction and operation of an above-ground gas pipeline parallel to the Dempster Highway will obstruct movements of the Porcupine caribou herd and prevent access to portions of the winter range.

The Dempster gas pipeline would only be constructed if the Alaska Highway gas pipeline was completed (R. Owens, pers. comm.). The Dempster lateral would be a large-diameter pipeline and would parallel the highway (i.e. within several hundred metres) in most areas. It would be buried in most places, except in short sections across river valleys. In below-grade sections, no above-ground berming would be used, although roaching would be left to allow for subsidence. Reclamation (reseeding) would also be done in winter. Above-ground sections would likely be placed on continuous gravel berms, several metres in height.

Within the range of the Porcupine caribou herd, it is expected that most of the pipeline would be buried. Obstruction of caribou movements would therefore only potentially occur during the construction period. Current development plans recommend .the restriction of pipeline construction, in areas where caribou traditionally cross, to periods when caribou are not present. The overall construction timeframe for the pipeline would be two years in order to allow for completion of some sections following the main construction year.

It was concluded that it is possible for the Dempster Highway pipeline to delay or obstruct the movements of the Porcupine caribou herd, particularly during construction, but that environmental protection measures (i.e. avoidance of temporal overlap with caribou movements) would be effective in eliminating the impact.

Link 13. Changes in distribution of the Bluenose caribou herd will affect the caribou harvest from Tuktoyaktuk and Inuvik.

As described in Link 11, changes in the fall distribution of the Bluenose caribou herd would likely reduce the accessibility of caribou to resident hunters from Tuktoyaktuk and Inuvik (F. Pope, pers. comm.). Link 13 is valid.

ASSESSMENT OF IMPACTS

The Wildlife Working Group separately assessed the impact significance for each of the seven impact pathways described earlier:

1. Obstruction or Delays in Summer Movements

If a road to King Point or an alternate road that affects Blow Pass are constructed, it is expected that the effects would be significant (i.e. affecting a major portion of an internationally important species for a long period). The impact could be reduced through control or prohibition of road traffic during the period of caribou movements, but such control was not thought to be feasible.

2. Obstruction or Delays in Winter Movements

If small-scale hydrocarbon development proceeds, increases in road traffic are anticipated to be marginal. As a result, caribou movements would likely not be affected or would only be delayed for short periods (e.g., hours). Impacts would therefore be insignificant.

In contrast, if development involved large-scale projects and large increases in traffic volumes, particularly during winter, caribou movements could be delayed or, in a worst case, prevented. Changes in energy balance and subsequent effects on overwinter survival and calf production would be significant (i.e. affecting a major portion of an internationally important species for a long period).

Mitigation of this impact would require (1) regulation of winter road traffic during periods of caribou movements (e.g., road closures, convoys); and (2) regulation of subsistence and recreational hunting adjacent to the road corridor.

3. Reductions in the Quality of Caribou Meat

Changes in the summer/fall and overwinter energy balance of caribou would directly affect meat quality (i.e. fat content) during the fall and spring hunts, respectively. Effects, be they real or perceived, would be significant (i.e., affecting the entire annual hunt). Mitigation, other than compensation, would not be possible.

4. Increased Road Kills

As road kills are expected to account for only a small portion of the annual mortality of caribou, impacts of road kills were concluded to be insignificant (i.e. a very small portion of the population for a long period of time).

5. Changes in the Quality and Availability of Caribou Forage

Impact is unknown. Insufficient information is available on which to assess this impact.

6. Changes in the Distribution of the Bluenose caribou herd

Changes in the fall distribution of the Bluenose herd as a result of pipeline gathering systems on the Tuktoyaktuk peninsula and adjacent river corridor would have no significant impact on the herd (i.e. impact would affect only a small portion of the population, be site specific and long term). Impacts could be mitigated through use of earthen berms and/or raised pipe to promote cr

In contrast, the impact on harvesting of caribou by residents of Inuvik and Tuktoyaktuk would be significant (i.e. affecting a large portion of the regional harvest over the long-term). Impacts could be mitigated through use of methods to promote crossing of the pipeline systems by caribou and hunters.

7. Obstruction of Movements by the Dempster Lateral Pipeline

As most of the pipeline would be buried, movements would only be obstructed during construction. Because pipeline construction in the vicinity of traditional crossing areas will only occur during periods when caribou are not present, obstruction of movements during construction would likely not occur.

RECOMMENDED RESEARCH

Eight research requirements for caribou were identified by the Wildlife Working Group. However, as described below, two of these research projects are currently underway and are funded. Four of the remaining six research needs, although important to a better understanding of caribou ecology and the long-term impacts of industrial and human activities on caribou, were concluded to be outside the current scope of BREAM. Each of these research requirements are described below.

Research Need 1: Effects of Insect Harassment on Body Condition

The working group identified the need to quantify the effects of insect harassment on the body condition of caribou, and the ultimate effect of these changes on production (e.g., fertility, conception, and pre-natal condition and survival).

The Central Arctic herd in the vicinity of the Prudhoe Bay development provides a good opportunity to assess effects of insect harassment as the herd has been divided into two groups by the Alyeska pipeline. The group to the west of the pipeline is directly affected by development and has had access to insect-relief areas reduced, whereas the group in the east has unrestricted access to insect-relief terrain (D. Klein, pers. comm.). A live capture and radiotelemetry study of caribou is planned to begin during summer 1992 to measure body size and condition prior to and after the insect season. Calf survival will also be assessed throughout the insect season. A similar study of animals in the Porcupine herd is planned to provide comparative data on animals not exposed to hydrocarbon development. Funding for two years of this latter study has been provided through NOGAP.

The proposed research is expensive, but addresses the importance of insect-relief habitat, and the potential effects to caribou of interfering with movement to insect-relief habitat. The study would require 3 to 5 years, but results would be applicable over a long-time period. As the study is underway and already funded, it was not considered as a research priority for the BREAM Program.

Research Need 2: Insect Ecology in Relation to Harassment of Caribou

The Working Group identified the need for research to determine the factors that influence the distribution and abundance of parasitic insects, and the degree of insect harassment to caribou. The study should address mosquitoes, as well as warble and bot flies. A suite of sample sites should be established to correlate environmental variables to insect densities and the level of harassment to caribou. Some research for mosquitoes has already been completed (Nixon 1991).

This study was rated by Workshop participants as the second highest research priority for caribou. Information from this research would allow the identification/prediction of cumulative effects of factors that result in changes in the level of insect harassment to caribou. In turn, this information is important in understanding the effects of delaying or obstructing caribou movements to insect relief areas (i.e. changes in caribou body condition, and the effects of these changes in body condition on production and survival).

Research Need 3: Effects of Hunting Pressure on Caribou Responses to Roads

Based on recent observation of the responses of the Porcupine caribou herd to the Dempster Highway and hunting pressures along the highway corridor, information is required on effects of the highway and hunting on crossings of the highway by caribou, caribou activity budgets and energy balance.

It was recommended that caribou movements and activities in areas adjacent to and away from the highway corridor be monitored through radiotelemetry and direct observation. It would also be useful to monitor caribou responses in relation to the highway in an area where snowmobile-based hunting does not occur. The latter would require cooperation from hunters which traditionally hunt the Porcupine herd. Movements and activity budgets would be compared between the four types of areas (highway corridor - hunting, highway corridor - no hunting, control area - hunting, control area - no hunting).

The study would be expensive to conduct and would require 3 to 5 years of data for adequate comparison relative to environmental variability. However, information from this research would be useful over the long term in assessing potential impacts of highways and hunting on caribou movements and energy balance.

This study was rated as the highest priority research requirement for caribou.

Research Need 4: Winter Habitat Quality

In order to understand the implications of changes in the seasonal distribution of caribou and the implications of reduced access to specific parts of the range, there is a need to assess habitat quality and caribou habitat use on a regional scale. Research to address this data need is currently being completed by the Canadian Wildlife Service (D. Russell, pers. comm.).

Radio-collared caribou are being relocated over short-time intervals using a global positioning system (GPS). Habitat use is then being related to habitat conditions within specific areas of the caribou range. Habitat conditions include both physical and biological parameters such as amount of snow fall, snow depth, vegetation composition and mosaic.

Information from this study is important in assessing the potential effects of obstructing caribou movements to specific portions of their traditional range. As research is currently underway and funded, it was not considered as a research priority for the BREAM Program.

Research Need 5: Assessment of Long-Term Responses of Caribou to Roadways

It is not known how long-term distributions of the Porcupine caribou herd within their traditional winter range have been affected by the construction and operation of the Dempster Highway. Although such information is of importance in assessing the impacts of hydrocarbon development on caribou, it would be extremely difficult to separate the effects of environmental factors (climate, vegetation) and man-caused disturbances (traffic, hunting, snowmobiles) on the long-term distribution and habitat use of caribou. The Working Group concluded that this research was not capable of being done. (Note: Research described in research need 3 on caribou responses to roadways relates to short-term behavioural and energetic effects [e.g., activity budgets, avoidance of the highway corridor], whereas research need 5 addresses long-term regional changes in habitat use).

Research Need 6: Pollution Effects on Vegetation

Although the Beaufort Sea gas is very sweet (i.e. contains almost no sulphur), concern was expressed that sulphur fallout may be significant over the medium to long term due to the large volume of gas that may be processed. As a result, there is a need to assess the potential for sulphur fallout/washout and subsequent long-term, low-level contamination of soils and vegetation. Other compounds of concern include methane, carbon dioxide and nitrous oxides.

It was also recommended that a monitoring program be established to monitor concentrations of sulphur oxides and nitrous oxides, and relate fallout/washout of these compounds to plant growth and distributions. Over the long term, such monitoring would help assess changes in the quality and availability of caribou range, and to make predictions regarding potential changes in carrying capacity for caribou (see Research Need 7).

Research Need 7: Monitoring of Caribou Range

It was recommended that permanent, long-term monitoring sites be established to assess changes in range quality for caribou associated with cumulative effects of global climate change and long range transport of contaminants. An international program has been initiated to establish long-term monitoring sites in Alaska and Russia (D. Klein, pers. comm.).

The range monitoring program is an important baseline biological study, but was considered to be outside the current scope of the BREAM Program. However, should range monitoring be initiated by oil and gas interests, the sites should be linked to the circumpolar effort to establish a long-term range monitoring network.

Research Need 8: Bioaccumulation

Workshop participants identified the need to monitor levels of potential contaminants and to develop transport/fate modelling to determine how uptake of these contaminants by caribou may occur. Such research specific to caribou was considered to be outside of the current scope of the BREAM Program. However, if transport/fate modelling of contaminants was identified as a research need for other hypotheses, inclusion of potential bioaccumulation effects in caribou should be considered.

LITERATURE CITED

Allaye-Chan, A.C. 1991. Physiological and ecological determinants of nutrient partitioning in caribou and reindeer. Ph.D. Thesis, University of Alaska, Fairbanks, Alaska. 135 pp.

Bissel, H.J. and G.V. Chilingarian. 1975. Subsidence. In: G.V. Chilingarian and K.H. Wolfe (Eds.). Compaction of coarse-grained sediments, I. Elsevier, Amsterdam, pp. 167-245.

Eastland, W.G. 1991. Influence of weather on movements and migrations of caribou. Ph.D. Thesis, University of Alaska, Fairbanks, Alaska. 111 pp.

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. pp. 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, pp. 69-80.

Gerhart, K.L., R.G. White and R.D. Cameron. 1992. B. Application of *in vivo* techniques to determine body composition in caribou. Pages 298 to 313 in Annual report of the united States Fish and Wildlife Service, 1002 Studies 1991/92.

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

Horejsi, B.L. 1981. Behavioural responses of barren ground caribou to a moving vehicle. Arctic 34: 1980-1985.

Hovey, F.W., L.L. Kremsater, R.G. White, D.E. Russell, and F.L. Bunnell. 1989a. Computer simulation models of the Porcupine Caribou Herd: II. Growth. Technical Report Series No. 54. Pacific and Yukon Region, Canadian Wildlife Service, 16 pp. + appendices.

Hovey, F.W., D.E. Russell, F.L. Bunnell, R. Farnell, and K.R. Whitten. 1989b. Computer simulation models of the Porcupine Caribou Herd: III. Harvest. Technical Report Series No. 55. Pacific and Yukon Region, Canadian Wildlife Service, 10 pp. + appendices.

Kremsater, L.L., F.W. Hovey, D.E. Russell, R.G. White, F.L. Bunnell, and A.M. Martell. 1989. Computer simulation models of the Porcupine Caribou Herd: I. Energy. Technical Report Series No. 53. Pacific and Yukon Region, Canadian Wildlife Service, 14 pp. + appendices.

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. pp. 73-85

Martin, J.C. and S. Serdengecti. 1984. Subsidence over oil and gas fields. pp. 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. pp. 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.

Nixon, W.A.C. 1991. Group dynamics and behaviour of the Porcupine caribou herd during the insect season. M.Sc. Thesis, University of Alaska, Fairbanks, Alaska. 109 pp.

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 pp. 509-516.

Ricke III, H.H. and G.V. Chilingarian. 1974. Compaction of argillaceous sediments. Elsevier, Amsterdam. 424 pp.

Russell, D.E. and A.M. Martell. 1985. Influence of the Dempster Highway on the activity of the Porcupine caribou herd. Pages 22 to 26 in A.M. Martell and D.M. Russell (eds.) Caribou and human activity. Proc. 1st North American Caribou Workshop. Whitehorse, Yukon. Canadian Wildlife Service Spec. Publication, Ottawa. 68 pp.

Russell, D., A.M. Martell and W.A.C. Nixon. 1991. Range ecology of the Porcupine caribou herd in Canada. Canadian Wildlife Service, Whitehorse, Yukon Territory. 22 pp.

Shideler, R.T. 1986a. Impacts of human developments and land use on caribou: a literature review. Volume I. Worldwide perspective. Technical Report No. 86-2. Alaska Dept. of Fish and Game, Juneau, Alaska. 219 pp.

Shideler, R.T. 1986b. Impacts of human developments and land use on caribou: a literature review. Volume II. Impacts of oil and gas development on the Central Arctic Herd. Technical Report No. 86-3. Alaska Dept. of Fish and Game, Juneau, Alaska. 128 pp.

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

Surrendi, D.C. and E.A. de Bock. 1976. Seasonal distribution, population status and behaviour of the Porcupine caribou herd. Prep. for the Mackenzie Valley Pipeline Investigations by the Canadian Wildlife Service, Edmonton. 144 pp.

BREAM HYPOTHESIS R-18

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.

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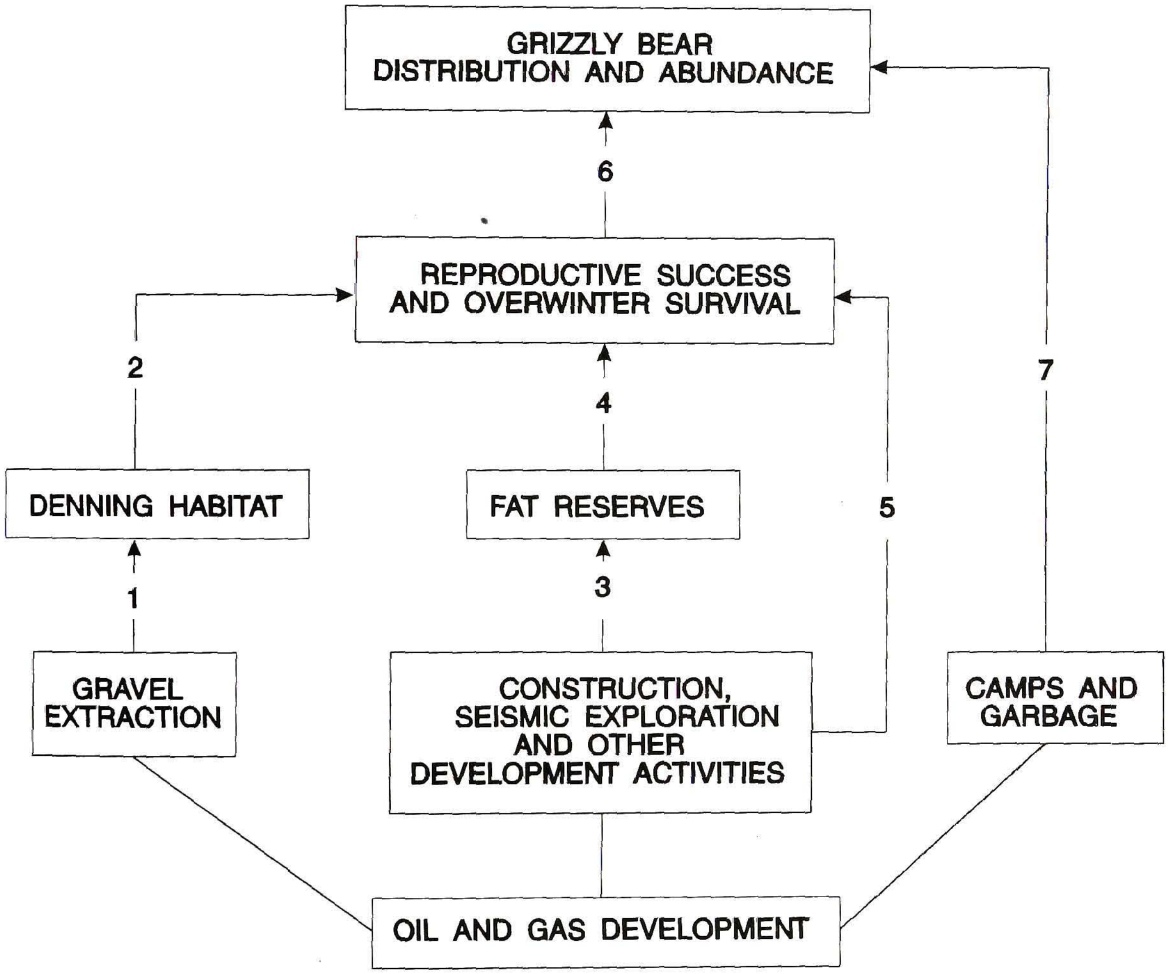
INTRODUCTION

Future development of hydrocarbon resources in the Beaufort and Mackenzie regions will overlap areas inhabited by grizzly bears (*Ursus arctos*) on a seasonal or year-round basis. As described during MEMP, there is potential for gravel extraction, seismic exploration, other development activities, and the presence of camps and garbage to result in decreases in the abundance of grizzly bears and changes in the distribution of this species.

The 1990/1991 BREAM Program (ESL 1991) identified a substantial body of new information of relevance to this hypothesis. During the mid to late 1980s, a study of grizzly bears on Inuvialuit lands was initiated by the Wildlife Management Advisory Council (N.W.T.) to collect information on demographics, distributions, movements and habitat use, as well as information on hunter kills (Clarkson and Liepins 1989a, 1989b, 1991a). A comprehensive review of information on grizzly bear biology and management was also completed for the Yukon North Slope (Nagy 1990). Recommendations for grizzly bear harvest and management were developed for the Inuvialuit Settlement Region and adjacent Gwich'in lands (Clarkson and Liepins 1991b). The Alaska Department of Fish and Game has also initiated a two-phase study to gather baseline information on bear use in the North Slope oilfields (Phase I), and assess the responses of grizzly bears to aversive conditioning as a management strategy (Phase II)

FIGURE 18-1

EFFECTS OF GRAVEL EXTRACTION, CONSTRUCTION, SEISMIC EXPLORATION AND OTHER DEVELOPMENT ACTIVITIES, AND THE PRESENCE OF CAMPS AND GARBAGE ON THE ABUNDANCE AND DISTRIBUTION OF GRIZZLY BEARS



Linkages

1. Gravel extraction will remove denning habitat.

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

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.

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

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.

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

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.

(Shideler and Hechtel 1991).

EVALUATION OF LINKAGES

Although new information is available on the baseline status of grizzly bears in the BREAM study area, as well as the responses of grizzly bears to oilfield development, the Wildlife Working Group concluded that this information would not alter the validity of linkages as discussed by MEMP (LGL *et al.* 1986). It was noted by J. Nagy (pers. comm.) during the final plenary of the BREAM workshop that during recent surveys of grizzly bear populations and habitat use in the Beaufort and Mackenzie regions that (1) no grizzly bear dens were located in gravel deposits, and (2) to date, disturbance of active grizzly bear dens by gravel extraction activities have not been documented. The validity of Link 1 (i.e. gravel extraction will remove denning habitat) may therefore be questioned.

ASSESSMENT OF IMPACTS

The Wildlife Working Group during the BREAM Workshop concurred with the conclusions of MEMP that effects of hydrocarbon development on grizzly bear populations such as control of nuisance animals and loss of denning habitats could be significant, but that environmental protection planning could reduce or eliminate these impacts.

RECOMMENDED RESEARCH

The ongoing study of the effectiveness of aversive conditioning in deterring bears from the Prudhoe Bay development area is of direct relevance to hydrocarbon development in the BREAM study area. If the aversive conditioning techniques are effective, they should be considered for use in the Beaufort and Mackenzie regions.

LITERATURE CITED

Clarkson, P. and I. Liepins. 1989a. Inuvialuit Wildlife Studies. Grizzly bear research progress report, 1987-88. Technical report No. 3. Wildlife Management Advisory Council (N.W.T.). 47 pp.

Clarkson, P. and I. Liepins. 1989b. Inuvialuit Wildlife Studies. Grizzly bear research progress report, 1988-89. Technical report No. 8. Wildlife Management Advisory Council (N.W.T.). 25 pp.

Clarkson, P. and I. Liepins. 1991a. Inuvialuit Wildlife Studies. Grizzly bear research progress report, 1989-91. Department of Renewable Resources, Inuvik, M.W.T. 25 pp.

Clarkson, P. and I. Liepins. 1991b. Grizzly bear harvest and management summary for the Inuvialuit Settlement region and adjacent Gwich'in lands, 1987-91. Department of Renewable Resources, Inuvik, N.W.T. 21 pp.

ESL Environmental Sciences Limited. 1991. Beaufort Regional Environmental Assessment and Monitoring Program (BREAM). Final report for 1990/1991. Indian and Northern Affairs Canada. Environmental Studies No. 67. 416 pp.

LGL Limited, ESL Environmental Sciences Limited, ESSA Environmental and Social Systems Analysts Limited and P.J. Usher Consulting Services Limited. 1986. Mackenzie Environmental Monitoring Project. 1985-1986 Final Report. Prep. for Indian and Northern Affairs Canada. 308 pp. + appendices.

Nagy, J.A. 1990. Biology and management of grizzly bear on the Yukon North Slope. Yukon Renewable Resources, Fish and Wildlife Branch, Whitehorse, Yukon Territory. 68 pp.

BREAM HYPOTHESIS R-19

WATER WITHDRAWALS FROM HYDROCARBON DEVELOPMENT AND LAND SUBSIDENCE AND DRAINAGE BARRIERS RESULTING FROM LINEAR CORRIDORS WILL CHANGE THE POPULATION CHARACTERISTICS OF BIRDS, SEMI-AQUATIC FURBEARERS AND FISH

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INTRODUCTION

The original MEMP hypothesis (MEMP 4), which dealt with the effects of water withdrawal and creation of physical drainage barriers on muskrat, was considered to be invalid or inconsequential (LGL *et al.* 1986). It was assumed that water required for hydrostatic testing, water injection and human consumption would be available from large water bodies or would be obtained from areas of poor muskrat habitat. Therefore, no significant decreases in the Mackenzie Delta muskrat population were expected. While the distribution of floodwaters in the outer delta could be influenced by the creation of physical barriers such as pipeline berms and access roads, the MEMP working group concluded that areas of the outer delta such as between Taglu to Niglintgak and/or Adgo are not typically used for the harvest of muskrat because of the lack of suitable denning habitat. Where localized groups of muskrat could be affected by operations, these effects were expected to be short term due to the high productive capacity of muskrats.

During the Planning Meeting of the Impact Hypothesis Working Group, it was concluded that there was a need to re-evaluate this hypothesis because of major restructuring of the hypothesis and its linkages to include: (1) the effects of water withdrawal and physical

FIGURE 19-1A

EFFECTS OF WATER WITHDRAWAL ON BIRDS, SEMI-AQUATIC FURBEARERS AND FISH

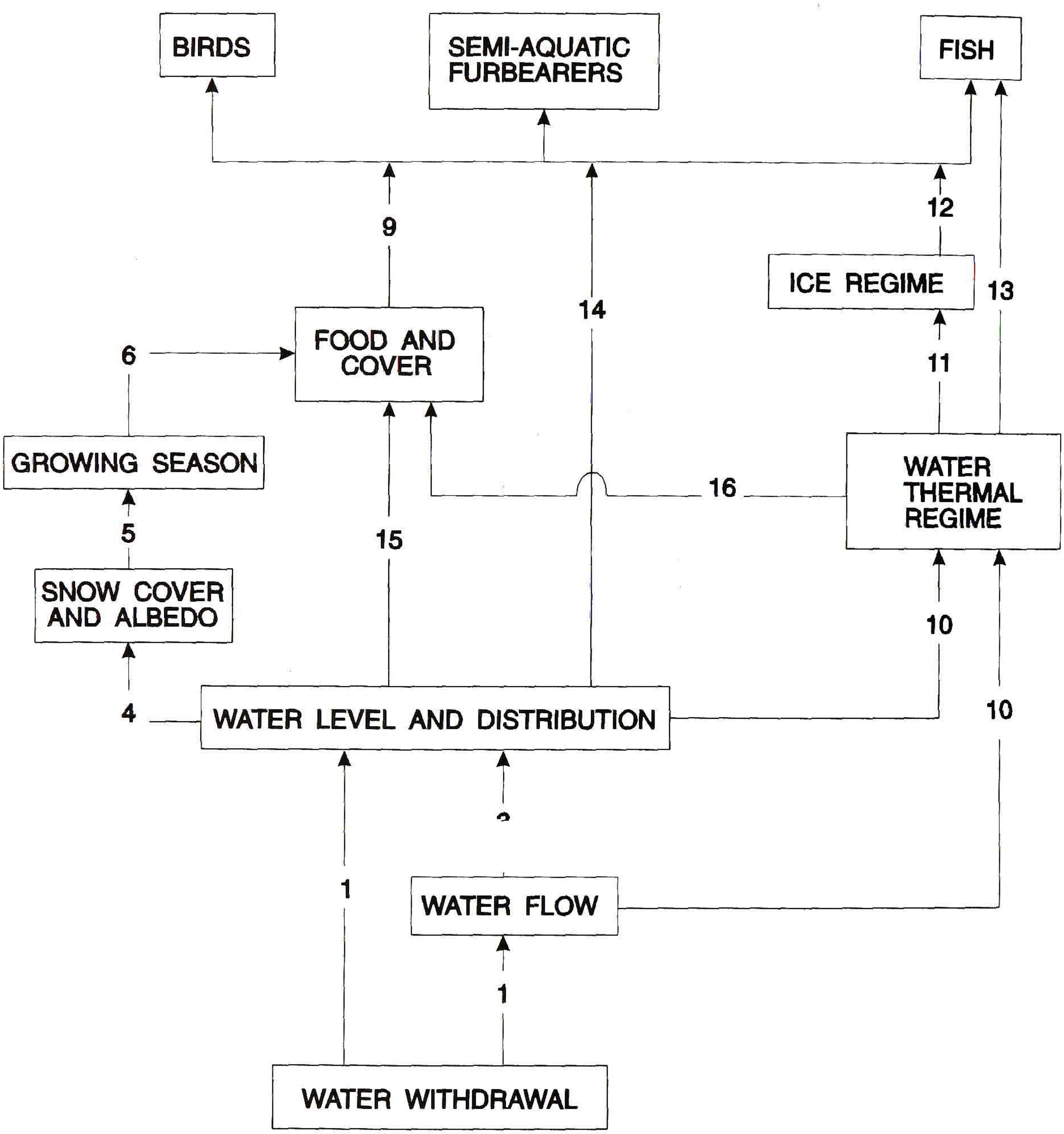
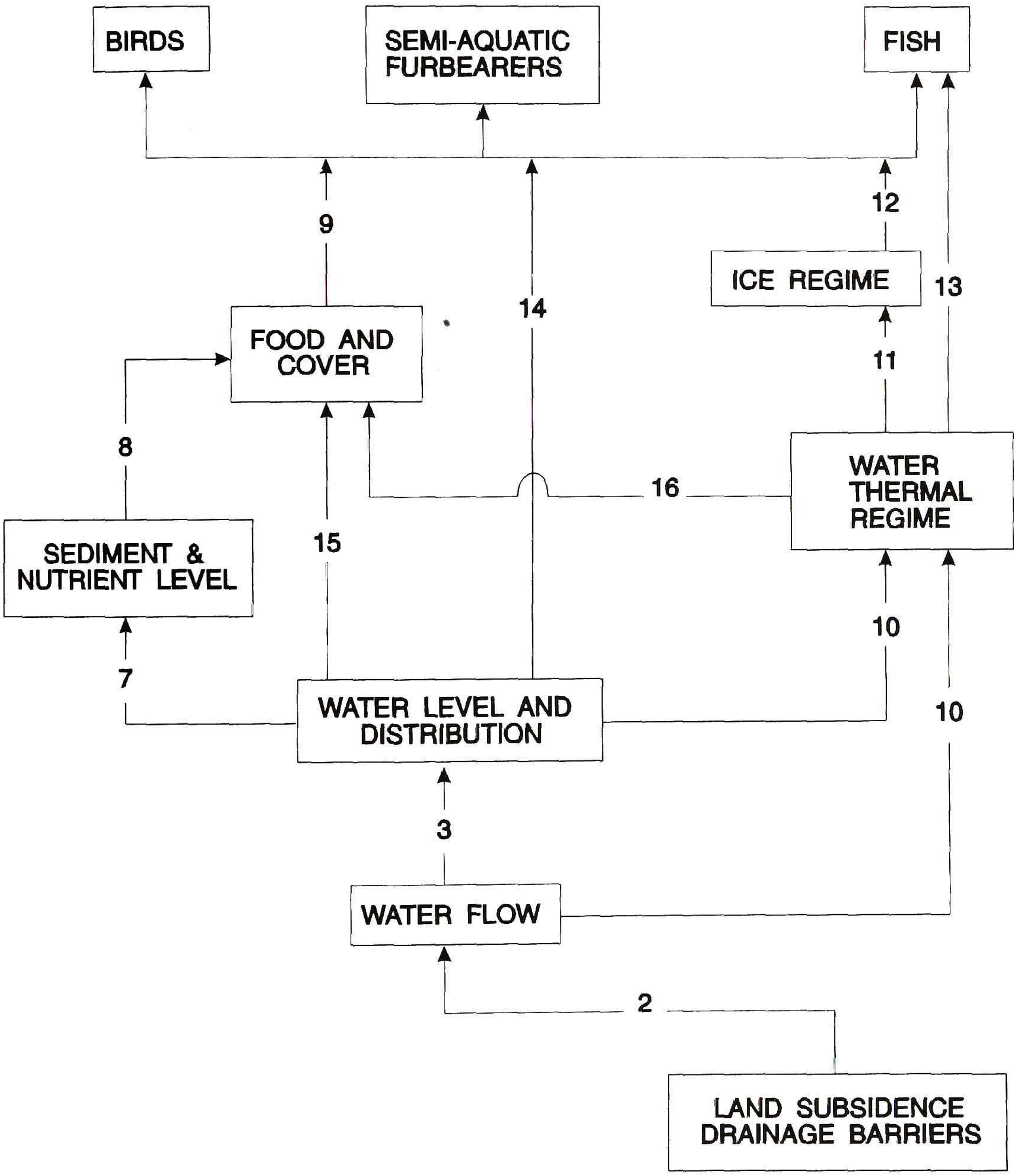


FIGURE 19-1B

EFFECTS OF LAND SUBSIDENCE AND DRAINAGE BARRIERS ON BIRDS, SEMI-AQUATIC FURBEARERS AND FISH



Linkages

1. Water withdrawals for hydrostatic testing, injection for reservoir enhancement and human consumption will decrease water flow in streams and water levels in lakes.

2. Subsidence and drainage barriers along pipelines and roads will change the pattern of water flow.

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

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

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

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

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

8. The levels and distribution of nutrients and sediments influence the quality and quantity of food and cover for birds, semi-aquatic furbearers and fish.

9. Food and cover affect the population size of birds, semi-aquatic furbearers and fish through influences on feeding and survival.

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

11. The water thermal regime affects the ice regime.

12. The ice regime affects the survival of birds, semi-aquatic furbearers and fish.

13. The water thermal regime will affect the population characteristics of fish.

14. Changes in water levels and distribution will affect the population characteristics of birds, semi-aquatic furbearers and fish.

15. Changes in water levels and distribution will affect the quality and quantity of food and cover.

16. Changes in the water thermal regime will affect the quality and quantity of food and cover.

drainage barriers on waterfowl and fish; and (2) the impact of local land subsidence along pipelines and roads within the Mackenzie Delta and Valley. Monitoring of the Norman Wells pipeline (MacInnes 1989) has indicated that subsidence along the ditch has presented a persistent erosion and maintenance problem. This has been reduced through IPL's replacement of select backfill in the ditchline. Subsidence along approximately 30% of the ditchline was visible in July, 1986. By 1988, only about 15% of the line had subsided (K. MacInnes, pers. comm.). In most cases, erosion control structures have performed well in limiting surface erosion, although numerous small-scale erosion events have occurred, frequently initiated by intense summer rainstorms.

Prior to and during the 1992 workshop, this hypothesis underwent significant restructuring and rewording of its linkages to reflect the addition of new VECs (birds and fish) and new development actions (land subsidence). The workshop subgroup agreed that because some of the linkages were not common to both development actions, the hypothesis should be teased into two sub-hypotheses: one dealing with the effects of water withdrawal (R-19a), and the other with the effects of land subsidence and drainage barriers (R-19b). The numbering of the linkages, however, remain unchanged because most of the links and evaluation of same are common to both sub-hypotheses. While this avoids repetition, it may cause some confusion for the reader. For this reason, it is suggested that further work to this hypothesis may be required.

Members of the subgroup also agreed that the statement of the hypothesis should be changed to read "population characteristics of" rather than "abundance and distribution of" to include not only the latter but also growth and reproductive success.

EVALUATION OF LINKAGES

Link 1: Water withdrawals for hydrostatic testing, injection for reservoir enhancement and human consumption will decrease water flow in streams and water levels in 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. It is expected that large waterbodies along the pipeline route and near the production facilities (such as main channels of the Mackenzie River, and offshore of the Delta within Mackenzie Bay) would provide the relatively large volumes of water required for these processes, and that large-scale changes in water levels would not likely occur. However, in areas where only smaller streams and lakes are available as sources of water, it is conceivable that water levels and water flows could be reduced. This linkage is, therefore, considered to be valid.

Link 2: Subsidence and drainage barriers along pipelines and roads will change the pattern of water flow.

Physical barriers (such as pipeline berms, frost bulbs and access roads) and subsidence of material along the pipeline have the potential to influence both the rate and direction of water flow. Ditching and construction of a berm over the ditch will interrupt minor surface drainage patterns, particularly diffuse runoff and small streams. The berm may redirect water along the right-of-way (ROW) and create ponding in level areas. There is also the potential for pooling of water behind frost bulbs and access roads and drying of wetlands downstream.

As general ROW surface subsidence occurs, there is a tendency for drainage to become channelled along the ROW and, particularly, in the subsided ditch. South of Fort Good Hope, subsidence of the entire ROW as a result of tree removal can pose a significant problem to the integrity of the pipeline. Although this is not an area of concern north of Fort Good Hope, ditchline subsidence could be a problem in ice-rich terrain (K. MacInnes, pers. comm.). Thaw settlement along the ditch may create local shallow, linear depressions which would further channel water along the ROW. Subsurface and surface flows may be interrrupted and re-directed along the trench or pipe.

Link 2 is valid. However, it is assumed that special construction procedures would be followed to minimize potential drainage and erosion problems, particularly in sensitive permafrost areas, and that ongoing monitoring and maintenance (e.g., placement of select backfill and trenching) would occur. It is assumed that through careful route selection, sensitive habitat areas in the delta (such as low-centre polygons which are utilized by shorebirds) would be avoided as much as possible. Given this, it is expected that the effects would be relatively localized and, in most instances, temporary.

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

Link 3 is considered intuitively valid.

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

It was noted during subgroup discussions that flooding of the Mackenzie River and tributary streams occurs well after snowmelt (D. Andre, pers. comm.) This link is, therefore, invalid.

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.

Because Link 4 is considered invalid, links 5 and 6 are inconsequential.

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

It was concluded by the subgroup that changes in the timing and extent of overbank flooding resulting from drainage barriers created by access roads could lead to changes in the level and distribution of nutrients and sediments in watercourses such as tributaries to the Mackenzie River or the river itself. Nutrient and sediment regimes in smaller stream and lakes could be influenced by drainage barriers created by subsidence, berms and frost bulbs along the pipeline.

Link 8: The levels and distribution of nutrients and sediments influence the quality and quantity of food and cover for birds, semi-aquatic furbearers and fish.

Based on general scientific principles, this link is considered to be valid.

Link 9: Food and cover affect the population size of birds, semi-aquatic furbearers and fish through influences on feeding and survival.

This link is generally valid for the groups of VECs considered in this hypothesis.

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

Based on general physical principles, this linkage is valid. However, any changes in water levels resulting from drainage barriers and subsidence along the pipeline and access roads would be relatively localized and unlikely to affect the thermal regime in larger watercourses such as the Macken[illegible]

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

Based on general physical principles, this link is also considered valid.

Link 12: The ice regime affects the survival of birds, semi-aquatic furbearers and fish.

Link 12 is valid. Changes in ice thickness and duration can affect the survival of: (1) birds through its effect on the timing of nesting and ultimately, their productivity; (2) semi-aquatic furbearers by affecting their ability to forage; and (3) fish by affecting the oxygen concentration within the water.

Link 13: The water thermal regime will affect the population characteristics of fish.

Changes in the water thermal regime could affect the spawning times of some fish species, particularly spring spawners.

Link 14: Changes in water levels and distribution will affect the population characteristics of birds, semi-aquatic furbearers and fish.

Changes in water levels and distribution could affect the quantity of available habitat for all VEC groups considered in this hypothesis. In the case of birds, the timing of drawdown from flooding determines the timing of nesting, which in turn affects their productivity. Effects of changes in water levels would be most significant for shorebirds, which show a preference for patterned wet/dry land for nesting. Similarly, muskrat habitat depends on predictable seasonal water levels (LGL *et al.* 1986). Increases in water levels can result in flooding of breeding chambers and increased winter predation under the ice, while decreases in water levels can result in the loss of habitat.

Link 15: Changes in water levels and distribution will affect the quality and quantity of food and cover.

Link 15 is valid. The quantity and quality of food and cover would be affected where drainage patterns are altered. Drying of areas downstream of drainage barriers could result in decreased growth of riparian and aquatic vegetation. Ponding of water could cause localized mortality of certain species of vegetation that are intolerant of flooding, but could favour the growth of more tolerant species. Similarly, changes in water levels could also affect the abundance and composition of invertebrate populations within affected watercourses.

Link 16: Changes in the water thermal regime will affect the quality and quantity of food and cover.

This link is valid. Changes in water temperature could affect the growth and distribution of aquatic vegetation as well as the abundance and diversity of aquatic invertebrates.

ASSESSMENT OF IMPACTS

The subgroup separately assessed the significance of potential impacts for each of the VEC groups using the procedure developed by Essa Ltd.

A. Water Withdrawal

Due to the lack of information regarding the source and amount of water required for hydrostatic testing, human consumption and water injection, the significance of the effects of water withdrawal on bird, semi-aquatic furbearer and fish populations could not be assessed.

B. Barriers/Land Subsidence

The impact significance of physical drainage barriers and land subsidence is described below.

1. BIRDS (OTHER THAN SHOREBIRDS)

Based on any one group of birds, the impact of land subsidence and drainage barriers is expected to be **insignificant**.

Spatial Scale: A **site-specific** effect would be expected due to the widespread distribution of birds throughout the Delta and Beaufort Sea region. Only a small portion of the total population would likely be affected.

Temporal Scale: Assuming the life of the pipeline would be 20-25 years and the lifespan of most bird species is less than 20-25 years, the effects would likely be **long term**.

Magnitude: Such a small portion of the total population would be affected that it is unlikely that a change could be measured statistically. Therefore, the magnitude of the effect would likely be **small**.

2. SHOREBIRDS

Due to the importance of the Delta as nesting habitat for a variety of shorebirds, this VEC was assessed separately from other birds. It was noted that while the IPL pipeline has provided much information on the effects of pipeline construction on terrain in an area of discontinuous permafrost, it remains uncertain as to how certain circumstances might be handled in continuous permafrost. It was suggested that mitigation for land subsidence and creation of frost bulbs and berms may differ from those used for the IPL line in the valley, where the topography is variable and the effects on drainage is very localized and limited due to this natural variability. While construction of a pipeline within the Delta would follow a firm set of design criteria to minimize environmental impacts (e.g., use of insulation, increase depth of pipe, avoidance of sensitive sites, etc.), land subsidence and creation of drainage barriers would occur and its effects on areas of wetland is unknown. Ponding of water behind pipeline berms and frost bulbs may have some beneficial effect on some shorebirds, however, the extent of this is unknown. Due to the lack of information regarding waterflow patterns and the extent of available nesting habitat on the Delta, this assessment was erred on the cautious side. It was concluded that the impact of drainage barriers and land subsidence on shorebirds could be **significant**.

Spatial Scale: The effects would be **local to regional**. Data to date suggest that for 4 species of shorebirds (whimbrel, long-billed dowager, stilts, hudsonian godwit) the effects would be at least local (L. Dickson, pers. comm.).

Temporal Scale: Assuming the lifespan of the pipeline is 20-25 years, the effects would be **long term** since one generation of shorebirds can be less than 10 years.

Magnitude: Changes in the density of nesting pairs due to alterations in nesting habitat would likely be detectable with statistics. Therefore, the magnitude of the impact is expected to be **moderate**.

3. SEMI-AQUATIC FURBEARERS

The effect of land subsidence and drainage barriers on semi-aquatic furbearers is expected to be **insignificant**.

Spatial Scale: Because the distribution of semi-aquatic furbearers is widespread throughout the region, the effect would likely be **site specific**.

Temporal Scale: Muskrat, otter and mink are short lived and, therefore, more than one generation could be affected. The impact would likely be **long term** for these species.

Magnitude: Any changes in the abundance of semi-aquatic furbearers would likely be within natural variation of the population. Species such as mink and otter probably occur in such low densities that it would be difficult to derive pre-construction estimates of numbers and productivity to allow detection of changes resulting from construction.

4. FISH

The effect of land subsidence and drainage barriers on fish is expected to be **insignificant**.

Spatial Scale: Channels of the Mackenzie are used primarily for overwintering and migrations by a portion of the regional populations of fish. However, only a small area would likely be affected and therefore the effects would likely be **local**.

Temporal Scale: Effects such as changes in waterflow patterns, and erosion can be expected to last the lifetime of the pipeline/roads (assumed to be 20-25 years). The generation time of some VEC fish species is 7-10 years and, therefore, the impact would be **long term** for these species.

Magnitude: Any effects on fish habitat would likely be masked by natural perturbations and would likely be undetectable. Similarly, the regional populations of most fish species in the region are large and any reductions in the numbers of fish would not be statistically detectable. The magnitude of the impact is, therefore, expected to be **small**.

RECOMMENDED RESEARCH

The subgroup identified two areas where further research is needed to properly evaluate the degree of impact of pipeline/road construction on the Delta on shorebird populations and their habitat.

Research Need 1: Examine the pattern of surface flows across shorebird nesting habitat in the Delta

It was concluded by the subgroup that construction of a pipeline on the Delta would cause changes in drainage as a result of the creation of drainage barriers (pipeline berms, frost bulbs) and land subsidence within the ROW. Although subsidence along the pipeline would likely be temporary in most instances due to remedial actions taken by the proponent, its effect on the direction and volume of waterflow on the Delta will be difficult to assess until natural flow patterns are better understood.

Research Need 2: Determine the distribution of shorebird habitat on the Delta.

The Canadian Wildlife Service has conducted shorebird habitat surveys in specific areas in the vicinity of gas fields on the Delta. However, the extent of available nesting habitat remains unknown. The subgroup supports continued research in this area.

RECOMMENDED MONITORING

In the event that pipelines/roads are constructed on the Delta in support of hydrocarbon development, the subgroup identified four monitoring requirements.

Monitoring Need 1: Monitor for drainage barriers and land subsidence along the pipeline.

It was assumed by the subgroup that a monitoring and maintenance program would be part of standard operating procedures and this would continue for a number of years after the pipeline is abandoned. If erosion and subsidence problems occur, it is recommended that the following monitoring programs also be implemented.

Monitoring Need 2: Monitor changes in water levels and distribution in shorebird habitat.

This would require that baseline data be collected prior to construction of the pipeline to allow changes to be detected.

Monitoring Need 3: Monitoring the distribution of nesting shorebirds on the Delta.

It was recommended that in the event that subsidence and the creation of drainage barriers along the pipeline and/or roads occur, a monitoring program should be implemented to determine the effects of changes in water levels and distribution on habitat use by shorebirds. It was suggested that this program focus on four species; whimbrel, long-billed dowager, stilt and hudsonian godwit (L. Dickson, pers. comm.). A series of sample transects should be established for counting the number of birds in the areas of concern.

Monitoring Need 4: Monitor the productivity of shorebirds on the Delta.

In order to understand the implications of changes in water levels and distribution on shorebirds in the Delta, there is a need to monitor the productivity of this VEC. It was suggested that this may be accomplished by taking egg counts, however, a shorebird biologist should be consulted as to the most appropriate procedure (L. Dickson, pers. comm.).

LITERATURE CITED

LGL Limited, ESL Environmental Sciences Limited, ESSA Environmental and Social Systems Analysts Limited and P.J. Usher Consulting Services Limited. 1986. Mackenzie Environmental Monitoring Project. 1985-1986 Final Report. Prep. for Indian and Northern Affairs Canada. 308 pp. + appendices.

MacInnes, K.L. 1989. Permafrost and Terrain Research and Monitoring: Norman Wells Pipeline, Volumes I and II. Indian and Northern Affairs Canada, Ottawa.

BREAM HYPOTHESIS R-20

OIL AND GAS DEVELOPMENT, CONSTRUCTION, AND ACTIVITIES AND THE PRESENCE OF AN ABOVE-GROUND PIPELINE AND GATHERING SYSTEM WILL CHANGE THE ABUNDANCE AND DISTRIBUTION OF MOOSE

PARTICIPANTS

John Bailey	Rob Owens
Johnny Charlie	Frank Pope
Jeff Green	Mike Rose
Dave Klein	Don Russel
Paul Latour	

INTRODUCTION

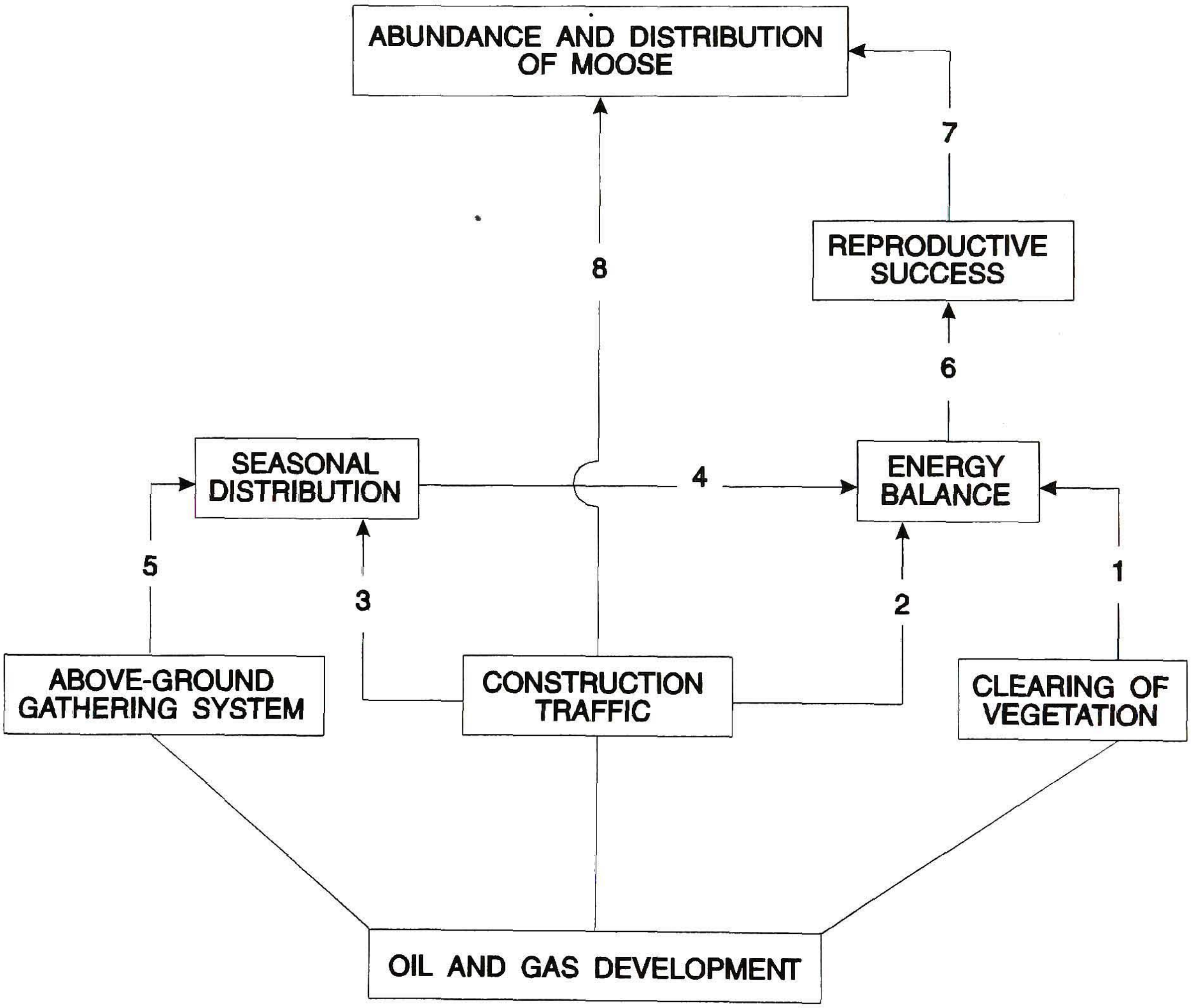
Current scenarios for hydrocarbon development in the western Beaufort region are likely to result in the clearing of mature shrub and forested cover, and a stimulation of early successional cover, with subsequent benefits to moose as a result of increased browsing availability. Construction activities and associated traffic may also disturb moose, thereby resulting in increased energy distributions, and changes in local, and possibly regional, distribution and habitat availability. As the hydrocarbon development scenario for the Beaufort and Mackenzie region will likely include some above-ground pipeline systems, as well as above-ground gathering systems, concern was expressed that local movements by moose may be obstructed.

The hypothesis was briefly revisited during the 1992 BREAM workshop to address minor changes in existing impact linkages (dealing with above-ground pipelines and gathering systems), as well as new information.

Above-ground gathering systems along the Beaufort coastline and, in particular, on the Tuktoyaktuk peninsula, were concluded to not be a major concern to local movements by moose, as this species is uncommon in coastal areas of the Beaufort Sea and Yukon North Slope (Smits 1991; P. Latour, pers. comm.). Hydrocarbon impacts to moose are of greatest

FIGURE 20-1

EFFECTS OF OIL AND GAS DEVELOPMENT CONSTRUCTION AND CLEARING ACTIVITIES AND THE PRESENCE OF AN ABOVE-GROUND GATHERING SYSTEM ON THE ABUNDANCE AND DISTRIBUTION OF MOOSE



Linkages

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

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.

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.

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

5. An above-ground pipeline and gathering system will prevent the passage of moose, and will alter distributions of moose within a local area.

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

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

8. Increased traffic on permanent roads associated with development will result in increased numbers of moose killed through collisions with vehicles.

interest in the Mackenzie region of the BREAM study area.

The Wildlife Working Group concluded that a pipeline within the Mackenzie River valley could potentially affect local movements of moose, depending on the final design and location of the pipeline. For example, the most recent concept plan for the Foothills Pipeline in Yukon includes 11 km of above-ground pipeline over a distance of approximately 800 km (R. Owens, pers. comm.). Above-grade sections of the pipeline are likely to be placed on continuous gravel berms, up to several metres in height, and may represent a barrier to movements by moose. Because the above-grade portions of the pipeline most often occur in river valleys, there is potential for raised sections of the pipeline to conflict with moose use of river valleys (which are important over-wintering habitats).

New information on moose abundance, seasonal distributions and habitat use which was considered in the 1992 BREAM workshop include the results of a three-year study of moose in the northern Richardson Mountains and adjacent Yukon Coastal Plain by the Yukon Fish and Wildlife Branch (Smits 1991).

EVALUATION OF LINKAGES

The Wildlife Working Group generally concurred with the current structure of the impact hypothesis, but suggested that impacts associated with Link 2 be merged with Link 3. It was noted that impacts to moose, as described in this hypothesis, are likely to be of greatest concern in the southern portion of the BREAM study area (i.e. the Mackenzie River valley and adjacent areas).

As in MEMP, the impact hypothesis addresses three major impact pathways:

1. Effects of clearing forested areas on food availability for moose.
2. Effects of increased vehicular traffic on the seasonal distribution and survival of moose; and
3. Effects of an above-ground pipeline and gathering system on local moose movements.

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

As described in MEMP, the Wildlife Working Group concluded that it is reasonable to assume that clearing of native vegetation through activities such as wood-chipping operations and development of seismic lines, particularly in the southern portion of the BREAM study area, will result in regeneration of shrub and tree seedlings, thereby increasing the amount of available browse. In some areas of Yukon, it appears that moose actively seek out tree and shrub-regeneration areas (P. Latour, pers. comm.). Although Link 1 was concluded to be valid, insufficient information exists to quantify the benefits of this impact to local or regional moose populations. As discussed in MEMP, it is unlikely, however, that the creation of additional moose habitat will result in an increase in the abundance of moose.

The Wildlife Working Group also noted that clearing of vegetation cover, particularly that associated with seismic lines or winter roads, will improve access for hunters. Although such improvements in access may increase moose mortality in a local area, it also serves to disperse hunting effort, particularly in the vicinity of existing remote settlements. It was concluded that although effects of small increases in local access on moose mortality would likely be insignificant, it could have a significant and beneficial effect on harvesting.

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.

The Wildlife Working Group concurred that construction traffic will disturb moose temporarily (as discussed in Link 3), but such movements would have very minor effects on moose energy balances. Although it was recommended that Link 2 be deleted from the hypothesis, concerns regarding energy balances should be incorporated into Link 3.

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.

MEMP concluded that Link 3 was invalid based on a lack of evidence that moose distributions were affected by construction activities associated with the IPL pipeline, temporary roads or highways. In contrast, a recent study of moose distributions in the Norman Wells area in relation to construction activities for a new road into the Mountain River valley suggested that moose did temporarily avoid the worksite area (P. Latour, pers. comm.). Although moose moved to alternate areas of suitable habitat, animals quickly returned to their original locale once construction ceased. The working group concluded that although short-term avoidance may occur, effects on moose distributions and energy balance are insignificant. Link 3 was therefore concluded to be invalid.

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

As Link 3 was concluded to be invalid, Link 4 is also invalid.

Link 5: An above-ground pipeline will prevent the passage of moose, and will alter distributions of moose within a local area.

It was noted that moose in the BREAM study area do not undergo seasonal migrations between winter and summer habitats, as is commonly observed in Alaska along some portions of the Alyeska pipeline (P. Latour, pers. comm.). Above-ground pipelines may therefore obstruct local movements by moose, as opposed to seasonal migrations. The wording of this linkage was therefore modified to read "will alter the distributions of moose within a local area" rather than "will lead to changes in moose migration patterns".

As noted above, development of a large-diameter gas pipeline (e.g., the proposed Foothills pipeline) may result in the construction of some above-ground sections of pipe. Current design guidelines for these sections recommend the construction of continuous gravel berms, several metres in height, on which the pipeline would be rested. It is therefore possible that the above-ground sections of the pipeline could obstruct local movements by moose. Given that the above-ground sections are most likely to occur in river flood plains or adjacent to rivers, these sections would likely overlap some important moose wintering areas (i.e. river valleys). However, as a number of techniques are available to permit moose movements under or over above-ground sections of pipelines, the Wildlife Working Group concluded that effects could be mitigated.

Buried sections of a gas pipeline would only affect moose movements during the actual period of construction (i.e. excavation and open ditch stages). Assuming that adequate environmental protection guidelines are followed (e.g., provision of crossing areas every 400 m along a pipeline string, minimizing the length of open ditch, use of ditch plugs when ditches remain open for more than several days), it was concluded that buried pipelines would have only short-term and insignificant effects on moose habitat use and distributions.

As buried pipelines would not significantly affect local movements by moose, and effects of above-ground pipelines on moose movements can be mitigated, Link 5 was concluded to be invalid.

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

Although this linkage is implicitly valid, the Wildlife Working Group concluded that Link 6 was unlikely since (i) negative effects on energy balance associated with changes in seasonal distributions were not valid (Linkages 3, 4 and 5), and (ii) beneficial effects of increased food supply are likely to be of such a localized nature that increased reproductive success, if it occurred, would be difficult to detect.

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

Although this link is inherently valid, the Wildlife Working Group concluded that since effects of clearing of vegetation, construction traffic or above-ground pipelines on energy balance and reproductive success are invalid or unlikely, Link 7 is unlikely.

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

As discussed in MEMP, it appears that moose-vehicle collisions are only likely to occur along permanent roads such as the Dempster Highway. In contrast, no moose-vehicle collisions have been reported on winter roads in the Norman Wells area (P. Latour. pers. comm.). Therefore, although Link 8 is valid, it is recommended that the wording of the linkage be changed from "Increased traffic associated with development" to "Increased traffic on permanent roads associated with development".

ASSESSMENT OF IMPACTS

Each of the three major impact pathways were considered to be partially or completely valid. Impact significance was concluded to be as follows:

1. Effects of Clearing of Forested Cover
   Although effects of clearing of forested cover on moose reproduction and abundance would be neutral to beneficial, the impact is expected to be insignificant (i.e. highly localized, moderate-term, and difficult to detect).

2. Effects of Increased Vehicular Traffic
   As numbers of road kills associated with permanent roads are small, the impact of moose-vehicle collisions on moose abundance and productivity were concluded to be insignificant (i.e. local, small incidence, and short to moderate term).

3. Effects of an Above-Ground Pipeline
   Effects of an above-ground pipeline on moose would be insignificant (local and short-term), and can be mitigated.

RECOMMENDED RESEARCH

No research specifically related to the effects of oil and gas development on moose in the BREAM study area was recommended.

LITERATURE CITED

Smits, C.M.M. 1991. Status and seasonal distribution of moose in the northern Richardson Mountains. Final Report TR-91-2. Yukon Renewable Resources, Fish and Wildlife Branch, Whitehorse, Yukon Territory. 64 pp.

BREAM HYPOTHESIS R-21

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

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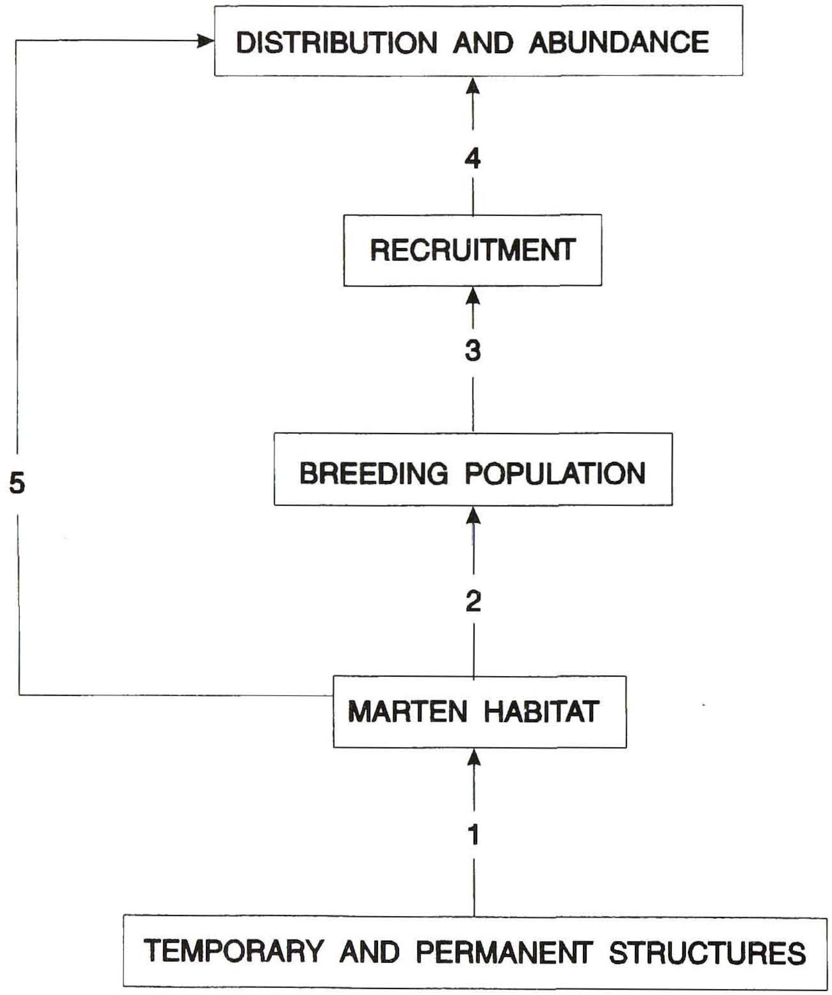
INTRODUCTION

Hydrocarbon development in the Beaufort region could affect the abundance and distribution of marten through permanent and temporary alterations to habitat, particularly denning and feeding habitats. Recent radiotelemetry studies of habitat use by marten (Latour and Poole 1989; Latour *et al.* 1991) indicate, however, that denning habitat is not limiting to marten populations in the Yukon Territory, and that denning and feeding habitat are essentially similar. The Wildlife Working Group therefore suggested that the hypothesis be simplified by combining denning and feeding habitats into a single category (marten habitat). Sensory disturbance from mechanical and human activities was also identified by the hypothesis working group as a potential impact.

Some new information is available on the demography, distribution and habitat use of marten in the Sahtu district of the N.W.T. (i.e. 20 km west of Norman Wells) (Latour and Poole 1989; Latour *et al.* 1991), other areas of the N.W.T. (Poole 1990) and the southern Yukon (Slough 1989; Slough *et al.* 1989). Research on marten in the Sahtu District is ongoing, and results should be considered in future evaluations of this hypothesis.

FIGURE 21-1

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



Linkages

1. Temporary disturbances such as seismic lines, wood-chip operations, temporary winter roads and pipeline rights-of-way, and permanent disturbances such as permanent roads, facility sites and borrow pits will decrease the availability of marten habitat.

2. A decrease in marten habitat will decrease the local breeding population of marten.

3. Changes in the size of the breeding population will directly influence recruitment.

4. Changes in recruitment will alter the abundance of marten.

5. Changes in the availability of marten habitat will alter the local abundance of marten.

Since simplification of the impact hypothesis was recommended and a considerable body of new information is available from recent field studies, the Wildlife Working Group re-evaluated the hypothesis during the BREAM workshop. Given that the Sahtu area of the N.W.T. produces some of the best quality marten fur in Canada (J. Bailey, pers. comm.), this hypothesis was deemed to be of particular concern for the southern region of the BREAM study area. A concern was also raised by local residents that oil and gas development may introduce contaminants into the food chain (e.g., through soil contamination and uptake by plants to small mammal prey of marten), which in turn may affect the quality of marten pelts to the fur industry (W. Jackson, pers. comm.).

EVALUATION OF LINKAGES

Link 1: Temporary disturbances such as seismic lines, wood-chip operations, temporary winter roads and pipeline rights-of-way, and permanent disturbances such as permanent roads, facility sites and borrow pits will decrease the availability of marten habitat.

The Wildlife Working Group concluded that temporary and permanent disturbances associated with oil and gas activities would remove areas of marten habitat, particularly in the southern portion of the BREAM study area. For example, recent studies of marten habitat use in relation to the IPL pipeline indicated that marten did not commonly use the IPL line (P. Latour, pers. comm.). Although animals would cross the pipeline right-of-way, little hunting activity was recorded within or adjacent to the pipeline corridor. Link 1 is therefore valid.

Link 2: A decrease in marten habitat will decrease the local breeding population of marten.

It was the opinion of the Working Group that unlike clear-cutting blocks associated with timber harvesting activities, oil and gas activities would not significantly affect the regional availability of habitat for marten or the local or regional abundance of marten.

Within the southern portion of the BREAM study area, where the highest quality marten habitat occurs, clearing activities will be associated primarily with the pipeline right-of-way, associated access roads, and compressor station sites. If the pipeline does not follow the existing CN right-of-way from Inuvik to Fort Norman, pipeline construction would require the greatest amount of clearing of forested areas. It was also noted that a probable development scenario might involve a large-diameter gas pipeline followed by a small oil pipeline within the same pipeline corridor (R. Owens, pers. comm.). If adequate gas reserves were found, it is likely that additional pipeline capacity would be provided by looping the pipeline within the same corridor, thereby minimizing the potential for habitat fragmentation. If this development scenario is not likely, and future development were to result in multiple lines through prime marten areas, it would be necessary to assess the use of multiple, parallel pipeline rights-of-way by marten (e.g., effects on home range, hunting, etc.).

Assuming that the most likely development scenario will involve a large diameter pipeline within a new right-of-way, the cleared corridor may be up to 50 m in width. Given that the average home range sizes for marten are in the order of 100 km^2 for males and 60 km^2 for females (P. Latour, pers. comm.), it was estimated that a 50 m pipeline right-of-way would remove approximately 0.6% to 0.7% of an average home range (assuming that home ranges are approximately circular). Because there would likely be only one pipeline during the initial phase of development, and only animals whose home ranges are intersected by the pipeline would be affected, the Working Group concluded that a pipeline right-of-way would not significantly reduce the local or regional availability of habitat or habitat quality for marten. Link 2 is therefore unlikely.

Link 3. Changes in the size of the breeding population will directly influence recruitment.

Link 3 is inherently valid. However, since Link 2 is considered unlikely, the Wildlife Working Group concluded that Link 3 was unlikely.

Link 4. Changes in recruitment will alter the abundance of marten.

Link 4 is also inherently valid. However, since Linkages 2 and 3 are unlikely, Link 4 is also unlikely.

Link 5: Changes in the availability of marten habitat will alter the local abundance of marten.

As discussed in MEMP, emigration of marten will increase if removal of forest cover affects a large portion of the home range of a marten. However, as discussed earlier, clearing of forested cover associated with a large diameter pipeline is not expected to significantly affect the local or regional availability or quality of marten habitat. Therefore, Link 5 was considered to be invalid (unlikely).

ASSESSMENT OF IMPACTS

The Wildlife Working Group concluded that clearing activities associated with oil and gas development in the southern portion of the BREAM study area will result in insignificant changes in the local availability of marten habitat (i.e. site-specific, small scale and long-term losses). Given that development will likely involve a single pipeline corridor, these localized losses of habitat will not have a significant effect on the distribution, abundance or productivity of marten in the BREAM study area.

RECOMMENDED RESEARCH

No research specifically related to the effects of oil and gas development on marten in the BREAM study area was recommended.

LITERATURE CITED

Latour, P. and K. Poole. 1989. Sahtu district marten research. Study proposal. Department of Renewable Resources, Yellowknife, N.W.T. 9 pp.

Latour, P., N. MacLean, and K. Poole. 1991. Movements of marten in burned and unburned taiga of the western Northwest Territories. Draft report. Department of Renewable Resources, Yellowknife, N.W.T. 14 pp. + figures.

Poole, K.G. 1990. Marten research in the N.W.T. 1989-90. Manuscript Report No. 38. Department of Renewable Resources, Yellowknife, N.W.T. 21 pp.

Slough, B. 1989. Movements and habitat use by transplanted marten in the Yukon Territory. J. Wildl. Manage. 53: 991-997.

Slough, B.G., W.R. Archibald, S.S. Beare and R.H. Jessup. 1989. Food habits of marten, *Martes americana*, in the south-central Yukon Territory. Can. Field-Nat. 103: 18-22.

BREAM HYPOTHESIS R-22

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

PARTICIPANTS

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INTRODUCTION

Since the last MEMP workshop, a number of new studies on raptors in the Mackenzie region have been conducted (Shank 1990, 1991; Shank *et al.* 1991; Mossop 1988). One new study on the effects of stationary facilities (pipelines) has been conducted in Alaska. This study suggests that at least some raptors, such as gyrfalcons and rough-legged hawks, in northern Alaska can make use of pipelines as nesting platforms (Ritchie 1991).

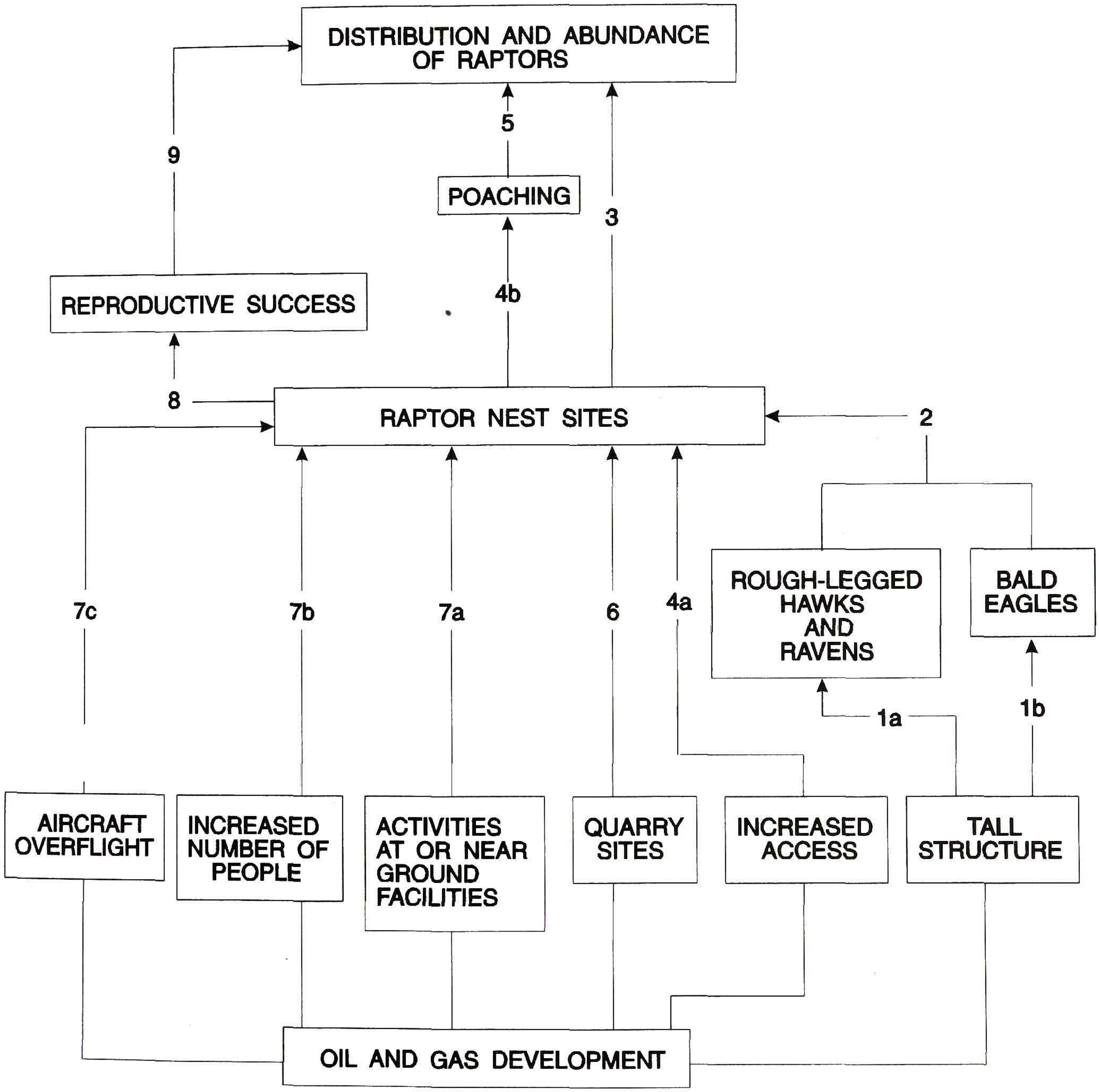
EVALUATION OF LINKAGES

During the planning meeting of the Impact Hypothesis Working Group, it was concluded that this hypothesis remains valid, but that it was not necessary to re-evaluate the hypothesis at this year's workshop. Although there is new information that will allow us to better predict the effects of disturbances on raptors, this information does not alter the conclusions of MEMP or the Working Group on its validity.

With exception to the addition of a linkage dealing with establishment of nests in tall structures by bald eagles, the subgroup did not recommend any further changes to the hypothesis.

FIGURE 22-1

EFFECTS OF DISTURBANCE AND HABITAT ALTERATIONS DUE TO HYDROCARBON DEVELOPMENT ON RAPTOR SPECIES



Linkages

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

1b. Bald eagles may establish nest sites in tall structures.

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

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

4a. Roads, pipeline right-of-ways and seismic lines will allow access to raptor nest sites.

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

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

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

7a. Activities at or near ground facilities will disrupt nesting raptors.

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

7c. Persistent aircraft activity at low altitudes will disturb nesting raptors.

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

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

ASSESSMENT OF IMPACTS

Using the assessment procedure developed by Duval and Vonk (1991), the subgroup concluded that the effects of disturbances on raptor populations would likely be significant due to the duration of the project and the fact that raptor populations in the region are small. However, the extent of the potential impacts would vary depending on the species and individual breeding pair (L. Dickson, pers. comm.). Several studies have shown that raptors can habituate to some disturbances such as aircraft overflights, and human activity and noise, and in most instances mitigative measures to prevent disturbances can be employed prior to initiation of development.

RECOMMENDED RESEARCH

No research or monitoring specifically related to the effects of disturbances associated with hydrocarbon development on raptors was recommended by the subgroup.

LITERATURE CITED

Duval, W. and P. Vonk. 1991. A semi-quantitative procedure for preparation of initial environmental evaluations and assessment of potential impact significance. Seakem Group Ltd., Vancouver, B.C.

Mossop, D. 1988. Yukon gyrfalcon project 1987 and 1988. Rep. by Yukon Dep. Renewable Resources, Whitehorse.

Ritchie, R.J. 1991. Effects of oil development on providing nesting opportunities for Gyrfalcons and Rough-Legged Hawks in northern Alaska. Condor 93: 180-183.

Shank, C. 1991. Gyrfalcons in the Richardson Mountains. Wildlife Management Division, Dep. Renewable Resources, GNWT, Yellowknife. Data not available.

Shank, C., R.G. Bromley and K.G. Poole. 1990. Numerical changes in two breeding populations of tundra peregrine falcons in the Central Canadian Arctic. Unpubl. MS by Wildlife Management Dvision, Dept. Renewable Resources, GNWT, Yellowknife. 17 p. + tables and figures.

Shank, C. 1990. 1990 summary of Northwest Territories raptor project. Unpubl. MS by Wildlife Management Division, Dept. Renewable Resources, GNWT, Yellowknife. 5 p.

BREAM HYPOTHESIS R-23

THE PRESENCE OF CAMPS AND GARBAGE DISPOSAL SITES WILL ATTRACT PREDATORS THAT CHANGE THE ABUNDANCE AND DISTRIBUTION OF BIRDS

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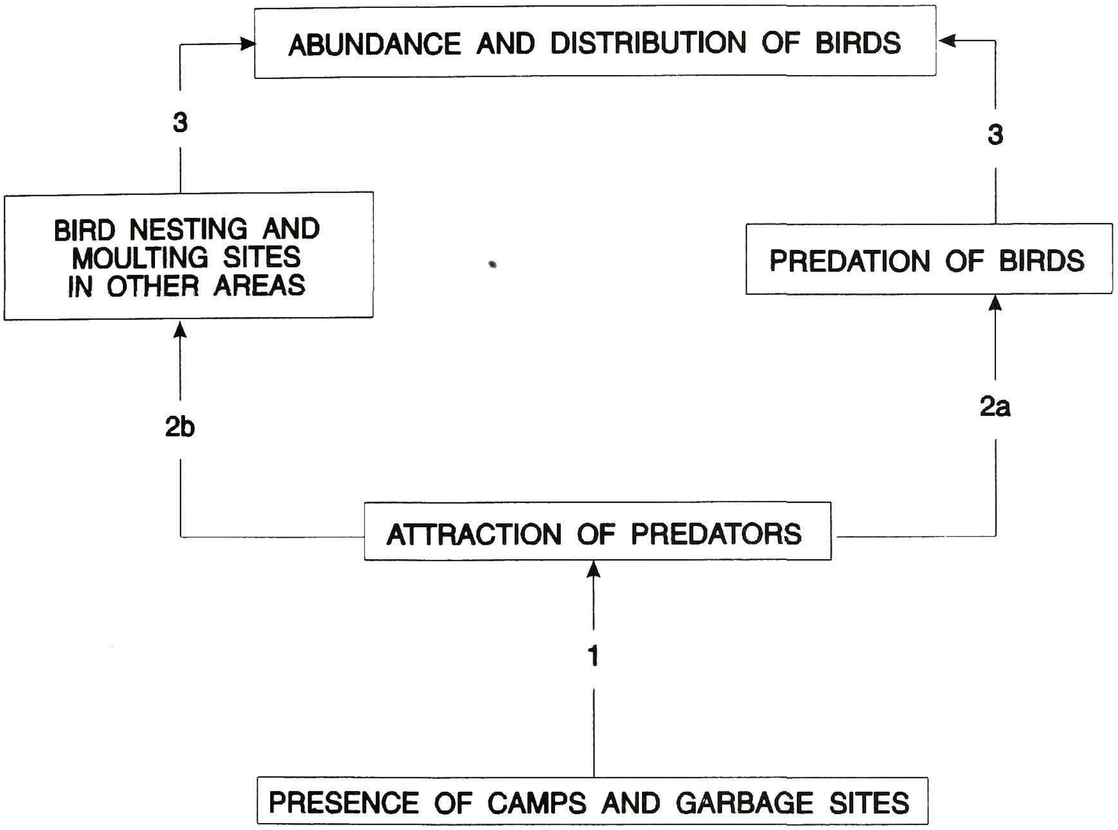
INTRODUCTION

BREAM Hypothesis R-22 (originally MEMP 9) states that camps and garbage sites will attract scavengers and predators that may also prey on local, and possibly more distant, nesting or moulting birds (waterfowl and loons), thereby causing a change in the distribution and abundance of these birds. Based on available information, this hypothesis is still considered to be valid.

No new published information concerning the effects of camp food or garbage have been made available. However, increased predation on waterfowl by arctic foxes and glaucous gulls in the Prudhoe Bay area of Alaska have prompted two new long-term oil/industry-funded studies. One investigation is an oil field-wide study on the current distribution and abundance of fox dens vs. historical distributions and abundance (1991-92 vs. pre-1980). The other study focuses on the actual predators and the extent of predation at waterfowl nesting colonies (black brant and lesser snow geese). The results of these studies will not be available until 1993.

FIGURE 23-1

EFFECTS OF INCREASED PREDATION AT CAMPS AND GARBAGE DISPOSAL SITES ON THE ABUNDANCE AND DISTRIBUTION OF BIRDS



Linkages

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

2a. Nesting or moulting birds near camps and garbage disposal sites will be subject to increased predation.

2b. Birds nesting or moulting away from camps and garbage disposal sites will be subject to reduced predation in the short term and may be subject to increased predation in the long term as predator populations in the area increase.

3. Increased predation of nesting and moulting birds near camps and garbage disposal sites will alter the abundance and distribution of birds.

EVALUATION OF LINKAGES

During the BREAM Planning Meeting, it was concluded that it was unnecessary to re-evaluate the hypothesis at this year's workshop. However, the subgroup was charged with the responsibility of reviewing the structure and wording of the linkages, and evaluating the significance of the potential impacts described in the hypothesis.

The following changes/comments regarding the wording of the hypothesis and its linkages were made by the subgroup.

1. All references to waterfowl should be changed to "birds" to include not only waterfowl but also loons.

2. Reference to "local" in the hypothesis statement should be removed as changes in predation rates could affect birds nesting and moulting in areas some distance away from camps and garbage disposal sites. Accordingly, the wiring and wording of linkage 2b should also be changed to reflect this.

ASSESSMENT OF IMPACTS

The subgroup concluded that further information gained through research and monitoring is required to properly evaluate the significance of potential negative impacts associated with this hypothesis. As noted earlier, there are two long-term studies currently ongoing that will provide information that is directly relevant to this hypothesis.

RECOMMENDED RESEARCH

In addition to ongoing research, the subgroup identified the need for the following research.

(1) **Effect of camps and disposal sites on local densities of fox, and in turn its effect on predation rates to local waterfowl populations.**

While it is known that camps and garbage disposal sites attract foxes if they provide an easily accessible source of food, the overall effect of this on densities of fox in the area is uncertain. The subgroup identified the need for research to examine the factors (i.e., availability of suitable denning habitat) that influence the density of fox in these areas. Furthermore, it is unknown what effect increased densities of fox would have on predation rates to local waterfowl populations.

(2) **Modification of Home Range by Foxes**

Waterfowl near to camps and garbage sites could be subject to increased predation if foxes vacate their established home territories to re-direct their feeding activities near camps and garbage sites. However, the extent to which foxes would vacate areas to occupy other feeding areas is unknown.

BREAM HYPOTHESIS R-24

THE CUMULATIVE EFFECTS OF NATURAL LAND SUBSIDENCE, INDUCED LAND SUBSIDENCE (FROM HYDROCARBON WITHDRAWAL) AND INCREASING SEA LEVELS DUE TO GLOBAL CLIMATE CHANGE WILL ALTER WETLAND AND AQUATIC HABITATS IN THE MACKENZIE DELTA AND RESULT IN CHANGES IN THE DISTRIBUTION AND ABUNDANCE OF WATERFOWL, FISH AND MUSKRAT

PARTICIPANTS

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INTRODUCTION

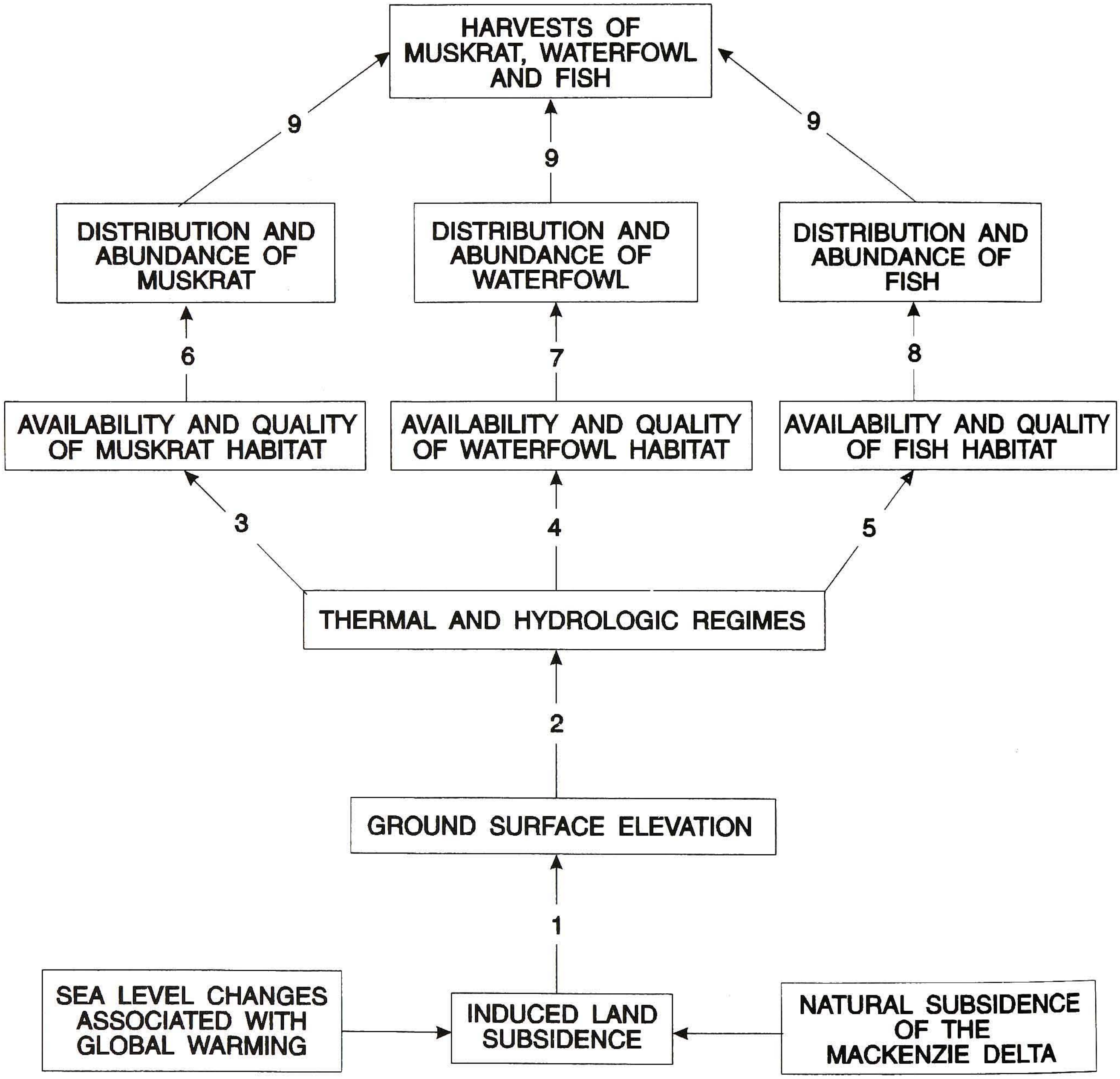
As discussed during MEMP (LGL *et al.* 1986), the active Mackenzie Delta is generally a low, flat area underlain by discontinuous permafrost, whereas most of the coastal plain in the Beaufort Region is low-lying and is underlain by continuous permafrost. Most land elevations are only 0.5 to 2.0 m above the river water level and sea level.

Natural subsidence of the Mackenzie Delta is occurring as a result of three major factors:

- regional subsidence of the Mackenzie sedimentary basin as a result of tilting of the continental plate associated with tectonic rebound;
- subsidence of the delta due to the weight of the accumulated sediment; and
- subsidence due to consolidation of the deltaic sediments.

FIGURE 24-1

EFFECTS OF NATURAL LAND SUBSIDENCE, INDUCED LAND SUBSIDENCE (FROM HYDROCARBON WITHDRAWAL) AND INCREASING SEA LEVELS DUE TO GLOBAL CLIMATE CHANGE ON WATERFOWL, FISH AND MUSKRAT



Linkages

1. Induced land subsidence resulting from hydrocarbon production, in combination with natural subsidence of the delta, and increasing sea levels associated with global climate change will decrease the ground surface elevation in the delta region relative to sea level.

2. Subsidence of the regional ground surface relative to sea level will cause a change in the thermal and hydrologic regime.

3. A change in the thermal and hydrologic regime will cause a change in the regional availability and quality of habitat for muskrat.

4. A change in the thermal and hydrologic regime will cause a change in the regional availability and quality of habitat for waterfowl.

5. A change in the thermal and hydrologic regime will cause a change in the regional availability and quality of habitat for fish.

6. A change in the availability and quality of habitat will cause a change in the distribution and abundance of muskrat.

7. A change in the availability and quality of habitat will cause a change in the distribution and abundance of waterfowl.

8. A change in the availability and quality of habitat will cause a change in the distribution and abundance of fish.

9. Changes in the distribution and abundance of waterbirds, muskrat and fish will result in reduced harvests of these species.

Hill *et al.* (1985) concluded that sea levels along the Beaufort coastline have risen 140 m in the last 27,000 years, with approximately 35 m of this increase attributable to natural subsidence of the Mackenzie Delta.

Induced land subsidence is caused by compaction of the reservoir rock when fluids such as gas and oil are extracted from the reservoir (McComiskey 1986). Induced subsidence is most likely to occur when: (1) reservoir fluid pressures are lowered without mitigative pressure maintenance techniques (i.e. water injection); (2) reservoir rocks are compactible; and (3) the overburden lacks internal support and easily deforms (McComiskey 1986). The potential for land subsidence as a result of hydrocarbon withdrawal has been identified as a concern in relation to effects on wetland habitats in the Beaufort coastal region, particularly in the low-lying areas of the outer Mackenzie Delta (LGL *et al.* 1986).

Global warming is expected to result in gradual, worldwide increases in sea level. Although quantitative estimates of potential sea level changes in the Beaufort coastal regions are not known, it is reasonable to assume that such changes will cumulatively increase inundation of coastal wetland habitats associated with natural and man-induced subsidence.

Inundation of coastal areas and the delta as a result of subsidence and sea level changes may cause changes in the ground thermal regime of the delta, which would increase the spatial extent of these impacts. Flooding of the delta and some coastal areas may result in thawing of ice-rich sediments which, in turn, could lead to increased erosion and surface subsidence (LGL *et al.* 1986).

In contrast, natural deposition of sediments in the delta will continue in the active portions of the delta, and may reduce the net effect of land subsidence and sea level changes.

The freshwater and brackish wetlands, lagoons and riverine areas of the Mackenzie Delta and the Beaufort coastal region are important seasonal and year-round habitats for a variety of fish, waterbirds and muskrat. These areas are also important to domestic harvesting. Inundation of these areas by the Beaufort Sea as a cumulative result of natural and induced subsidence and increases in sea level associated with global warming may result in losses of important reproductive, overwintering and feeding habitats for these species, as well as lost opportunities for resource harvesting.

EVALUATION OF LINKAGES

The validity of the linkages of this hypothesis were not assessed by the working group since (1) no members of the working group had technical expertise in land subsidence and sea level changes, and (2) insufficient time was available during the remaining portion of the workshop to complete the evaluation and discussion of this hypothesis. Most of the limited discussion on this hypothesis focused on research needs.

ASSESSMENT OF IMPACTS

As noted above, several factors precluded the assessment of impacts by this working group.

RECOMMENDED RESEARCH AND MONITORING

Due to a lack of expert knowledge on land subsidence and sea level changes in the working group, detailed research needs were not discussed. A number of general research requirements were identified.

Research Need 1: Quantification of Potential for Land Inundation

The working group concluded that in order to assess this hypothesis, it was necessary to determine:

- the rate and distribution of natural subsidence in the Mackenzie Delta and the Beaufort coast;
- the potential rate and distribution of induced subsidence resulting from hydrocarbon activities (i.e. a site-specific assessment of potential risk);

- the potential rate of increase in sea level as a result of global warming;
- net effect of delta deposition on subsidence and sea level changes.

No members of the working group were aware of ongoing monitoring efforts to assess any of the above factors, although several of these factors have been theoretically considered in conjunction with specific oil and gas projects in the Beaufort region (McComiskey 1986). As all of these factors, with perhaps the exception of induced subsidence, are occurring on a geological time scale, all of the identified research will need to be conducted over long-time periods. With the exception of the assessment of induced subsidence, the remaining research needs were concluded to be outside of the current scope of BREAM. Industry should fund research to assess the magnitude and distribution of risk of induced subsidence in combination with hydrocarbon withdrawal.

Research Need 2: Effects on Wildlife and Fish

If the cumulative effects of subsidence and sea level changes on land inundation are significant, an assessment should be initiated to determine the effects of habitat loss on fish, waterbirds and muskrat. Quantitative modelling of existing baseline habitat conditions and potential future changes in habitat availability and quality will be required.

LITERATURE CITED

Hill, P. *et al.* 1985. Sea level curve for the Canadian Beaufort Shelf. Canadian Journal of Earth Science. 22(11). Cited in LGL Limited *et al.* 1986.

McComiskey, J.E. 1986. Land subsidence as a result of fluid withdrawal. Prep. by Gulf Canada Resources. Appendix B. Mackenzie Environmental Monitoring Program. LGL Limited *et al.* (1986). Pages B1 to B5.

LGL Limited, ESL Environmental Sciences Limited, ESSA Environmental and Social Systems Analysts Limited and P.J. Usher Consulting Services Limited. 1986. Mackenzie Environmental Monitoring Project. 1985-1986 Final Report. Prep. for Indian and Northern Affairs Canada. 308 pp. + appendices.

BREAM HYPOTHESIS R-25

IMPROVED ACCESS AND INCREASED FISHING PRESSURE WILL DECREASE THE ABUNDANCE OF FISH AND AFFECT THEIR DISTRIBUTION

PARTICIPANTS

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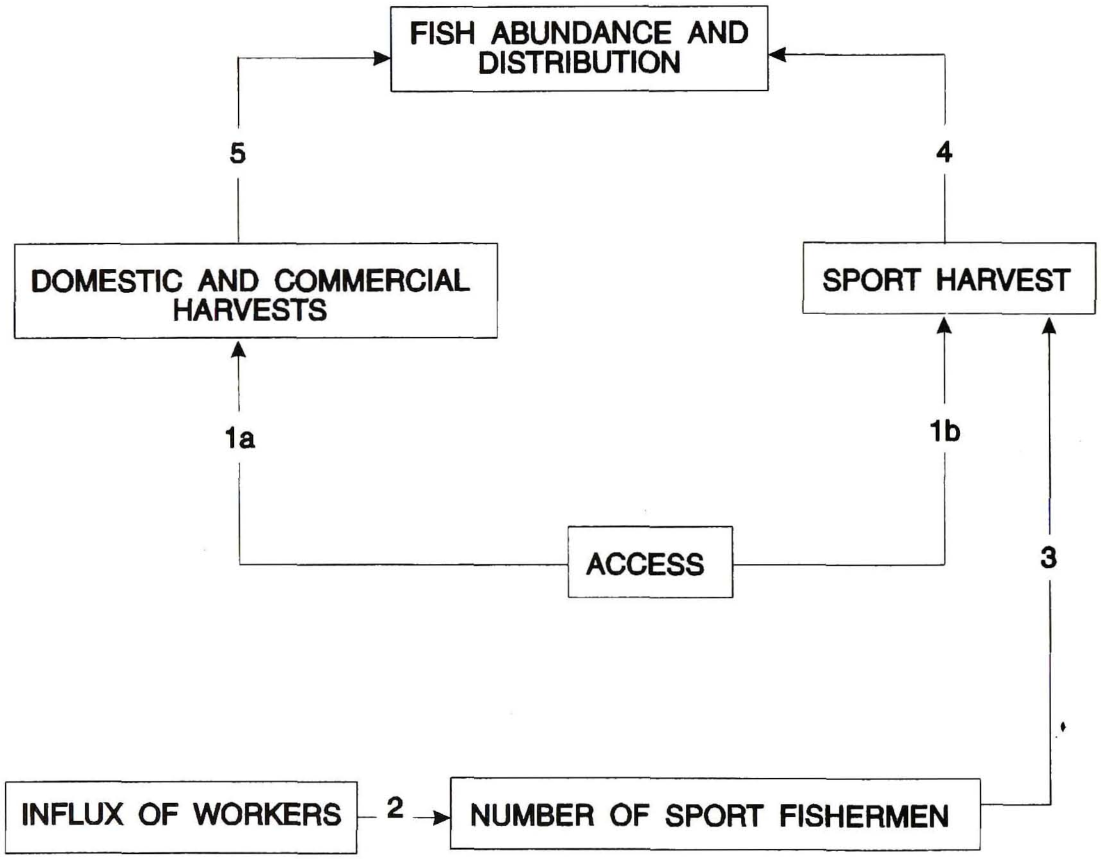
Mike Lawrence	David Thomas

This hypothesis was examined only briefly during the workshop. While it was concluded that the hypothesis is valid and the impacts of improved access and resultant increased fishing pressure on fish populations could be significant, members of the working group agreed that it would be more appropriate to evaluate this issue in a future workshop focusing on community-based concerns. It was noted that more information is now available on different fisheries than when this hypothesis was last evaluated as part of MEMP in 1986. However, little is actually known about the basic biology and population size of the species of fish captured. In the absence of this information, it is impossible to estimate the size of the fishery. DFO is presently conducting a study of Mackenzie Delta broad whitefish, which should be instrumental in providing information relevant to this hypothesis.

During further evaluation of this hypothesis, it will be important to add linkages from changes in fish abundance and distribution to fish harvest opportunities and patterns. Because present and future research are directed at effects of fishing pressure on fish populations rather than use of the resource, it was also suggested that research is necessary to refine the latter databases.

FIGURE 25-1

EFFECTS OF IMPROVED ACCESS AND FISHING PRESSURE ON THE ABUNDANCE AND DISTRIBUTION OF FISH



Linkages

1a,1b. Improved access will increase sport, commercial and domestic harvests of fish.

2. The number of sport fishermen will increase due to an influx of workers associated with hydrocarbon development.

3. An increase in the number of recreational fishermen will increase harvests of sport fish.

4. Increased sport harvest will reduce local and regional populations of sport fish, and alter their distribution and population structure.

5. Increased domestic and commercial harvests will reduce local and regional populations of fish, and alter their distribution.

The group concluded its brief discussion of this hypothesis by noting that concerns related to exploitation of fish resources due to increased access would be less in a development scenario that involved winter construction of a pipeline and associated facilities as is presently envisioned. During winter, most fish populations would be present in areas outside the pipeline corridor and there would be less interest in sport fishing at this time of year. However, if the pipeline corridor allows access to undiscovered overwintering areas (such as a deep riverine hole, coastal bay or a lake trout lake), there would be the potential of renewed interest in domestic or commercial winter fishing at these sensitive sites (K. Chang-Kue, pers. comm.).

BREAM HYPOTHESIS R-26

CONTAMINANTS FROM LOCAL AND DISTANT SOURCES WILL LEAD TO DECREASED ACCEPTABILITY AND AVAILABILITY OF FISH AS A FOOD SOURCE

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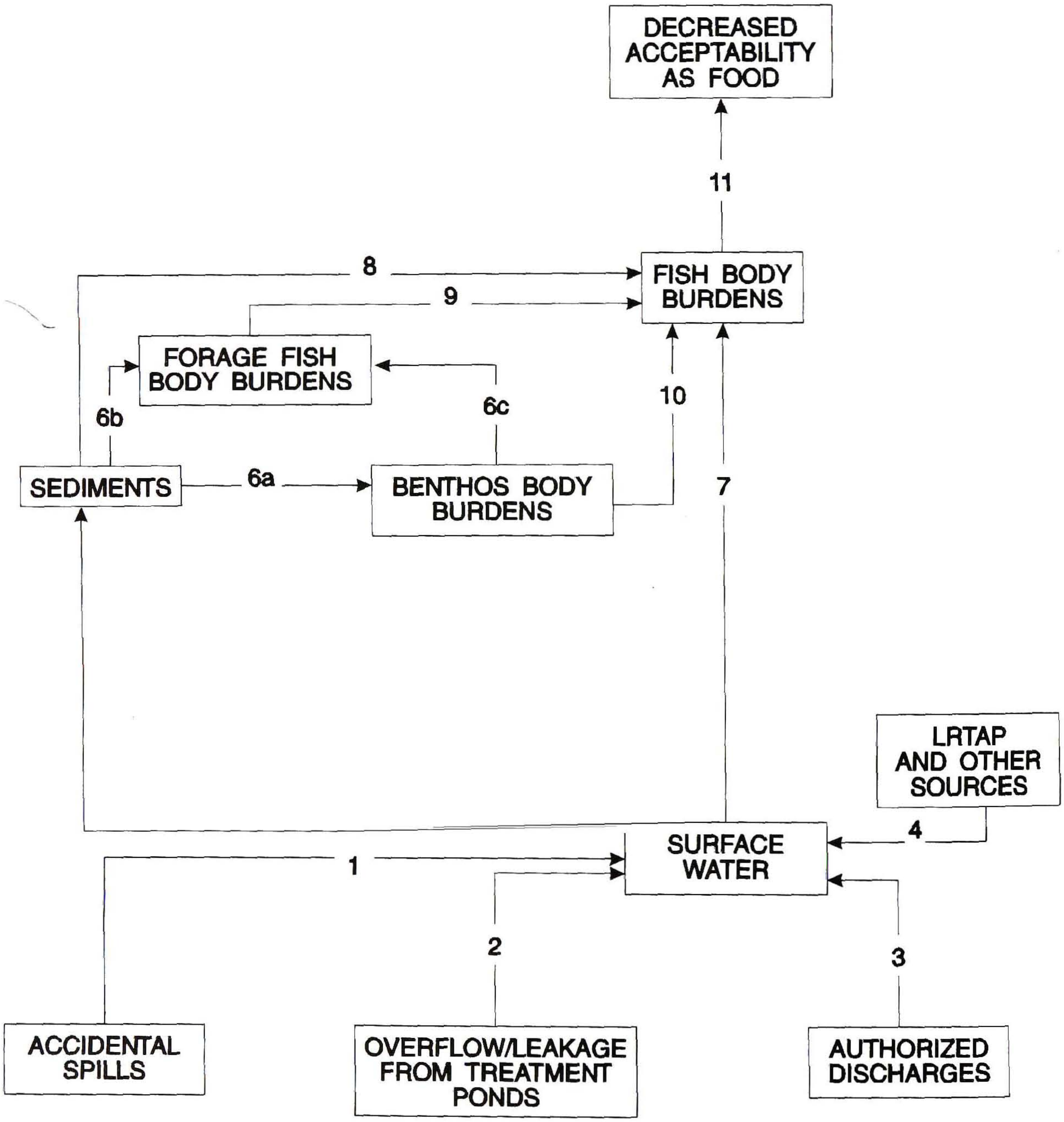
SYNOPSIS OF HYPOTHESIS R-26

This synopsis is provided for those who wish to understand the essence of Hypothesis 26, but have no strong interest in all the technical details. Readers that are interested in these technical details need not review this synopsis and can move directly to the main body of the discussion beginning on Page 211.

Under typical conditions associated with petroleum exploration, development and production, a variety of chemical contaminants enter the environment. Once in the environment, some of these contaminants are readily neutralised or are not incorporated into living things. Other contaminants, however, can persist in the environment for long periods of time and can become incorporated into animals. This becomes a concern when the exposure to these chemical contaminants affects the health of the animals themselves, the health of the animals (including humans) who eat them, or the quality of animals as food.

FIGURE 26-1

CONTAMINANTS FROM LOCAL AND DISTANT SOURCES WILL LEAD TO DECREASED ACEPTABILITY AND AVAILABILITY OF FISH AS A FOOD SOURCE



Linkages

1. Accidental spills of contaminants into rivers, streams and lakes will increase their concentrations in surface water.

2. Overflow/leakage from treatment ponds will lead to increased contaminant concentrations in surface water.

3. Authorized (regulated) discharges will lead to increased contaminant concentrations in surface water.

4. The input of contaminants due to long-range transport of atmospheric pollutants (LRTAP) will result in increased contaminant concentrations in surface water.

5. Increased contaminant concentrations in surface water will result in increased contaminant concentrations in sediments.

6a. Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in benthos.

6b. Increased contaminant concentrations in sediments will lead to increased body burdens in forage fish.

6c. Increased contaminant concentrations in benthos will lead to increased body burdens in forage fish.

7. Increased contaminant concentrations in surface water will lead to contaminant uptake by fish.

8. Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in bottom-feeding fish.

9. Increased contaminant body burdens in forage fish will lead to increased body burdens datory fish.

10. Increased contaminant body burdens in benthos will lead to increased body burdens in bottom-feeding fish.

11. Increased contaminant body burdens in fish will lead to decreased acceptability of fish as a food source by local residents.

The main concern in the Mackenzie River system is the possible build up of hydrocarbons and heavy metals (such as mercury, cadmium and lead) in fish as a result of petroleum industry activities. The reasons for this concern are that: (1) fish are currently used as food by native people; (2) the desirability of fish as food may increase in the future; (3) there have already been reports that the quality of some fish in the Mackenzie River system has deteriorated in recent years; and (4) there is a known relationship between the uptake of hydrocarbons by fish and a resulting decrease in palatability. The importance of this "tainting" issue is strengthened by the fact that eating patterns, harvesting activities and the desirability of fish can be severely altered even when only the suspicion of a taint exists.

There is a great deal of scientific information relating the accumulation of hydrocarbons and heavy metals in fish and the subsequent effect on fish health and the quality of fish flesh. Details are provided in the complete account of Hypothesis R-26 presented below. The following logical sequence of steps (the occurrence of these steps can be supported by scientific knowledge) outlines how contaminants can lead to decreased acceptability and availability of fish as a food source.

1. Contaminants are known to enter rivers, streams and lakes from petroleum-related activities due to accidental spills, overflow/leakage from treatment ponds, and authorised discharges.

2. These contaminants eventually become part of the sediments at the bottom of lakes and rivers.

3. Animals that live in the sediments can take up the contaminants into their bodies. The amount of contaminants in fish increases when they eat these sediment-dwelling animals or when they eat fish which have eaten the sediment-dwelling animals.

4. Fish can also take in contaminants directly from the water.

5. When certain levels of the contaminants are reached in fish flesh the texture of the fish, the taste of the fish or the appearance of the fish may change to the point that people find the fish undesirable as food or unhealthy to eat.

The participants of the BREAM workshop concluded on the basis of all the known information on this topic (including scientific, local and traditional knowledge), that potential tainting was a significant issue because it is a high profile issue and exists as a management problem even when only the perception of taint exists rather than a true taint. It is important on site-specific, local, regional and international spatial scales as well as on short-term and long-term time scales.

It was also recognised during the BREAM workshop that hydrocarbons and metals also enter the Mackenzie River system as the result of long-range transport from distant places. It was recommended that future studies be undertaken to estimate the contribution of these sources to the overall quantity of contaminants in the region. This recognises that the ultimate potential for tainting/quality deterioration of fish flesh will depend on the total of all contaminating substances, not just those that can be accounted for by petroleum-related activities.

INTRODUCTION

This hypothesis was previously called Hypothesis 15 during the MEMP exercise. It comprised two parts, the first (Hypothesis 15A) dealing with the effect of contaminants on potable water and the second (Hypothesis 15B) dealing with the effect of contaminants on fish. During the BREAM workshop, the hypothesis directed at potable water was deleted because potable water does not satisfy the definition of a valued ecosystem component. Consequently, BREAM R-26 involves only the hypothesis directed at fish as the VEC.

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 or near the study area, in the Mackenzie River system, 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 buildup of some of these substances in the receiving environment can, under certain conditions, result in bioaccumulation and biomagnification of some pollutants in fish. The potential for hydrocarbon or heavy metal contamination and subsequent decrease in the palatability of fish 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; (2) reports of the possible deterioration of fish quality in the Mackenzie River; and (3) experiences associated with tainting elsewhere in the world.

On the basis of the magnitude of contaminant inputs, it is expected that hydrocarbons and heavy metals will be the areas of greatest potential concern. Accordingly, they become the focus for evaluation of this hypothesis.

Hydrocarbons

Exposure of fish to hydrocarbons can result in a range of sublethal, physiological, pathological and behavioural effects. Some of the pathological changes and abnormalities observed in fish 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 (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 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. 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, the molecular structure of, and number of carbons in 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.

While many researchers have reported many specific compounds in fish that have been shown to cause taint or be associated with it, few have described threshold concentrations of these compounds.

Motohiro and Iseya (1976) conducted laboratory studies to detect organoleptically the taint in scallop caused by various hydrocarbons. They found that n-tetradecane and/or n-hexadecane did not cause a taint at the 0.3 mg/g (300 ppm) level, while crude oil, xylene and toluene caused taint when present at the 0.1 to 0.2 mg/g level.

C_{11} - C_{22} n-paraffins, 5-ethyltridecane and 8-propylpentadecane were detected in brown trout (*Salmo trutta L.*) caught eleven days after a diesel spill in the area (Mackie *et al.*, 1972).

Shipton *et al.* (1970) determined the composition of a volatile extract from mullet (*Mugil cephalus*) possessing a kerosene taint to be n-tetradecane, naphthalene, 2-methylnaphthalene, 1-methylnaphthalene and possibly methyl-isopropyl-benzene, 3-(2-methylphenyl)pentane, 2,6-dimethyl-1,2,3,4-tetra-hydronaphthalene and 2,3-dimethyl-1,2,3,4-tetrahydronaphthalene.

Kameda and Yasumoto (1974) found that oily tainted fish contained C_9-C_{11} hydrocarbons, alkylbenzene, olefins and a trace of compounds containing sulphur.

Connell *et al.* (1975) found kerosene-like hydrocarbons (C_9 -C_{15} n-alkanes) in bream fish (*Mylio australis*) exposed to kerosene and judged to have a kerosene-like taste. Connell (1974) also found a similar mixture of hydrocarbons in tainted sea mullet (*Mugil cephalus*). These compounds were found at concentration levels ranging from 25 to 500 mg/kg.

Laboratory studies conducted by Ogata and Miyake (1973) identified monoaromatic compounds such as toluene, benzene and o-, m- and p-xylene in tainted fish and eels. Later, Ogata *et al.* (1979) conducted laboratory experiments to identify substances transferred to fish and shellfish from petroleum suspension. Eels and short-necked clams were found to take up alkylated naphthalenes and dibenzothiophene. The clams also contained alkylated dibenzothiophenes.

Paradis and Ackman (1975) analyzed lobster tissue which had been exposed to diesel fuel, and were judged to be tainted. They found low levels (2 to 4 ppm) of hydrocarbons in the tissue. Its composition was very similar to that of marine diesel characterized as primarily straight chain hydrocarbons from C_9 to C_{24} superimposed on a broad envelope region of unresolved minor peaks and high levels of pristane and phytane.

GESAMP (1977) reviewed available data for tainting thresholds of various hydrocarbons. They reported a threshold of 5 ppm for kerosene spiked into muscle tissue (Kerkhoff, 1974), 4 to 12 ppm of diesel oil components in lobster (Paradis and Ackman, 1975) to 10 to 30 ppm of crude oil in spiked tissue (Whittle and Mackie, 1976). Kerkhoff (1974; cited by GESAMP, 1977) reported that the middle distillate fraction of crude oil (e.g., diesel fuel), contains many of the odorous compounds present in the crude. Diesel in water can be detected nasally at 0.0005 ppm, while fuel and crude oils can only be detected at 0.1 to 0.5 ppm.

Brandl *et al.* (1976) simulated the effects of an oil spill on salmon kept in the laboratory. Tainting was observed and the components of significance in the tissue were found to be alkyl-naphthalene and benzene compounds. The taint threshold level of 0.3 ppm naphthalene was reported in this study.

McGill *et al.* (1987) studied dabs (*Limanda limanda*) caught near the Beatrice oil platform. Although contamination from petrogenic hydrocarbons (n-alkanes and polynuclear aromatic hydrocarbons) was apparent, the fish were not found to have a taint.

Connell and Miller (1981) published a review article on the topic of the effects of sub-lethal concentrations of hydrocarbons in the marine ecosystem and includes a list of compounds which can cause tainting of fish flesh and other aquatic organisms. The estimated threshold level of each compound in water concentration that can cause tainting is also given. These data indicate that the chlorophenols, cresols, kerosene and butylmercaptan have the lowest thresholds in water.

From the review of the literature, a list of candidate compounds implicated in tainting can be compiled. This is shown in Table 26-1. A compilation of hydrocarbon compounds for which a tainting threshold has been reported is given in Table 26-2.

Heavy Metals

Exposure of fish to heavy metals can result in mortality and a range of sub-lethal 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 biomagnified through food chains and, therefore, should not affect human health. On the other hand, it has been well documented that mercury bioaccumulates, biomagnifies 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.

TABLE 26-1 Compounds Identified as Taints Ranked By Frequency of Citation

Compound Name	Compund Type	Citations in Literature
Naphthalene	PAH	12
C9-C13 n-Alkanes	Alkanes	8
C1-Naphthalene	Alkylated PAH	8
Xylenes	Volatile Aromatics	7
Toluene	Volatile Aromatics	6
C2-Naphthalene	Alkylated PAH	6
Propylbenzenes	Alkylated Benzenes	4
C14-C20 n-Alkanes	Alkanes	4
Trimethylbenzenes	Alkylated Benzenes	3
Thiophene	S-Hetero Aromatic	3
Ethylbenzene	Volatile Aromatic	3
3(2-Methylphenyl)Pentane	Volatile Aromatic	3
2,6-Dimethyl-Tetrahydronaph.	Alkylated PAH	3
Dichlorophenols	Chlorophenols	3
Methyl Isopropylbenzene	Volatile Aromatic	3
Dibenzothiophene	S-Hetero PAH	3
Pyridine	N-Hetero Aromatic	3
n-Butylmercaptan	Mercaptan	2
1-Decene	Olefin	2
Ethanethiol	Mercaptan	2
Chlorophenols	Chlorophenols	2
Alkyl Dibenzothiophenes	S-Hetero PAH	2
C3-Naphthalene	Alkylated PAH	2
Dichlorobenzenes	Chlorinated Volatile Aromatics	2
Phenol	Phenol	2
Butylbenzenes	Volatile Aromatics	2
Styrene	Volatile Aromatic	2
Naphthols	Phenols	2
Quinolene	N-Hetero Aromatic	2
Alkyl-Chlorophenols	Chlorophenols	2
Cresols	Phenols	2
Acetophenone	OHC	2
Benzene	Volatile Aromatic	2
Fluorene	PAH	1
Thiophenol	Phenol	1
Dibenzofuran	PAH	1
Tetramethylbenzene	Volatile Aromatic	1
Butanol	OHC	1
Diphenyl Ether	Aromatic Ether	1
Alkyl Styrene	Volatile Aromatic	1
Dimethylamine	Amine	1
Benzothiophene	S-Hetero Aromatic	1
Cyclohexene	Olefin	1
Pristane	Alkane	1
Isopropylphenol	Phenol	1

TABLE 26-2 Tainting Threshold Concentrations for Selected Hydrocarbon Compounds

Compound	Tainting Threshold in Water (ppb) (Connell and Miller 1981)	Boiling Point °C
Benzene	250 - 1000	80
Toluene	250	110
Ethylbenzene	250	136
O-Xylene	250 - 1000	144
Phenol	1000 - 10,000	182
m-Cresol	200	202
Naphthalene	100	218
Quinoline	500 - 1000	238

EVALUATION OF LINKAGES

Link 1: **Accidental spills of contaminants into rivers, streams and lakes will increase their concentrations in surface water.**

Accidental spills of hydrocarbons, particularly refined hydrocarbons are an inevitable fact of life around hydrocarbon developments. This link is, therefore, valid.

Link 2: **Overflow/leakage from treatment ponds will lead to increased contaminant concentrations in surface water.**

This link is valid, but the extent to which contaminants may enter the surface 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.

In a study conducted by Hardy BBT (1988), drilling waste containment in eight abandoned sumps in the Mackenzie Valley region was assessed. It was found that six of the eight sumps had leaked to some degree.

Link 3: **Authorized (regulated) discharges will lead to increased contaminant concentrations in surface water.**

This link is valid.

From time to time, contaminants are intentionally released to the environment as part of the routine operations of hydrocarbon development. Such operational discharges are regulated by permit. The refinery at Norman Wells is an example. This refinery produces approximately 500 m^3/day oil and the waste discharge from the refinery to the Mackenzie River is 45 L/sec. Contaminant concentrations in the effluent are regulated by permit as follows:

oil and grease	(max. annual average)	5 mg/L
phenols	(max. annual average)	0.10 mg/L
sulphide	(max. annual average)	0.10 mg/L
ammonia nitrogen	(max. annual average)	2.0 mg/L
pH		between 6 and 9.5

Link 4: **The input of contaminants due to long-range atmospheric transport will result in increased contaminant concentrations in surface water.**

This link is valid.

Long-range transport of atmospheric pollutants (LRTAP) is a well acknowledged mechanism for delivering metals, radionuclides, hydrocarbons, and organochlorines to the Canadian Arctic from distant sources (Barrie 1986; Biddleman *et al.* 1976; Eisenreich *et al.* 1979; Hoff and Chan, 1986; Ottar 1981; Rapaport and Eisenreich 1986; Thomas *et al.* 1992; Lockhart *et al.* 1992; Hargrave *et al.* 1988).

In addition, contaminants have reached the lower Mackenzie River basin from activities within Canada, such as petroleum hydrocarbons from oil sands and coal mining activities in the Athabasca River drainage area, and organochlorines, including dioxins and furans, from effluents of pulp mills operating in British Columbia and Alberta.

Link 5: **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, chlorinated 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 solution; and
3. the affinity of the contaminant for particle surfaces.

Of particular interest in the area of particle-contaminant associations are toxic organic compounds. Many of these compounds such as organochlorines and polynuclear aromatic hydrocarbons (PAH) are hydrophobic in nature. Consequently, suspended particles are a very effective means of removing such compounds from the liquid phase and concentrating them in the sediment.

The degree to which contaminant concentrations could increase in sediments will depend on how far out from the source of contamination the particles settle, 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 6a: Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in benthos.

Benthic invertebrates have been shown to accumulate in their tissues the various classes of aliphatic, alicyclic and aromatic hydrocarbon compounds found in crude oil and refined petroleum products (Ehrhardt 1972; Scarratt and Zitko 1972; Farrington and Quinn 1973; Clark and Finley 1974; Fossato and Siviero 1974; Hunter *et al.* 1974; Mayo *et al. 1974*; Stegeman 1974; DiSalvo *et al.* 1975; Ehrhardt and Heinemann 1975; Neff and Anderson 1975; Gilfillan *et al.* 1977; Sirota and Uthe 1981; Widdows *et al.* 1983). In fact, the bioaccumulation of the contaminants (including hydrocarbons) by benthic invertebrates is the foundation of the U.S. National Mussel Watch Programme (Goldberg 1975; Goldberg *et al.* 1978; Philips and Segar 1986; Risebrough *et al.* 1983).

Specific examples of bioaccumulation of hydrocarbons by benthic invertebrate are given below.

(a) The marine worm, *Neanthes arenaceodentata* accumulated 30 ppm of aromatic hydrocarbons and 5 ppm aliphatic hydrocarbons when exposed to the water-soluble fraction of No. 2 fuel oil for 4 hours (Rossi and Anderson 1976).

(b) Bivalves (*Ostrea lurida* and *Mytilus edulis*) accumulated paraffinic hydrocarbons following exposure to outboard motor fuel (Clark and Finley 1974).

(c) The clam *Rangia cuneata* accumulated benzo(a)pyrene from sea water during a 24-hour exposure (Neff and Anderson 1975).

(d) Uptake and depuration of petroleum hydrocarbons were measured in five species of bivalves (Boehm 1983), a sea urchin and a polychaete (Engelhardt and Norstrom 1982) at the Baffin Island Oil Spill site on Baffin Island following experimental spills of partially weathered Lago Medio crude and an oil/dispersant mixture in 1981. Petroleum hydrocarbons were detected in the tissues of all of the species within days of both spills. Initially, the oil was detected primarily in the gut of bivalves. Persistence of the hydrocarbons in the sediments resulted in a steady uptake by deposit feeders and tissue concentrations remained high. By the summer of 1982, the hydrocarbon concentrations in filter feeders were much lower than in deposit feeders as the deposit feeders continued to remove significant quantities of oil from the sediment, whereas the filter feeders had depurated most of their body burden of hydrocarbons by this time.

(e) Blackman and Law (1981) studied the uptake of hydrocarbons from North Sea diesel-oiled cuttings by the bivalve detritivore *Scrobicularia plana*. They found maximum tissue concentrations of 6200 ppm and concluded that uptake must have occurred directly from the solid phase to produce such high body burdens.

Benthic invertebrates can also bioaccumulate metals as indicated by the following table (data from EPA 1979):

Element	Bioconcentration factor in freshwater invertebrates conc. in invertebrate tissue / conc. in water
Cd	4000
Cr	2000
Cu	100
Pb	200
Hg	100 000
Ni	100
Zn	40 000

For both hydrocarbons and metals, uptake is strongest from water and food. Direct uptake from sediment is usually insignificant. However, animals in contact with contaminated sediment can still show considerable bioaccumulation when contaminant solubilisation (resuspension) occurs at the sediment water interface. The rate of depuration of hydrocarbons and metals from the benthic invertebrates varies from days to years depending on the exposure concentrations and the duration of the exposure.

Link 6b: **Increased contaminant concentrations in sediments will lead to increased body burdens in forage fish.**

The major route of intake of contaminants by fish is through food and water. Direct uptake from sediment is not significant. Fish in contact with sediment can show considerable bioaccumulation; however this usually results when contaminants are mobilized to the liquid phase at the sediment/water interface.

Link 6c: **Increased contaminant concentrations in benthos will lead to increased body burdens in forage fish.**

This link is strong. Food is a major pathway of contaminants into fish.

Link 7: Increased contaminant concentrations in surface water will lead to contaminant uptake by fish.

This is the most important pathway for uptake of hydrocarbons 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 mediated detoxification processes (MFO) 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. Uptake is strongest from food and water. 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. The following table summarizes the bioconcentration factors of several metals in freshwater fish (EPA 1979):

Element	Bioconcentration factor in fish conc. in invertebrate tissue / conc. in water
Cd	3000
Cr	200
Cu	200
Pb	60
Hg	1000
Ni	40
Zn	1000

Organochlorines are generally very lipophilic and consequently bioaccumulate at all levels of the food chain including fish (Muir *et al.* 1992; Hargrave *et al.* 1988)

Link 8: **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.

Link 9: **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, although most metals are readily transferred among trophic levels, it is believed that only mercury and cadmium biomagnify. Organochlorines are generally very mobile among trophic levels (Muir *et al.* 1992) and would very likely be transferred from forage fish to predatory fish.

Link 10: **Increased contaminant body burdens in benthos will lead to increased body burdens in bottom-feeding fish.**

As outlined in Link 9, metals and organochlorines will likely be transferred from benthos to bottom-feeding fish to a much greater extent than would hydrocarbons.

Link 11: **Increased contaminant body burdens in fish will lead to decreased acceptability of fish as a food source by local residents.**

This link is valid. The presence of taint has had demonstrable negative impact on fisheries in Japan (Kimura 1988) and the U.S.A. (O'Connor and Huggett 1988). In the Mackenzie region (river and inland "fishing lakes") fishermen have described fish flesh as having a bad taste, bad smell and bad appearance (lesions) and texture. Whitefish appear to be affected most often. It has also been reported that fishermen might have to catch many more fish than they want to catch in order to obtain sufficient palatable ones. Ultimately, an overriding factor in the area of fish taint is this: fish need not be truly tainted to cause decreased acceptability by local residents; often all it takes is the mere perception or suggestion that fish might be tainted to deter consumers.

ASSESSMENT OF IMPACTS

The group concluded that the potential tainting of fish was important on all spatial levels; i.e. (1) site-specific (near a point source); (2) local (fish are mobile and can move within a local area); (3) regional (fish can migrate on a regional basis); and (4) international (some species (i.e. arctic cisco, charr and salmon) can move between Canadian and U.S. waters). The temporal scale can be both short-term (aftermath of spills) and long-term (collective effects of chronic exposure to hydrocarbons). The status of the assessment was judged SIGNIFICANT because tainting is a high profile issue and exists as a management problem even when only the perception of a taint exists rather than a true taint.

RECOMMENDED RESEARCH AND MONITORING

The working group agreed that there was a need to determine the relative importance of local and LRTAP sources for the major contaminants (metals, petroleum hydrocarbons, PAH and organochlorines) in the study region. This would include obtaining an understanding of (1) the standing stock of contaminants in and flux of contaminants to air, water, sediment and biota of the region; (2) temporal trends; and (3) spatial trends. A further research need would be to identify which contaminant pathways are most relevant to each harvest group of the area.

LITERATURE CITED

Barrie, L.A. 1986. Arctic air pollution: an overview of current knowledge. Atmos. Environ. 20, 643-663.

Biddleman, T.F., C.P. Rice and C.E. Olney. 1976. High molecular weight chlorinated hydrocarbons in the air and sea: Rates and mechanisms of air/sea transfer. (In) H.L. Windom and R.A. Duce. Marine Pollutant Transfer. pp. 323-351.

Blackman, R.A.A. and R.J. Law. 1981. The oil content of discharged drill cuttings and its availability to benthos. International Council for the Exploration of the Sea. ICES CM 1981/E:23.

Boehm, P.D. 1983. Chemistry 2: Analytical biogeochemistry - 1982 study results. (BIOS) Baffin Island Oil Spill working report 82-2. Environmental Protection Service. Environment Canada. Ottawa. 260 pp.

Brandl, P.O., O. Grahl-Nielsen, T. Neppelberg, K.H. Palmork, K. Westrheim, S. Wilhelmsen. 1976. Oil tainting of fish: a laboratory test on salmon and saithe. ICES CM 1976/E:33. (Mimeo).

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.

Clark, R.C. Jr. and J.S. Finley. 1974. Paraffin hydrocarbon patterns in petroleum polluted mussels. Marine Pollution Bulletin 4:172.

Connell, D.W. 1974. A kerosene-like taint in the sea mullet *Mugil cephalus* (L.). 1. Composition and environmental occurrence of the tainting substances. Aust. J. Mar., Freshwater. Res., 25, 7-24.

Connell, D.W. K. Cox and R.L. McLauchlan. 1975. Occurrence of kerosene-like hydrocarbons in the Bream *Mylio australis* Gunther. Aust. J. Mar. Freshwat. Res. 26, 419-22.

Connell, D.W. and G.J. Miller. 1981. Petroleum hydrocarbons in aquatic ecosystems -behaviour and effects of sublethal concentrations: Part 2. Critical Reviews in Environmental Control. 11(2), 105-162.

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. Bd. Can. 35: 1060-1066.

DiSalvo, L.H., H.E. Guard and L. Hunter. 1975. Tissue hydrocarbon burden of mussels as a potential monitor of environmental hydrocarbon insult. Environmental Science and Technology 9:247.

Ehrhardt, M. 1972. Petroleum hydrocarbons in oysters from Galveston Bay. Environmental Pollution, 3:257.

Ehrhardt, M. and J. Heinemann. 1975. Hydrocarbons in blue mussels from the Kiel Bight. pp. 221-225. (In) Marine Pollution Monitoring (Petroleum) National Bureau of Standards Special Publication 409.

Eisenreich, S.J., G.J. Hollod and T.C. Johnson. 1979. Accumulation of polychlorinated biphenyls (PCBs) in surficial Lake Superior Sediments. Atmospheric deposition. Environ. Sci. Tech. 13, 569-573.

Englehardt, F.R. and N. Norstrom. 1982. Baffin Island Oil Spill. Environmental Protection Service. Environment Canada, Ottawa.

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. Toxicology 1, 175-186.

EPA. 1979. Water related environmental fate of 129 Priority Pollutants. United States Environmental Protection Agency. EPA 440/4-79-029.

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.

Farrington, J.W. and J.G. Quinn. 1973. Petroleum hydrocarbons in Narragansett Bay. I. Survey of hydrocarbons in sediments and clams (*Mercenaria mercenaria*). Estuarine and Coastal Marine Science 1:71.

Fossato, V.U. and E. Siviero. 1974. Oil pollution monitoring in the lagoon of Venice using the mussel *Mytilus galloprovincialis*. Marine Biology 25:1.

Gardner, G.R. 1975. Chemically-induced lesions in estuarine or marine teleosts. pp. 657-693. (In) W.E. Ribelin and G. Migaki (eds.). The pathology of fishes. Madison, Wisconsin.

GESAMP. 1977. IMCO/FAO/UNESCO/WHO/IAEA/UN. Joint group of experts on the scientific aspects of marine pollution (GESAMP). Impact of oil on the marine environment. Rep. Stud. GESAMP, 6, 250 pp.

Giesy, 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.

Gilfillan, E.S., D.W. Mayo, D.S. Page, D. Donovan and S. Hanson. 1977. Effects of varying concentrations of petroleum hydrocarbons in sediments on carbon flux of *Mya arenaria*. pp. 299-314. (In) Physiological responses of marine biota to pollutants (F.J. Vernberg. A. Calabrese, F.P. Thurnberg and W.B. Vernberg, Eds). Academic Press, New York.

Goldberg, E.D. 1975. The Mussel Watch - a first step in global marine monitoring. Marine Pollution Bulletin 6:111.

Goldberg, E.D., V.T. Bowen, J.W. Farrington, G. Harvey, J.H. Martin, P.L. Parker, R.W. Risebrough, W. Robertson, E.D. Schneider and E. Gamble. 1978. The Mussel Watch. Environmental Conservation 5:101

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 of fish from the Severn Estuary and Bristol Channel. Mar. Pollut. Bull. 5:61-63.

Hardy BBT. 1988. Geophysical assessment of waste drilling fluid containment sites in the Mackenzie Valley Region, N.W.T. Environmental Studies No. 54. Indian and Northern Affairs Canada. Ottawa.

Hargrave, B.T., W.P. Vass, P.E. Erickson and B.R. Fowler. 1988. Atmospheric transport of organochlorines to the Arctic Ocean. Tellus 40B, 480-493.

Hawkes, J.W., E.H. Gurger, 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.

Hoff, R.M. and K.-W. Chan. 1986. Atmospheric concentrations of chlordane at Mould Bay, N.W.T., Canada. Chemosphere 15, 449-452.

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.

Hunter, L., H.E. Guard and L.H. Disalvo. 1974. Determination of hydrocarbons in marine organisms and sediments by thin layer chromatography. pp. 213-216. (In) Marine Pollution Monitoring (Petroleum). National Bureau Standards Special Publication 409.

Kameda, N. and Yasumoto, T. 1974. A study on the composition in oil wastes for taint of fish. Rept. Appl. Res. Agency Fishery. 1-13 (in Japanese).

Kerkhoff, M. 1974. Oil pollution of the shellfish in the Oosterschelde Estuary: December 1973. ICES C.M. 174/E:13:

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.

Kimura, I. 1988. Aquatic pollution problems in Japan. Aquatic Toxicology II, 287-301.

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.

Lockhart, W.L., R. Wagemann, B. Tracey, D. Sutherland and D.J. Thomas. 1992. Presence and implications of chemical contaminants in the freshwaters of the Canadian Arctic. The Science of the Total Environment. 122, 165-243.

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 467-59. (In) D.A. Wolfe (ed). Fate and effects of petroleum hydrocarbons in marine ecosystems and organisms. Permagon Press, New York. 478 pp.

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. Proceeding of international workshop on *in-situ* sediment contaminants August 20-24, 1984. Aberystwyth, Wales.

Mayo, D.W., D.J. Donovan and L. Jiang. 1974. Long-term weathering characteristics of Iranian crude oil: The wreck of the *Northern Gulf*. pp. 201-208. (In) Marine Pollution Monitoring (Petroleum). National Bureau of Standards Special Publication 409.

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. Bd. Can. 35:657-664.

McGill, A.S., P.R. Mackie, P. Howgate and J.G. McHenery. 1987. The flavour and chemical assessment of Dabs (*Limanda limanda*) caught in the vicinity of the Beatrice Oil Platform. Mar. Pollut. Bull., 18, 186-189.

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. 15, No. 6-7.

Motohiro, T. and Iseya, Z. 1976. Effects of water polluted by oil on aquatic animals. II. n-paraffins, aromatic hydrocarbons and crude oil concentration on taint in scallop (*Pecten yessoensis*). Bull. Fac. Fish. Hokkaido Univ. 26(4), 367-372.

Muir, D.C.G., R. Wagemann, B.T. Hargrave, D.J. Thomas, D.B. Peakall and R.J. Norstrom. 1992. Arctic marine ecosystem contamination. The Science of the Total Environment 122, 75-134.

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 pp.

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.

Neff, J.M. and J.W. Anderson. 1975. Accumulation, release and distribution of benzo(a)pyrene-C14 in the clam *Rangia cuneata*. pp. 169-171. (In) Proceedings of 1975 Conference on prevention and control of oil pollution.

Nitta, T. 1972. Marine pollution in Japan. (In) M. Ruivo (ed). Marine pollution and sea life. Fishing News (Books). 77 pp.

O'Connor, J.M. and R.J. Huggett. 1988. Aquatic pollution problems, North American coast, including Chesapeake Bay. Aquatic Toxicology II, 163-190.

Ogata, M. and Y. Miyake. 1973. Identification of substances in petroleum causing objectionable odours in fish. Wat. Res. 7, 1493-1504.

Ogata, M., Y. Miyake and Y. Yamasoki. 1979. Identification of substance transferred to fish or shellfish from petroleum suspension. Wat. Res., 13, 613-618.

Ottar, B. 1981. Transfer of airborne pollutants to the arctic regions. atmos. Environ. 15, 1439-1445.

Paradis, M. and R.G. Ackman. 1975. Differentiation between natural hydrocarbons and low level diesel contamination in cooked lobster meat. J. Fish Res. Bd. Can. 32:316-320.

Philips, D.J.H. and D.A. Segar. 1986. Use of bio-indicators in monitoring conservative contaminants: programme design imperatives. Marine Pollution Bulletin 17:10.

Rapaport, R.A. and S.J. Eisenreich. 1986. Atmospheric deposition of toxaphene to eastern North America derived from peat accumulation. Atmos. Environ. 20, 2367-2379.

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. Wat. 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. Bd. Can. 32:1339-1345.

Risebrough, R.W., B.W. De Lappe, W. Walker II, B.R.T. Simoneit, J. Grimalt, J. Albaiges, J.A.G. Regueiro, A.B. Nolta and M.M. Fernandez. 1983. Application of the Mussel Watch concept in studies of the distribution of hydrocarbons in the coastal zone of the Ebro Delta, Marine Pollution Bulletin 14:181.

Rosenthal, H. and D.F. Alderice. 1976. Sublethal effects of environmental stressors, natural and pollutional, on marine fish eggs and larvae. J. Fish. Res. Bd. Can. 33:2047-2065.

Rossi, S.S. and J.W. Anderson. 1976. Toxicity of water-soluble fractions of No. 2 fuel oil and south Louisiana crude oil to selected stages in the life history of the polychaete, *Neanthes arenaceodentata*. Bull. Environ. Contam. Toxicol. 16:18.

Sabo, D.J. and J.J. Stegeman. 1977. Some metabolic effects of petroleum hydrocarbons in marine fish. pp. 337-357. (In) F.J. Vernberg, A. Calabrese, F.P. Thurberg and W.B. Vernberg (eds). Physiological responses of marine biota to pollutants. Academic Press. New York.

Scarratt, D.J. and V. Zitko. 1972. Bunker C oil in sediments and benthic animals from shallow depths in Chedabucto Bay, N.S. J. Fish. Res. Bd. Can 19:1047.

Shipton, J., J.H. Lost, K.E. Murry and G.L. Vole. 1970. Studies of kerosene-like taint in mullet (*Mugil cepholus*). II. Chemical nature of the volatile constituents. J. Sci. Td. Agric. 21, 429-432.

Sirota, G.R. and J.F. Uthe. 1981. Polynuclear aromatic hydrocarbon contamination in marine shellfish. pp. 329-341. (In) Polynuclear Aromatic Hydrocarbons. M. Cooke and A. Dennis (eds). Battelle Press. Columbus, Ohio.

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.

Stegeman, J.J. 1974. Hydrocarbons in shellfish chronically exposed to low levels of fuel oil. pp. 329-347. (In) Pollution and Physiology of Marine Organisms. F.J. Vernberg and W.G. Vernberg (eds).

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. pp 71-77. (In) D.A. Wolfe (ed). Fate and effects of hydrocarbons in marine ecosystems and organisms. Permagon Press, New York. 478 pp.

Thomas, D.J., B. Tracey, H. Marshall and R.J. Norstrom. 1992. Arctic terrestrial ecosystem contamination. The Science of the Total Environment 122, 135-164.

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 pp.

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. pp. 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.

Whittle, K.J. and P.R. Mackie. 1976. Hydrocarbons in marine zooplankton and fish; Part II. Fish hydrocarbon levels. (In) Effects of Pollutants on Aquatic Organisms. A.P.M. Lockwood (ed). Cambridge, England. Cambridge University Press. pp. 85-105.

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.

BREAM HYPOTHESIS R-27

THE CONSTRUCTION AND PRESENCE OF LINEAR CORRIDORS WILL AFFECT THE NUMBER, DISTRIBUTION AND QUALITY OF FISH, AND FISHING SUCCESS

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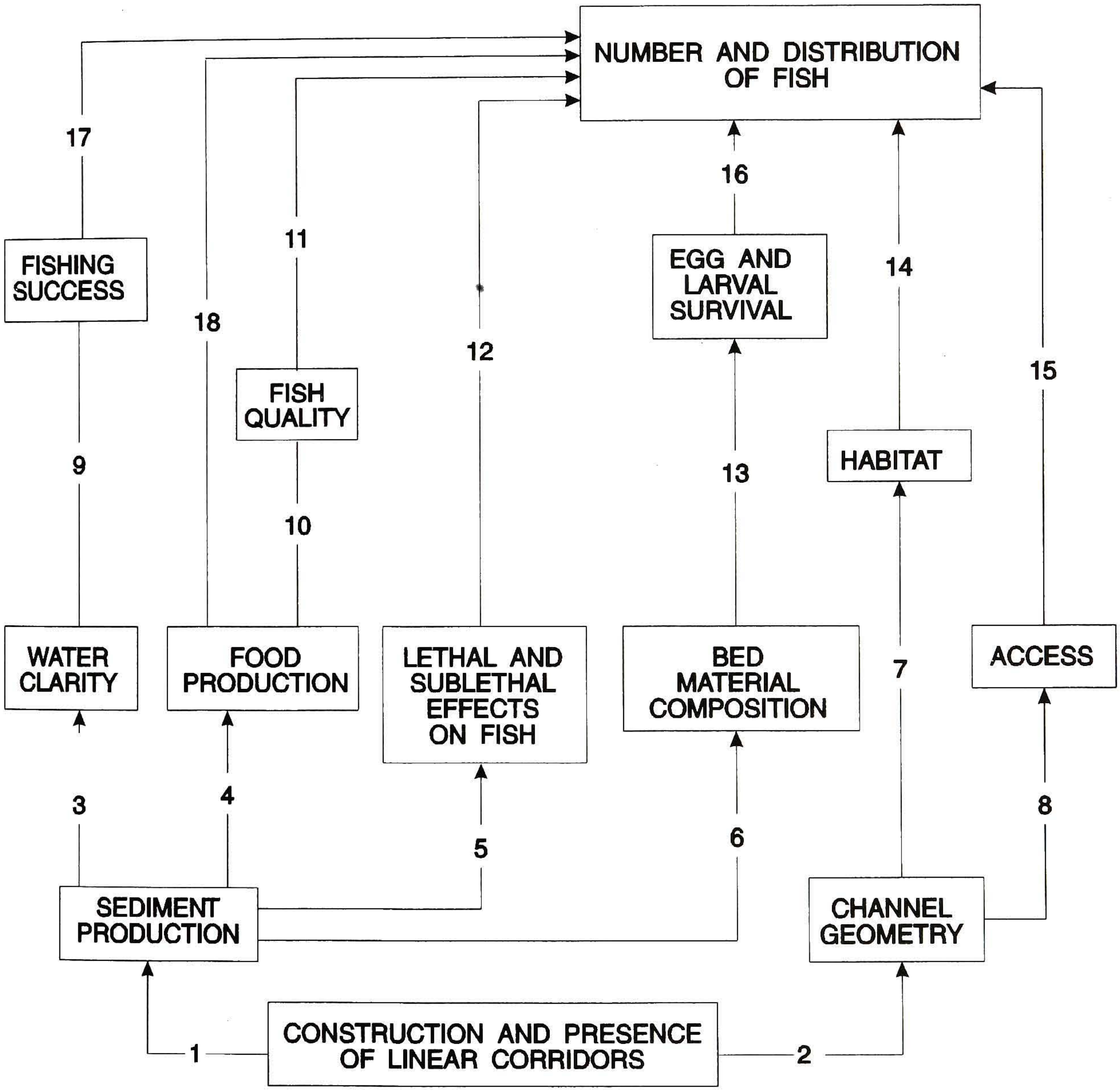
Brian Fergusson	Doug Meade
Wilfred Jackson	Don Meisner
Mike Lawrence	David Thomas

As in the case of Hypothesis No. 25, only a brief discussion of this hypothesis occurred during the workshop. Again, it was concluded at the outset that issues relating to fishing success and harvest opportunities/patterns would be more appropriately assessed by a different group in a community-based concerns workshop at some future date. Participants noted, however, that before this hypothesis is re-evaluated there is need to restructure some of its linkages such that fishing success rather fish populations is its primary focus. Effects of construction and the presence of linear corridors could have a signicant effect on fish numbers, quality and distribution, as well as on fishing success, but the group also concluded that such effects would be mitigable.

FIGURE 27-1

EFFECTS OF CONSTRUCTION AND PRESENCE OF LINEAR CORRIDORS ON THE NUMBER, DISTRIBUTION AND QUALITY OF FISH, AND FISHING SUCCESS



Linkages

1. Construction and operation of linear corridors will increase rates of sediment production at specific locations or over large areas.

2. Construction activities will alter channel configuration and morphometry at specific locations.

3. Increased rates of sediment production at specific locations will decrease water clarity.

4. Increased rates of sediment production at specific locations will decrease the abundance or availability of prey species.

5. Increased suspended sediment concentrations and exposure durations will have lethal and sub-lethal effects on fish and will change their behaviour patterns.

6. Local changes in sediment production will affect streambed material size.

7. Alterations in channel morphology will directly affect the extent or distribution of instream habitat at specific locations.

8. Local changes in channel geometry or thermal regime will result in blockage of fish movement.

9. Local decreases in water clarity will decrease angling success and increase gill net fishing success.

10. Local decreases in the production of prey organisms will reduce the size and quality of fish.

11. Local decreases in the production of prey organisms will result in fish mortality or changes in their distribution.

12. Fish avoidance, attraction or migrations due to high suspended sediment concentrations will affect the number and distribution of fish.

13. Increased concentrations of fine-textured materials within the river bed will reduce egg and larval fish survival.

14. Local changes in the amount and quality of habitat will change the number and distribution of fish.

15. Local restrictions in access will reduce spawning or rearing success and overwinter survival and, therefore, affect the number and distribution of fish.

16. Local decreases in fish egg and larval survival rates will reduce numbers and alter the distribution of fish.

17. Changes in fishing success will affect the number and distribution of fish.

18. Local decreases in the production of prey organisms will affect the number and distribution of fish.

BREAM HYPOTHESIS R-28

WAGE EMPLOYMENT WILL CHANGE THE HARVEST OF WHITE WHALES

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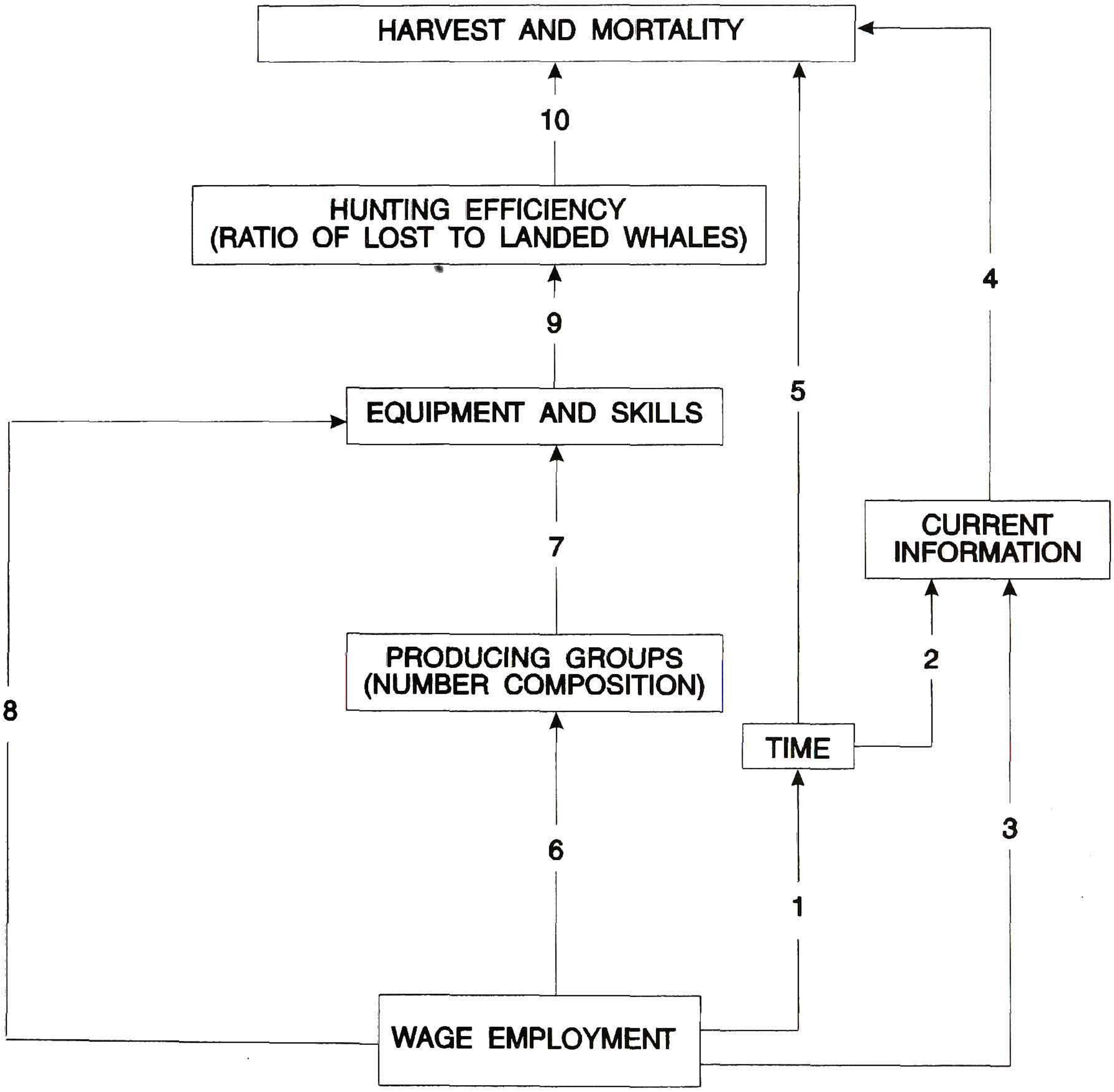
During the planning meeting of the Impact Hypothesis Working Group, it was agreed that Hypothesis R-28 remains valid but that there is no need to re-evaluate the hypothesis at this year's workshop. The workshop subgroup was charged with the responsibility of reviewing the structure and wording of the linkages and undertaking a preliminary assessment of the hypothesis. No changes to the wording of the hypothesis or its associated linkages were recommended by the group.

A preliminary assessment of the potential impacts described in this hypothesis was not completed by the subgroup. Rationale for this decision is described earlier in Section 4.2.

FIGURE 28-1

EFFECTS OF WAGE EMPLOYMENT ON THE WHITE WHALE HARVEST



Linkages

1. Wage employment of Mackenzie Delta residents will result in less time available for hunting and thereby reduce native hunting effort.

2. Reduced hunting effort will decrease the amount of new information obtained each year concerning the distribution and availablility of white whales.

3. Wage employment will affect the current level of information by changing the travelling routes and living areas of natives.

4. A change in the current level of information will affect the harvest.

5. Reduced hunting effort will decrease the number of whales taken and/or change the age/sex composition of the harvest.

6. Wage employment will alter the number and/or the composition of harvesting groups.

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.

8. Wage employment will change the quality of the equipment used by hunters.

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).

10. An increase in the ratio of lost to landed whales will increase white whale mortality.

BREAM HYPOTHESIS R-29

CHANGES IN ACCESS WILL AFFECT THE HARVEST OF BIRDS, FISH AND MAMMALS, WHICH WILL LEAD TO A REDUCTION IN THE ABUNDANCE AND ALTER THE DISTRIBUTION OF THESE POPULATIONS

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Kaye MacInnes	Patricia Vonk

INTRODUCTION

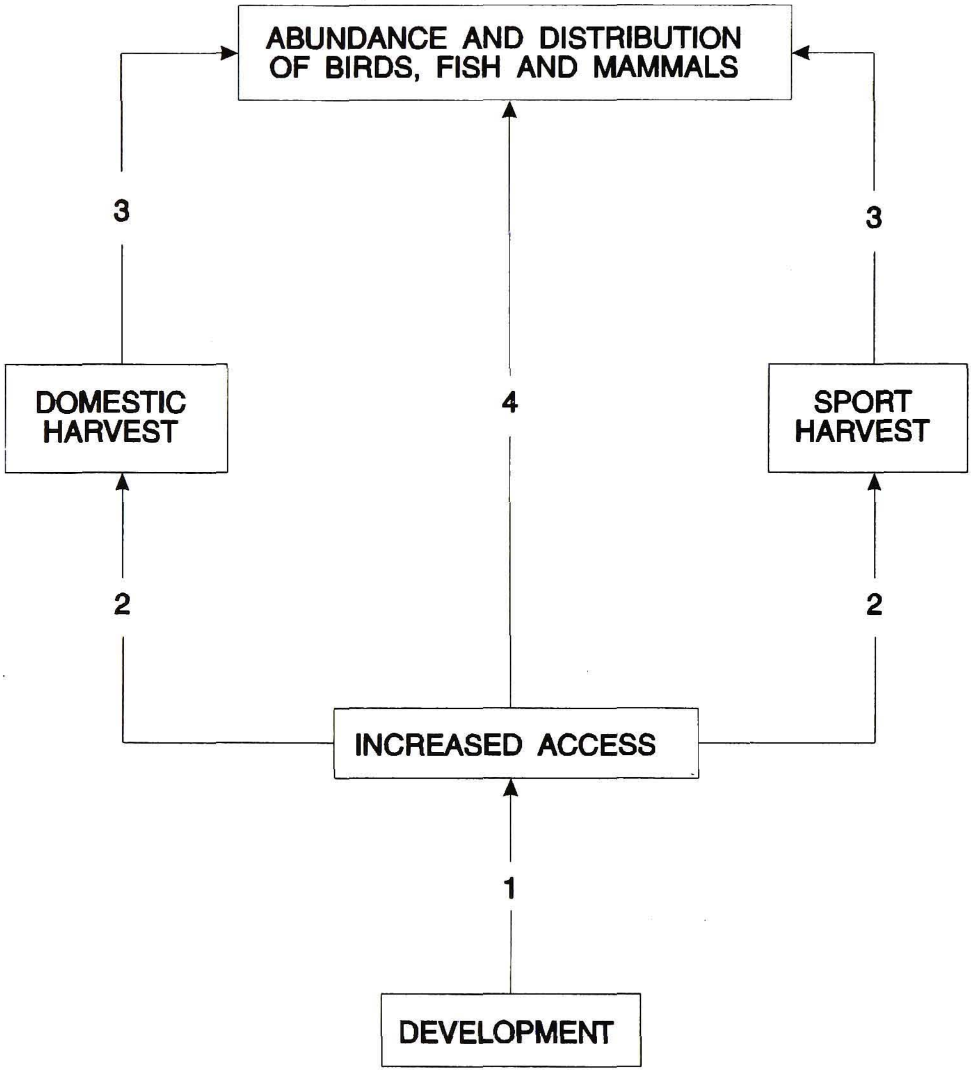
During the 1991/1992 BREAM Planning Meeting, it was recommended that MEMP 23 be merged with MEMP 21 to focus on all harvested resources that could be affected by increased or improved access to traditional hunting, trapping and fishing areas. It was also recommended that access be linked directly to the numbers and distribution of resources as well as through the domestic and sport harvests. Members of the Planning Group concluded that while the hypothesis is valid, it is unlikely to occur given the current development scenario.

EVALUATION OF LINKAGES

Although a link-by-link evaluation was not conducted by the workshop subgroup, they disagreed with the conclusions of the Planning Group that increased harvest levels on fish, birds and mammals would not likely occur as a result of hydrocarbon development. The subgroup believed that for particularly big oil/gas developments, the presence of linear corridors such as roads, pipeline rights-of-way and seismic lines would increase access to previously remote areas and would, in turn, increase exposure of birds, fish and wildlife to hunters in those areas. Industry-built roads and other facilities would be privately operated and used primarily by industry personnel and, therefore, would be subject to company policy regarding use.

FIGURE 29-1

EFFECTS OF INCREASED ACCESS ON THE HARVEST OF BIRDS, FISH AND MAMMALS



Linkages

1. Hydrocarbon development will result in increased or improved access to areas supporting bird, fish and mammal populations.

2. Increased or improved access will increase the harvest of birds, fish and mammals.

3. Increased harvest will reduce local populations and alter the distribution of birds, fish and mammals.

4. Increased access will lead to a reduction in the number and alter the distribution of birds, fish and mammals.

However, regulations on use would be difficult and expensive to enforce on residents and non-residents and, therefore, may not be mitigable.

RESEARCH RECOMMENDATIONS

The subgroup did not recommend any research or monitoring related to this hypothesis.

BREAM HYPOTHESIS R-30

WAGE EMPLOYMENT AND HARVESTING

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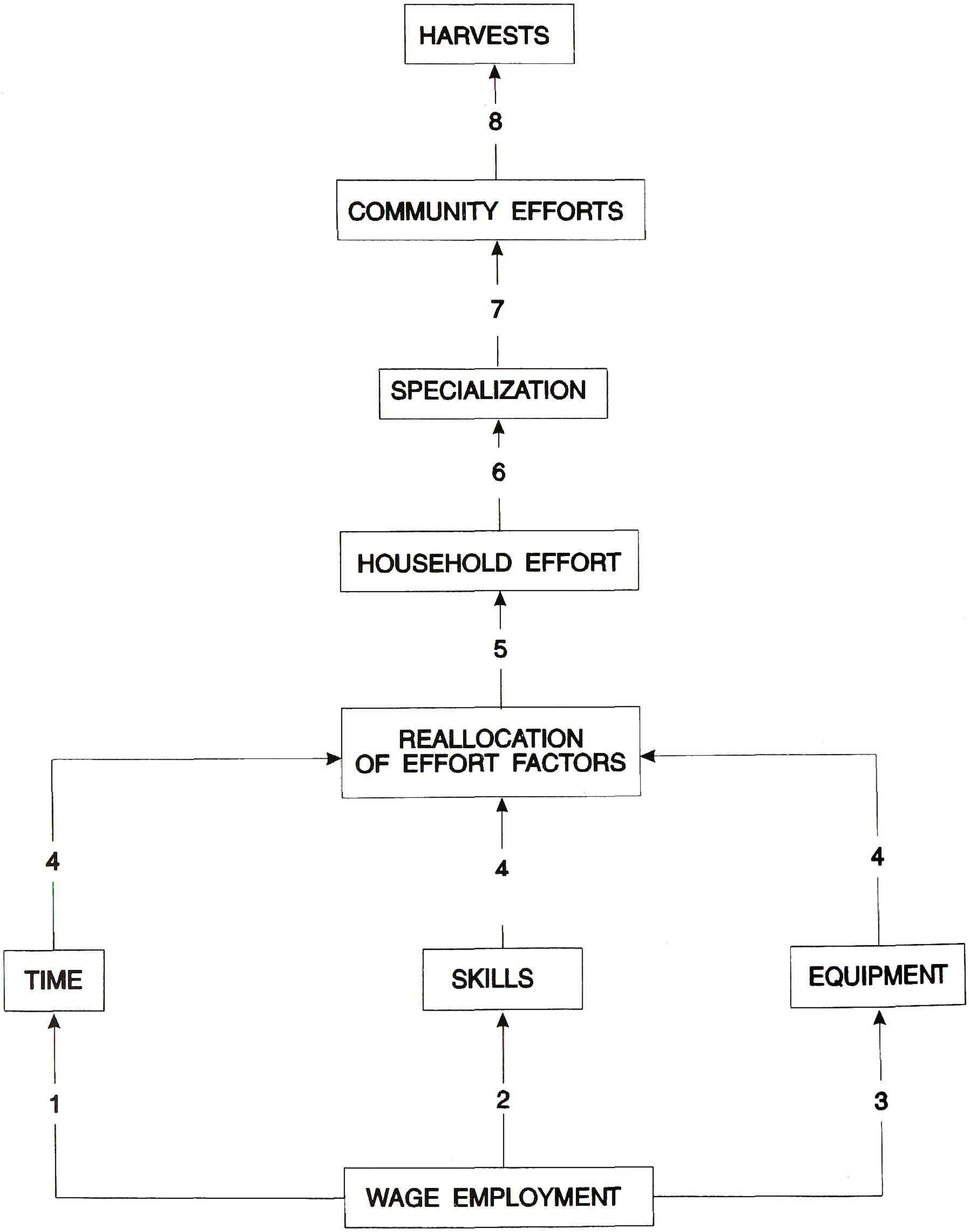
INTRODUCTION

The working group had a problem understanding the wording and intent of this hypothesis. The links need to be re-written in understandable terms that people can relate to. There was general discomfort in the working group that (1) we did not understand the hypothesis or its details well, and (2) that we should re-write the hypothesis linkages. The following is an attempt, but it is not clear if this re-wording fulfills the intent of the original MEMP authors.

FIGURE 30-1

EFFECTS OF INCREASED LEVELS OF WAGE EMPLOYMENT ON THE TOTAL ANNUAL HARVESTS OF RESOURCES BY COMMUNITIES IN THE REGION



Linkages

1. Wage employment will change the amount of time available for harvesting (it was noted that during construction that this may be true since people will want to get as many working days in as possible, but that during operations it is likely that employees will be able to take time off for harvesting).

2. Wage employment will interfere with opportunities to teach/learn harvesting skills.

3. Cash incomes allow for the purchase of better/new harvesting equipment.

4. Harvesting roles within a family or related group of harvesters (e.g., neighbours) will change.

5. Harvesting effort by individual families or related groups of harvesters will change.

6. Harvesting roles within the community (as a whole) will change.

7. Harvesting effort within the community (as a whole) will change.

8. The level of harvesting effort is positively related to the volume of harvest.

BREAM HYPOTHESIS R-31

DEVELOPMENT ACTIVITIES WILL CHANGE THE HARVEST OF BOWHEAD WHALES

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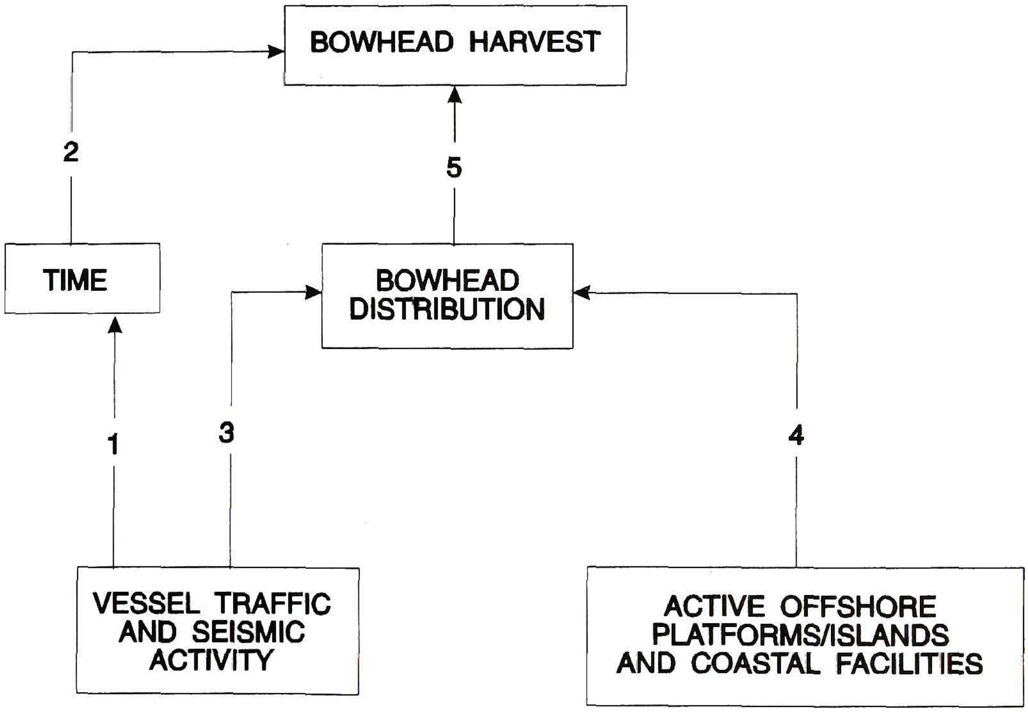
INTRODUCTION

BREAM Hypothesis R-31 is new. It was necessitated by the resumption of bowhead whaling off the Yukon coast in September 1991 by Inuvialuit from Aklavik. There is a concern that vessel traffic and/or stationary facilities could interfere with the bowhead hunt directly or by changing the distribution of huntable animals. The Working Group carefully evaluated the linkages in this new hypothesis.

At present, only the community of Aklavik is involved in the bowhead harvest. It is likely that the hunt will be expanded in the future to include more whalers from Aklavik and from other communities. The Inuvialuit and DFO are developing a Bowhead Management Plan that will be similar in form to the Beaufort Sea Beluga Management Plan. The contents of the bowhead plan are not yet known.

FIGURE 31-1

EFFECTS OF DEVELOPMENT ACTIVITIES ON THE HARVEST OF BOWHEAD WHALES



Linkages

1. Vessel traffic and seismic exploration will reduce the time available for hunting by directly interfering with hunting activities.

2. Less time available for hunting will result in a decrease in the bowhead harvest.

3. Vessel traffic and seismic exploration will disturb bowhead whales and change their distribution and availability in potential hunting areas.

4. The presence of occupied offshore islands and platforms and coastal facilities will disturb bowhead whales resulting in changes in the distribution of the animals.

5. Changes in bowhead distribution will affect the harvest of bowheads.

EVALUATION OF LINKAGES

Link 1: Vessel traffic and seismic exploration will reduce the time available for hunting by directly interfering with hunting activities.

This link was considered to be valid. Any vessel traffic in the areas where bowhead whaling is occurring is likely to interfere with the hunt and reduce the time available for pursuing the animals. There have been many studies that have demonstrated that the short-term response of bowheads to ship traffic is to swim away from the ship. These studies have been reviewed in detail in previous BEMP and BREAM reports.

It is expected that the Bowhead Management Plan will address the question of interference with the hunt.

Link 2: Less time available for hunting will result in a decrease in the bowhead harvest.

This link is intuitively obvious. However, there is no information about how many individual hunts must be interfered with before the actual harvest will decrease.

Link 3: Vessel traffic and seismic exploration will disturb bowhead whales and change their distribution and availability in potential hunting areas.

It is clear that ship traffic can change the short-term (a few hours) distribution of bowheads. There is some evidence from naturally-marked animals that some bowheads will return to areas from which they have been frightened (Koski and Johnson 1987) although there is also evidence that this does not always occur (Davis *et al.* 1986). The Working Group concluded that this link was valid and that vessel traffic could lead to changes in bowhead distribution.

Link 4: The presence of occupied offshore islands and platforms and coastal facilities will disturb bowhead whales resulting in changes in the distribution of the animals.

In general, bowheads and other marine mammals respond less to stationary disturbance sources than to mobile sources (Richardson *et al.* 1989). Nonetheless, it is apparent that offshore facilities are avoided by bowheads if there is much human activity and noise and if supply ships and helicopters are present. For example, the zone of exclusion for migrating bowheads around an offshore drillship operation was at least 10 km in radius, centred on the drillship (Davis 1987). The Working Group considered this link to be valid.

Link 5: Changes in bowhead distribution will affect the harvest of bowheads.

If disturbance causes bowheads to move farther offshore or into floating ice fields, then the whales will become less accessible to the hunters and more difficult to kill. Thus, changes in whale distribution could lead to reductions in the harvest, particularly in difficult ice years. On the other hand, it is possible that offshore ship traffic might cause bowheads to move closer to shore where they would be more easily hunted. It is clear that this link is valid, i.e. changes in bowhead distribution will lead to changes in harvest. It is not clear what the net direction of the change will be, although it is more likely to be negative than positive.

CONCLUSIONS

The Working Group concluded that the new BREAM Hypothesis R-31 was valid. The group also concluded that if the bowhead harvest was negatively affected by industrial activity, then the Inuvialuit would consider this to be a significant effect. It is evident that it would be relatively easy to mitigate each of the links in the hypothesis by imposing restrictions on vessel traffic (temporal and spatial) and the locations of stationary structures. As noted earlier, the Bowhead Management Plan that is being prepared will be relevant to this hypothesis.

RECOMMENDED RESEARCH AND MONITORING

The Working Group did not recommend any research and monitoring initiatives for this hypothesis since the effects were thought to be mitigable with known techniques at the levels of development presently proposed. The Group did feel that it is very important that DFO continue to monitor the bowhead hunt and to sample the take. It is also necessary for DFO to document the areas used for the hunts and the numbers of whaling crews involved.

LITERATURE CITED

Davis, R.A. 1987. Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea; autumn 1986: Integration and summary report. Rep. by LGL Ltd., King City, Ontario, for Shell Western E & P Inc., Anchorage, AK. 51 p.

Davis, R.A., W.R. Koski and G.W. Miller. 1986. Experimental use of aerial photogrammetry to assess the long term responses of bowhead whales to offshore industrial activities in the Canadian Beaufort Sea. Rep. by LGL Limited, King City, to Canada Dept. Indian and Northern Affairs, Ottawa. 155 p.

Koski, W.R. and S.R. Johnson. 1987. Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986: Behavioral studies and aerial photogrammetry. Rep. by LGL Ltd., King City, Ontario, for Shell Western E & P Inc., Anchorage. 129 p.

Richardson, W.J., C.R. Greene, J.P. Hickie, R.A. Davis and D.H. Thomson. 1989. Effects of offshore petroleum operations on cold water marine mammals: a literature review. 2nd Edition. Rep. by LGL Limited to Amer. Petrol. Inst., Washington, D.C. 385 p.

BREAM HYPOTHESIS R-32

DREDGING TO FACILITATE BARGE ACCESS TO THE PARSONS LAKE GAS FIELD WILL RESULT IN A DECLINE IN THE HUSKY LAKES LAKE TROUT POPULATION

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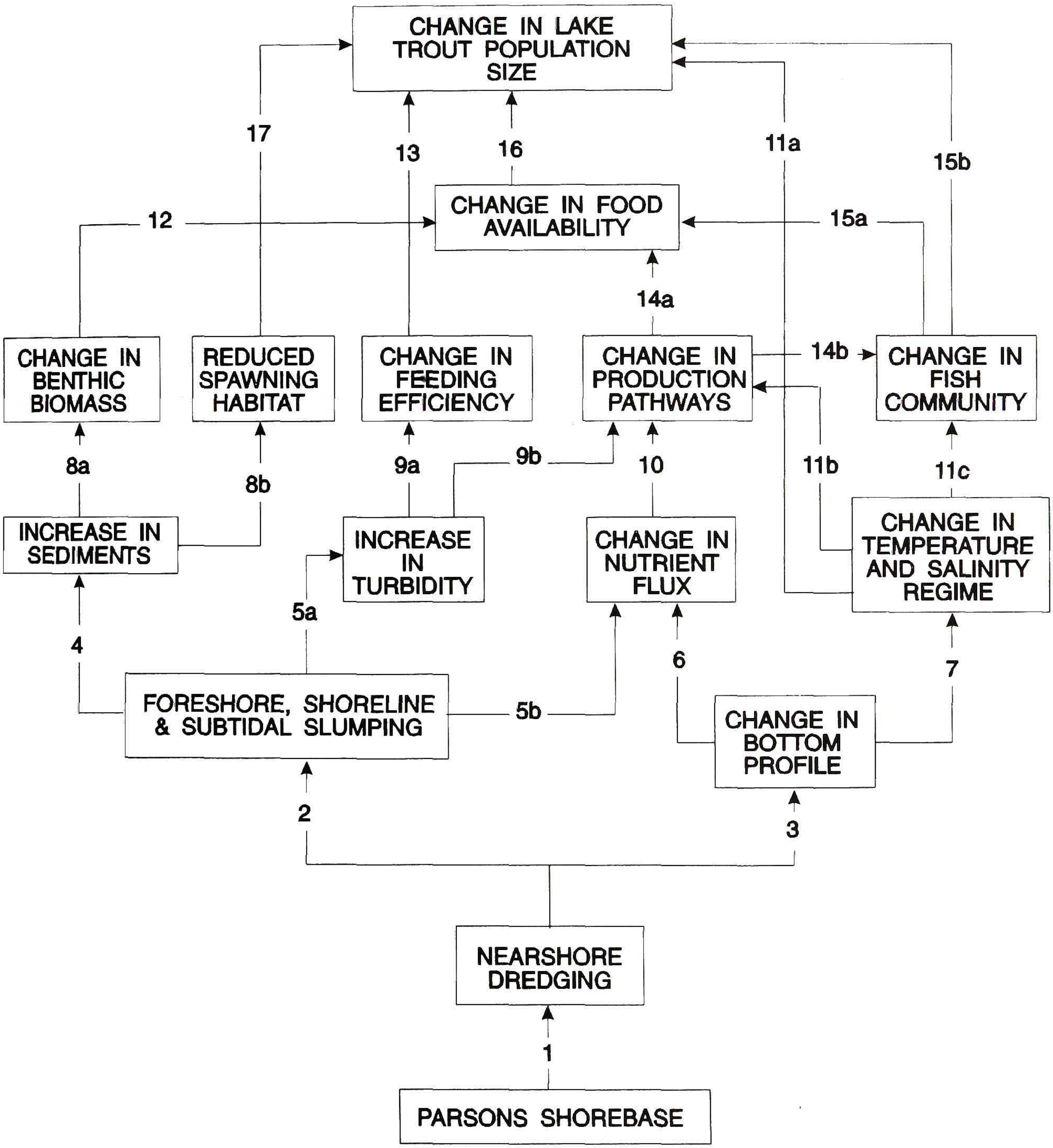
INTRODUCTION

The likely scenario for the first phase of gas development in the region would be the construction of a gas processing plant at Taglu on Richards Island and one at Parsons Lake on the mainland to develop reserves at Taglu, Niglintgak and Parsons Lake. These are the largest gas reserves located to date in the Delta. As these primary reserves begin to deplete, a number of smaller onshore and, eventually, offshore gas fields would be developed.

Under this "two plant" scenario, a separate plant would be required at Parsons Lake. This facility would be capable of processing 470 MMSCFD (millions of standard cubic feet per day) of gas and 6500 barrels/day of condensates. Development of this field would involve 13 production wells drilled from two drilling pads. During construction of the gathering systems and plant facilities, transport of materials such as prefabricated modules to the site would be required. Two modes of transport for the construction phase are possible, either overland from the Mackenzie River during winter or by water via Liverpool Bay and the Husky Lakes during the open-water season. While both modes would be technically feasible, the use of a natural waterway (dredging where necessary) was assumed to be the most likely scenario.

FIGURE 32-1

EFFECTS OF DREDGING TO FACILITATE BARGE ACCESS TO THE PARSONS LAKE GAS FIELD ON THE HUSKY LAKES LAKE TROUT POPULATION



Linkages

1. Barge access to the Parsons field will require dredging in the "fingers" area and in the nearshore next to Parsons Lake area to create a suitable harbour.

2. Nearshore dredging will result in sub-tidal, shoreline, and nearshore slumping of consolidated and high-ice content soils.

3. Dredging will increase depth and alter the bottom profile and relief.

4. Slumping and erosion will mobilize sediments in the aquatic environment.

5a. Increased suspended sediments will increase turbidity and reduce light penetration in the water column.

5b. Increased suspension of sediments will increase carbon and nutrient availability.

6. Change in bottom profile will alter water exchange rates between Husky Lakes and Liverpool Bay and result in a change in nutrient supply.

7. Change in bottom profile will alter water exchange rates between Husky Lakes and Liverpool Bay and result in a change in salinity and temperature regimes.

8a. Increased suspended sediments will result in increased sedimentation, which will affect the abundance and distribution of benthic invertebrates.

8b. Increased sedimentation will reduce availability of suitable spawning substrate for lake trout.

9a. Increased turbidity will affect the feeding efficiency of sight-feeders such as lake trout.

9b. Increased turbidity will decrease light penetration and later primary productivity.

10. Change in availability of nutrients will affect the relative contribution of heterotrophic and autotrophic production processes.

11a. Change in salinity will affect the distribution and movements of lake trout, a low salinity-tolerant species.

11b. Change in temperature and salinity regimes will alter the rate of heterotrophic production and the composition of the phytoplankton community.

11c. Change in salinity and temperature regimes will affect the fish species community structure due to differing tolerances for the newly-established temperature and salinity regimes.

12. Change in benthic community and biomass will change the availability of food for lake trout, which feed extensively on benthic and epibenthic invertebrates.

13. Reduced feeding efficiency of lake trout will reduce the population biomass.

14a. Change in production pathways will alter the food community for lake trout, which will result in a change in the availability of food for lake trout.

14b. Change in production pathways will alter the food community for other species of fish, which will result in a change in the fish community of the Husky Lakes area.

15a. Change in the fish community will alter the availability of food for piscivorous lake trout.

15b. Change in the fish community will alter predator-prey relationships, and competition for food and spawning substrate.

16. Change in the availability of food will change the lake trout population biomass.

17. Reduction in available spawning habitat will result in a decline in the lake trout population.

Based on this scenario, a new impact hypothesis dealing with the effects of dredging on lake trout populations in the Husky Lakes was formulated, and subsequently evaluated during the project workshop.

EVALUATION OF LINKAGES

Given the extent of available information regarding the development scenarios, a number of assumptions regarding the scope of the project were made by the working group in order to assess this hypothesis.

(1) Dredging would only be required once in the life of the project to transport materials to the site during the construction phase. Winter roads would be maintained during the operation phase to move supplies to the plant facilities.

(2) This one-time dredging requirement would involve dredging in Liverpool Bay and Husky Lakes where there is insufficient draft to allow barge access, and construction of a temporary dock/shorebase and a roadway to Parsons Lake.

(3) Based on a 5-m requirement for draft and the bathymetry of the lakes, it was assumed that dredging would be required at select areas along a 100-km stretch from the shorebase to about 30 km into Liverpool Bay, involving the flat areas of the Bay and lakes 1 and 3, the three sets of fingers and at the shorebase. It was assumed that there would be no need to widen any of the channels.

(4) Based on a dredge channel of about 10-30 km in length and 100 m in width, approximately 3-9 million m^3 of material would be removed. The material would be predominantly clays and silts, with some cobble in spawning areas.

(5) Most of the dredgeate would be side cast via a floating pipeline, but there may be a need to move some of the material by barge for disposal elsewhere.

(6) It was assumed that a cutter suction or stationary suction dredge with a 4-4.5 m draft would be used to dredge within the lakes and fingers. There may be a need to use explosives to remove bedrock. A clam shell or dragline dredge would probably be used near the shorebase.

(7) The dredging operation would be conducted from July to mid September.

(8) Based on a dredge capacity of 30,000 m^3/d operating at 2/3 efficiency (i.e. 1/3 of the working day would be spent moving the pipe), it would take at least 2 seasons and multiple dredges working simultaneously to remove this large volume of material.

It was noted by participants of the working group that industry would need authorization under the Fisheries Act to proceed with a dredging project of this nature. It is unlikely that they would receive approval from DFO, and the project would probably be referred to an EIRB and, possibly, an EARP review. The Husky Lakes/Liverpool Bay area is a high profile area culturally and the project would also be an area of considerable concern to regional communities. It was agreed that this project would not likely proceed and that it was unnecessary to further evaluate the hypothesis until there is a need to do so or until further information on the development scenario becomes available.

As indicated earlier, use of winter roads to transport construction materials to the Parsons Lake field has been considered. It was suggested that this alternate mode of transport would be most desirable from both the regulators and industry perspective. A winter road from the east channel to the site would be maintained during the operation phase and could be used during the construction phase.

RECOMMENDATIONS

It was noted by the working group that the hypothesis, in its present form, does not include all potentially-affected VECs. It was recommended that new hypotheses be developed to address the effects of dredging on marine mammals and resource harvesting within Husky Lakes when/if there is a need to re-evaluate this hypothesis.

5. COMMUNITY-BASED CONCERNS

5.1 Introduction

This section summarizes the discussions that occurred during the first meeting of the Community-Based Concerns Working Group. The meeting was held in Yellowknife, N.W.T. on February 19-20, 1992. A separate report discussing the results of this planning meeting was released earlier in mid-April and distributed among interested parties in the north. The present section contains parallel information but has been reformatted, edited, and condensed slightly for the purpose of this document.

The main role of the Community-Based Concerns Working Group is to identify ecological issues and concerns that residents from northern communities and the region believe should be included in environmental assessments of future hydrocarbon development. During the 1991/92 BREAM Program, activities of this Working Group focused on:

1. introducing the BREAM process to northern communities, and
2. identifying some of the environmental issues of importance to northerners.

The geographic extent of BREAM corresponds to the proposed hydrocarbon development scenario (Section 3), which assumes exploration and production activities in the Mackenzie Delta/Beaufort region and a pipeline along the Mackenzie Valley to southern Canada. The western N.W.T. regions potentially concerned about these activities include the Inuvialuit Settlement and Gwich'in Settlement regions, as well as the Sahtu or Great Bear and Deh Cho regions. Each of these regions is represented in the Community-Based Concerns Working Group (Appendix I).

5.2 Meeting Preparation

Following the BREAM Project Initiation Meeting (held in Vancouver in November, 1991), regional organizations in the Mackenzie Valley and Beaufort Sea regions were invited to attend a meeting of the Community-Based Concerns Working Group. These organizations were asked to select a representative familiar with hydrocarbon developments and the relationship of these activities to the region's ecology. It was emphasized from the outset that BREAM focuses on environmental concerns of northern communities, and that social issues associated with hydrocarbon development were outside the scope of the program.

In preparation for the technical meeting, an overview of BREAM and the Terms of Reference for the Community-Based Concerns Working Group (Appendices A and B) were distributed to the regional organizations to:

- familiarize these individuals with the BREAM process;
- outline the work of the Community-Based Concerns Working Group, and
- detail the specific responsibilities of the Working Group members.

Four specific tasks of the Community-Based Concerns Working Group for 1991/92 were identified during the Project Initiation Meeting. These were as follows:

1. to develop a good understanding of the BREAM process and its role in environmental assessment(s) of future oil and gas developments;
2. to identify the types and extent of community-based ecological issues and concerns that environmental assessments of future oil and gas developments should consider;
3. to determine priorities for 1992/93 activities of the Community-Based Concerns Working Group; and
4. to ensure representatives of the regional organizations participate in the Impact Hypothesis Interdisciplinary Workshop in Vancouver in May, 1992.

5.3 Community-based Concerns Working Group Members

The Community-Based Concerns Working Group consists of representatives from the federal and territorial governments, the oil and gas industry and northern communities. The northern communities were represented by the:

- Inuvialuit Game Council, Inuvialuit Settlement Region;
- Joint Secretariat, Inuvialuit Settlement Region;
- Gwich'in Tribal Council, Gwich'in Settlement Region;
- Shihta Regional Council/Development Impact Zone Committee, Sahtu Region; and
- Deh Cho Regional Council, Deh Cho Region.

At this first meeting of the Community-Based Concerns Working Group, all groups were represented except the Deh Cho Regional Council (see Appendix I). The designated representative of the latter organization was unable to attend due to a scheduling conflict, although the Deh Cho Regional Council has expressed an interest in being involved in BREAM in the future.

5.4 Planning Meeting Objectives

The primary objective of the Community-Based Concerns Planning Meeting was to respond to the tasks outlined in the Terms of Reference for the Working Group. Specifically, the meeting was intended to:

- ensure that Working Group members understood the BREAM Program and its role in the environmental assessment(s) of future oil and gas developments including the identification of associated research and monitoring needs;

- identify the types and extent of community-based ecological issues and concerns that environmental assessments of future oil and gas developments should consider; and

- explore processes for addressing community-based ecological issues and concerns.

5.5 Community/Regional Understanding of BREAM

Most participants had some familiarity with the Beaufort Environmental Monitoring Program (BEMP) or the Mackenzie Environmental Monitoring Program (MEMP), the predecessors of BREAM. The history of community/regional involvement in past environmental monitoring programs enabled both the Inuvialuit Game Council (IGC) and the Government of the Northwest Territories (Department of Renewable Resources) to express support for BREAM. Support was expressed in part because local interests and concerns would be reflected in the process.

The role of BREAM in assisting the decision-making processes related to industrial development was discussed in light of the often competing socio-cultural, political and economic agendas of various northern and national interest groups. Some participants sought clarification of this role, particularly in relation to other government-sponsored environmental initiatives in the North and concerns related to possible overlapping objectives of different programs. However, the objectives of BREAM are quite distinct from these other programs and relate specifically to research and monitoring needs associated with hydrocarbon development in the region.

Members of the Community-Based Concerns Working Group expressed a general familiarity with the structure of BREAM impact hypotheses. During the Planning Meeting, participants were informed that the Impact Hypothesis Working Group had reviewed the existing 32 BREAM hypotheses (Table 2-1) and identified 10 hypotheses that require further attention. Based on new information and/or restructuring of the hypothesis, it was indicated that eight of these required a detailed evaluation, while two needed to be briefly examined. The Impact Hypothesis Working Group also considered the cumulative effect of global warming and concluded that it would be adequately addressed by the addition of new linkages to existing impact hypotheses. This evaluation of existing and new BREAM hypotheses was the focus of an interdisciplinary workshop held during May, 1992, in Richmond, B.C. (Section 4).

5.6 COMMUNITY-BASED CONCERNS WORKING GROUP - ISSUES AND CONCERNS

This section presents the issues and concerns raised by members of the Community-Based Concerns Working Group at the Planning Meeting on February 19-20, 1992. Written submissions of some representatives on community concerns are included in Appendix D of this report.

5.6.1 Ecological Concerns and Issues

Food sources (i.e. harvestable resources) and the overall quality of the northern environment are the fundamental ecological concerns that must be addressed by BREAM, from the perspective of the Community-Based Concerns Working Group. In particular, these concerns are related to: (1) baseline data collection and monitoring; (2) fish quality; (3) solid waste disposal and associated contamination; (4) catastrophic oil spills; (5) refined oil spills; (6) an east-west pipeline route; (7) effects of increased ambient noise and traffic; and (8) cumulative effects of industrial developments.

5.6.1.1 Baseline Data Collection and Monitoring

Representatives from the Inuvialuit Settlement Region expressed concern that BREAM must develop "adequate and agreed upon baseline data for harvestable resource populations". Baseline data should include information on resource populations, harvest locations, harvester effort, and habitat requirements for major harvestable resource populations. The extent of information collected on polar bears is an example of the level of baseline data that is required. Existing data on Arctic cisco and herring was cited as an example of where this baseline information is incomplete.

Similarly, representatives from the Inuvialuit Settlement Region identified a need to establish relevant monitoring programs "which will reliably assess the effects of any industrial activities" on harvestable resource populations. Monitoring programs should enable harvesters to identify and assess changes in the resource, as well as the impacts of these changes.

The need to place priority on developing baseline data and reliable monitoring programs is considered important by residents of the Inuvialuit Settlement Region. One representative from this region stated that "there have been no major problems in the Beaufort as a result of hydrocarbon activities, and we want to keep it that way."

5.6.1.2 Fish Quality

Residents of the Sahtu Region, particularly communities north of Norman Wells, continue to be concerned about the tainting and texture of whitefish and the appearance of loche (burbot) livers (i.e. spotted, shrunken livers) harvested in the Mackenzie River. This has been an issue since the construction of the Norman Wells pipeline in the mid 1980s. Research conducted by the Department of Fisheries and Oceans (DFO) has not been able to establish cause-effect relationships between hydrocarbon activities and fish quality. The results of this research, however, have not been readily understandable to members of northern communities. Working Group members recommended that the fish quality hypothesis (BREAM Impact Hypothesis R-26) should be re-evaluated to underscore the importance of fish resources to community residents, and to promote a better local understanding of fisheries research that has occurred.

If hydrocarbon activities are not the cause of poor fish quality, community residents speculated that pulp mill discharges upstream of the Mackenzie River may be responsible for these changes. Community residents recommended that cumulative impacts associated with upstream (of the Mackenzie River) effluents discharged by pulp mills be reflected in new linkages of BREAM Impact Hypothesis R-26. These recommendations were acted upon during the project workshop through a re-structuring of the hypothesis to include contaminant inputs from outside the region and detailed discussions by one of the workshop subgroups (Section 4.3.26).

5.6.1.3 Solid Waste Disposal Sites and Associated Contaminants

Representatives from both the Sahtu Region and the Gwich'in Settlement Region expressed concerns related to buried and abandoned solid waste (i.e. drums). Communities are uncertain about the location and toxic nature of these materials, and the potential for leakage into streams and creeks. These concerns were most strongly expressed by the Sahtu Region, which has experienced some 70 years of oil and gas development activity.

Efforts to identify and cleanup hazardous waste sites are currently being undertaken through the Arctic Environmental Strategy, a program under the federal government's Green Plan.

5.6.1.4 Catastrophic Oil Spills

Northern communities, particularly those in the Inuvialuit Settlement Region, are concerned about the potential impacts of a catastrophic oil spill (e.g., uncontrolled well blow-out) in the Beaufort Sea on harvestable resources (i.e. fish, marine mammals, polar bears, seabirds) and their habitat.

Northern residents find it difficult to categorize the range of potential impacts that may result from a catastrophic oil spill. Because BREAM does not address socio-economic concerns, members of the Working Group recommended that a parallel process be established to research and monitor needs related to these issues. While some social and economic issues related to catastrophic oil spills are outside the scope of BREAM, concerns related to effects of spills and their cleanup on resource harvesting activities and opportunities will be addressed through new impact hypotheses that have been developed for future BREAM workshops (Section 6.3).

Working Group members identified a need to broaden the existing information base on impacts of catastrophic oil spills in order to develop effective wildlife compensation and/or species rehabilitation plans. Over 100 studies were initiated in response to the *Exxon Valdez* spill in Prince William Sound, Alaska. The results of many of these research programs are expected to augment the existing database on the impacts of large oil spills.

5.6.1.5 Refined Oil Spills

The potential for oil spills from the Inter-Provincial Pipeline at Norman Wells is not a major concern of residents in the Sahtu Region because of ongoing monitoring of the pipeline and a good "track record" to date. However, there is concern in this and other regions related to possible spills of refined petroleum products as a result of increased winter road travel and barge traffic, and the potential impacts of these spills on rivers and lakes. Working Group members agreed that there is increased awareness of the impacts of crude oil spills to offshore and onshore northern ecosystems but refined oil spills have received little attention in the N.W.T.

5.6.1.6 East-West Pipeline Route

There is concern within the Inuvialuit Settlement Region that an east-west pipeline tying the North Slope or adjacent and subsequent feeder lines to a Mackenzie Valley pipeline may have an impact on beluga calving areas in Shallow Bay, west of Tuktoyaktuk.

Current oil and gas transportation scenarios presented by the industry representative at the Planning Meeting suggest that a north-south pipeline may be anticipated in 10-15 years, but an east-west pipeline would not be constructed for 20-30 years, if at all. It was also suggested that any east-west pipeline development scenario would recognize critical beluga calving areas and efforts would be made to minimize potential impacts on the resource and its habitat.

5.6.1.7 Effects of Increased Ambient Noise and Traffic

Communities in the Inuvialuit Settlement Region are concerned about the overall effects of increased ambient noise and traffic, both air and sea, on harvestable resources. Two hypotheses, BREAM R-1 and BREAM R-2, consider the impacts of ships/icebreakers on bowhead whale populations and the beluga whale harvest. These hypotheses are considered valid and were re-evaluated at the 1992 Interdisciplinary Workshop (Sections 4.3.1 and 4.3.2). Other hypotheses address the impacts of airborne and underwater noise on other resources including seals, birds and several species of terrestrial mammals (Table 2-1).

5.6.1.8 Cumulative Effects of Industrial Developments

The cumulative effects of atmospheric deposition and other inputs of contaminants on the northern ecosystem is an area of concern to northern communities. There is a need to improve our understanding of the cumulative effects of industrial developments on air and water quality and harvestable resources. The concerns of northern residents are heightened by a lack of information on the effects on the northern ecosystem of pulp mill developments upstream of the Mackenzie River, potential Bear and Liard River hydroelectric developments, logging in the upper Liard Valley, and agricultural waste (i.e. pesticides and herbicides) entering the Mackenzie River watershed. It was recommended that, where appropriate, additional linkages be added to the existing BREAM hypotheses to help address the concerns related to cumulative impacts.

5.6.2 Process-Related Issues and Concerns

Members of the Community-Based Concerns Working Group discussed how communities should be more involved in addressing ecological issues and concerns, and in the BREAM process itself. Reflecting traditional knowledge, new northern environmental monitoring and assessment authorities (i.e. Inuvialuit and Gwich'in structures), and better communication of research and monitoring results, were three themes which underlie most process-related issues and concerns.

5.6.2.1 Accessing and Incorporating Traditional Knowledge into BREAM

Working Group members agreed that traditional knowledge is different than scientific knowledge but is both important and useful to improving the understanding of the northern environment and enabling better decisions to be made about future hydrocarbon developments. Traditional knowledge can be incorporated into ecological research and monitoring to:

- improve the design of research and monitoring programs;
- provide additional perspectives on the nature of the problem/concern or in the interpretation of research and monitoring results; and
- give logistical and practical guidance during the design and conduct of research and monitoring programs.

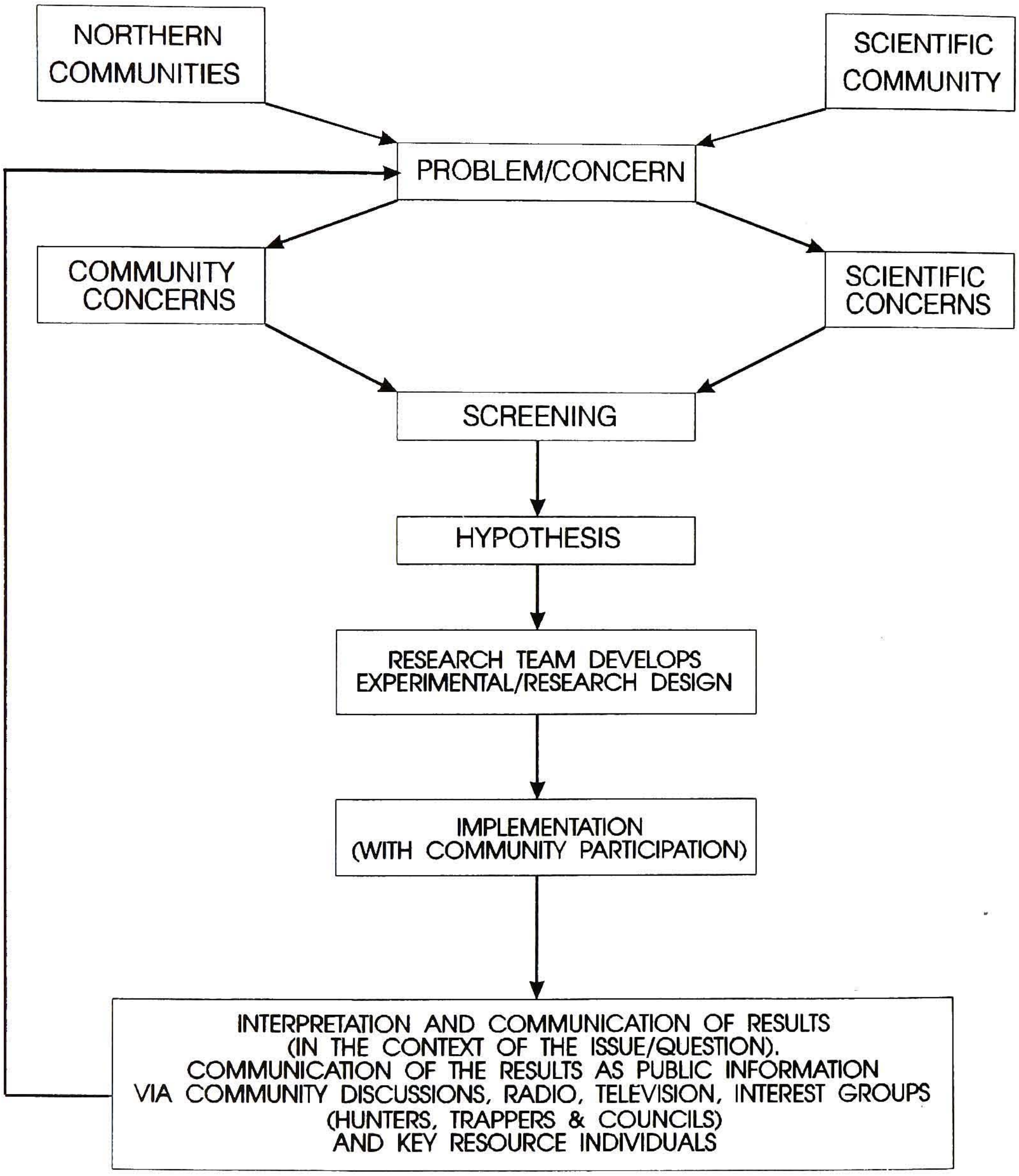
Working Group members cited the Beaufort Regional Land Use Plan and Polar Bear Management Agreements as examples of processes that have successfully accessed and incorporated traditional and local knowledge (the latter is generally defined to be geographic-specific information). Their success was a result of the high level of trust that was built among the traditional knowledge holders, resource users, researchers/scientists, and resource managers. Trust and consensus are developed over time and with a commitment to involve resource users and traditional knowledge holders at critical stages in agreement negotiations or planning. Polar Bear Management Agreements that have been developed in the Inuvialuit Settlement Region provide a model for similar agreements elsewhere in the N.W.T.

Members of the Community-Based Concerns Working Group developed a model for accessing and incorporating traditional and local knowledge into decisions related to environmental research and monitoring. The main elements of this model are described in Figure 5-1 and include:

- recognizing that regional communities and the scientific community can contribute jointly to problem/concern identification;

FIGURE 5-1

A MODEL FOR ACCESSING AND INCORPORATING TRADITIONAL AND LOCAL KNOWLEDGE AND COMMUNITY CONCERNS INTO THE BREAM PROGRAM



- assurance that problems/concerns are cooperatively considered and screened by northern communities and the scientific community;
- a cooperative community and scientific effort in the formulation of the hypothesis/question to be answered;
- a cooperative approach between the scientific community and northern communities in developing the experimental/research design;
- community participation in the scientific experiment, research study or monitoring activity, and where appropriate, in the interpretation of the results; and
- a communications plan which ensures that communities receive and understand the results of the experiment/research.

5.6.2.2 Northern Community Participation

Members of the Community-Based Concerns Working Group agreed that involvement of northerners in all stages of research, monitoring and assessment will be essential to maximize the acceptance of BREAM. The development of new northern authorities for environmental monitoring and assessment provides the mechanisms for this involvement to occur.

Working Group members also agreed that northern participation in environmental research, monitoring and assessment can be improved through better information sharing at all stages of a research or monitoring project, and by better communicating the results of research and monitoring to the community. When information is obtained from community members during the conduct of scientific research, it is very important that the results of this research be brought back to the community in a readily-understandable form, even to the extent of personal communication with the information sources.

Working Group members reiterated that community people, particularly elders and resource harvesters, think about the environment and its resources in holistic terms. It is difficult for community people to communicate their ecological concerns in the absence of social and economic issues. While BREAM does not address social and economic concerns associated with hydrocarbon development, Working Group members believe that there should be a linkage to those processes which do address these issues to ensure complete communication with northern communities.

5.6.2.3 Existing Sources of Community-Based Ecological Concerns

Members of the Working Group identified a number of information sources that list and/or discuss community-based ecological concerns related to hydrocarbon activity. The most recent documentation of these concerns includes:

- Inuvialuit Game Council Harvest Studies;
- Community Conservation Plans for communities in the Inuvialuit Settlement Region (completed and draft documents are available for Paulatuk, Sachs Harbour and Tuktoyaktuk);
- the Land Use Plan for the Mackenzie Delta-Beaufort Sea Region;
- the Mackenzie Delta-Beaufort Sea Land Use Issues Document;
- preliminary Sahtu Region Land Use Issues Document; and
- the Environmental Atlas for Beaufort Sea Oil Spill Response.

Working Group members concluded that documentation of community-based ecological concerns is relatively comprehensive for the Beaufort, Mackenzie Delta and Mackenzie Valley Regions (Beaufort Sea south to Norman Wells). However, very few concerns have been documented for the south Mackenzie Valley regions of Deh Cho, North Slave and South Slave. Efforts to centralize and manage resource and land use data are ongoing by Indian and Northern Affairs Canada (INAC) and the Department of Renewable Resources, G.N.W.T. Much of the data has been digitized/computerized and is available through these government agencies. Working Group members suggested that existing documentation related to community-based concerns should be stored and accessible in a central location in the Northwest Territories. The nature of the information that does exist should be communicated to the various interests.

5.6.3 Social and Economic Concerns

While the scope of BREAM is limited to environmental concerns associated with hydrocarbon development, members of the Working Group emphasized that northern people do not necessarily categorize their concerns by discipline. This was demonstrated throughout the meeting, as socio-cultural and economic issues and concerns were part of most discussions. Particular socio-economic concerns raised by the Working Group include:

- a need to train and employ more northerners in all aspects of scientific and traditional knowledge research occurring in the community, and
- a need to continue research and monitoring related to the cumulative impact of increased populations associated with the development of infrastructure (i.e. temporary or permanent roads, pipeline corridors facilitating improved access to harvest areas, improved level of harvest effort and subsequent resource loss).

Working Group members stressed that because socio-economic matters are outside the scope of BREAM, a parallel process should be established to address these concerns.

5.7 Recommendations

Members of the Community-Based Concerns Working Group recommended several activities and actions as follow-up to their first meeting:

1. Continue efforts to prepare and involve the Deh Cho region in the Community-Based Concerns Working Group and other aspects of BREAM.
2. Pursue discussions to identify and link BREAM with a parallel process to address social and economic concerns associated with hydrocarbon development.

3. Complete a review of existing publications to assess the extent of documented community-based ecological concerns.

4. Improve communications with communities by expanding the distribution of BREAM Project Updates.

6. CATASTROPHIC OIL SPILLS

6.1 Introduction

Planning activities for the catastrophic oil spill component of BREAM were initiated with a combined meeting of this Working Group and most of the members of the Impact Hypothesis Working Group on January 30, 1992, in Richmond, B.C. The overall purpose of this meeting was to define those tasks which could be accomplished within the scope of the 1991/92 BREAM program in preparation for a workshop on catastrophic oil spills in the future. It was concluded that three useful outputs would be:

1. a list of Valued Ecosystem Components (VECs);
2. a series of oil spill scenarios for hypothetical accidents affecting onshore (terrestrial/freshwater) and offshore (marine) environments and resources; and
3. some new impact hypotheses relating these VECs and oil spill scenarios.

6.2 Valued Ecosystem Components

In the case of the VECs, it was concluded that the lists previously developed for BEMP and MEMP were unlikely to encompass all environmental features and resources that would be at risk in the event of a large oil spill. Furthermore, it was suggested that even the existing VECs adopted by BREAM from its predecessors had not been reviewed for 8-10 years, and that the present process need not be constrained by the definitions of VECs and VSCs (Valued Social Components) employed by BEMP and MEMP. This was considered particularly important in light of the greater scope of BREAM and the need to focus on community-based ecological concerns. In the discussion of VECs, it was also stressed that they should be selected to include those environmental components that could be affected by oil-spill countermeasures as well as oil itself.

Participants reviewed the lists of VECs presented in earlier BEMP and MEMP reports and then suggested that the following list (Table 6-1) be tentatively adopted for BREAM. These VECs would be reviewed by participants in an interdisciplinary workshop focusing on catastrophic oil spills. In view of the large number of VECs, it was suggested that it may be necessary, from a practical point of view, to consolidate some resource groups and focus on those VEC species that can act as surrogates for others by virtue of similar life histories and sensitivity to oil.

6.3 Oil Spill Scenarios for Future Consideration

Participants in the Catastrophic Oil Spill Planning Meeting agreed that six oil spill scenarios should be developed to provide the framework for evaluation of spills in the offshore vs. onshore, from pipelines vs. production platforms, and of different petroleum hydrocarbons (crude oil vs. condensate). These six scenarios were subsequently developed by S.L. Ross Environmental Research Ltd. using information presented in the following documents:

- Esso Resources Canada Limited and S.L. Ross Environmental Research Ltd. 1980. Norman Wells oilfield expansion, oil spills and countermeasures.
- S.L. Ross Environmental Research Ltd. 1990. Amauligak Pipeline Study: The behaviour and cleanup of oil spills. A report prepared for Gulf Canada Resources Limited, Calgary, Alberta.
- Adams Pearson Associates Inc. 1991. Recommended philosophy for development of a worst case blowout scenario for wells drilled in the Beaufort Sea. Prepared for Canadian Petroleum Association, Task Group #1, Beaufort Sea Steering Committee.
- S.L. Ross Environmental Research Ltd. and Environmental Protection Branch, COGLA. 1991. Assessing the costs of a major oil spill in the Canadian Beaufort Sea. Report prepared for Task Group #1, Beaufort Sea Steering Committee.
- S.L. Ross Environmental Research Ltd. and Energetex Engineering. 1986. Decision-making aids for igniting or extinguishing well blowouts to minimize environmental impacts. Environmental Studies Revolving Funds Report Number 051, November, 1986.

TABLE 6-1

TENTATIVE LIST OF VALUED ECOSYSTEM COMPONENTS FOR CATASTROPHIC OIL SPILLS AND ASSOCIATED COUNTERMEASURES

1. **Air quality**
2. **Surface and groundwater quality**
3. **Coastlines**
4. **Landscape quality**
5. **Populations, harvest (where appropriate) and quality of the following biological resource groups:**

    a. marine and marine-associated mammals
    - *Bowhead whale*
    - *Beluga whale*
    - *Ringed seal*
    - *Bearded seal*
    - *Polar Bear*

    b. terrestrial mammals
    - *Arctic fox*
    - *Red fox*
    - *Grizzly bear*
    - *Caribou*
    - *Moose*
    - *Beaver*
    - *Muskrat*
    - *Marten*
    - *Wolverine*

    c. fish
    - *broad whitefish*
    - *Arctic cisco*
    - *Inconnu*
    - *Lake whitefish*
    - *Lake trout*
    - *Pike*
    - *Burbot*
    - *Arctic charr*
    - *Arctic cod*
    - *Arctic grayling*
    - *Pacific herring*

    d. birds
    - *Snow geese*
    - *Ducks*
    - *Loons*
    - *Raptors*
    - *Common eider*
    - *King eider*
    - *Thick-billed murre*
    - *Black guillemot*
    - *Phalaropes*

    e. epontic organisms

As is the convention with scenarios such as these, they are written in the present tense and describe hypothetical events that are assumed to occur for the purpose of subsequent evaluation. It should also be noted that these six scenarios do not include the refined fuel spills that were later identified as a community-based concern (Section 5.6.1.5). There will be a need to develop one or perhaps two additional scenarios around refined fuel spills to address this area of concern at any future workshop dealing with oil spills.

6.3.1 Condensate Pipeline Leak Under Ice

6.3.1.1 Incident Description

A pinhole leak develops in an 8" condensate pipeline at a river crossing. Condensate leaks from the submerged pipeline at an approximate rate of 10 barrels per day, from February 15 to May 15, when breakup occurs and the leak is discovered.

6.3.1.2 Environmental Conditions

The water temperature is 0°C and the water current is 0.5 m/s. During breakup, the air temperature is 5°C and the wind speed is 5.5 m/s.

6.3.1.3 Spill Behaviour

The condensate from the leak, flowing at about 1 L/min, rises up to collect on the underside of the ice. It is then moved along under the ice by the currents, progressively filling under-ice depressions caused by cracks, broken ice and the insulating effect of snow drifts.

The ice sheet continues to grow downwards and encapsulates the pooled condensate 48 to 72 h after its release. Given an average under-ice coverage of 1 cm, the 1000 bbl spill covers an area of 16,000 m^2 or a swath 20-m wide and 800-m long extending downriver from the spill site.

Because condensate is more soluble in water than is crude oil, dissolution of condensate from beneath the under-ice slick could be significant. It is assumed that 10% of the condensate released is dissolved from the under-ice pools before they are encapsulated. Initially, the dissolved oil concentrations directly downstream of a 20 m-wide swath of condensate pools would be 37 ppb, assuming the water-soluble fraction is evenly mixed to a depth of 5 m. These concentrations would decline as the plume moved further downriver from the contaminated ice area.

Once breakup begins and the ice starts to rot, the condensate would migrate to the surface of the ice, collect in melt pools on the river surface and evaporate rapidly. Any condensate remaining in the ice at breakup would be released slowly from the rotting ice and evaporate quickly. Light sheens would be present in and around the rotting ice.

6.3.1.4 Countermeasures

It is assumed that countermeasure operations are not mounted in response to this spill because the leak is not detected until after breakup, thereby precluding any response.

6.3.1.5 Shoreline Oiling

No shoreline oiling is assumed to occur as a result of this hypothetical spill.

6.3.1.6 Summary

The following is a summary of the fate of the oil from this scenario:

CONDENSATE RELEASED: 1000 bbls
CONDENSATE INITIALLY DISSOLVED: 100 bbls
CONDENSATE ENCAPSULATED IN ICE: 900 bbls (evaporates during melt)

6.3.2 Condensate Pipeline Leak at a River-Crossing in Summer

6.3.2.1 Incident Description

On August 1, a weld in a section of a condensate pipeline beneath the Mackenzie River fractures and leads to the release of 1000 barrels (159 m^3) of condensate into the river over a 2-h period before the automatic leak detection computer shuts down the pipeline and closes the block (safety) valves on either side of the river.

6.3.2.2 Environmental Conditions

The wind is light (1 m/s) and blowing down the river. The air temperature is 15°C and the water temperature is 10°C. The current velocity in the river is 0.5 m/s.

6.3.2.3 Spill Behaviour

The condensate rises to the river surface just downstream of the leak location and forms a slick that is initially 8-m wide and 5-mm thick. Figure 6-1 illustrates the subsequent spreading of the slick as it expands and drifts downstream. After 10 h, the slick extends 18 km downriver from the leak and is 750-m wide at that point.

FIGURE 6-1

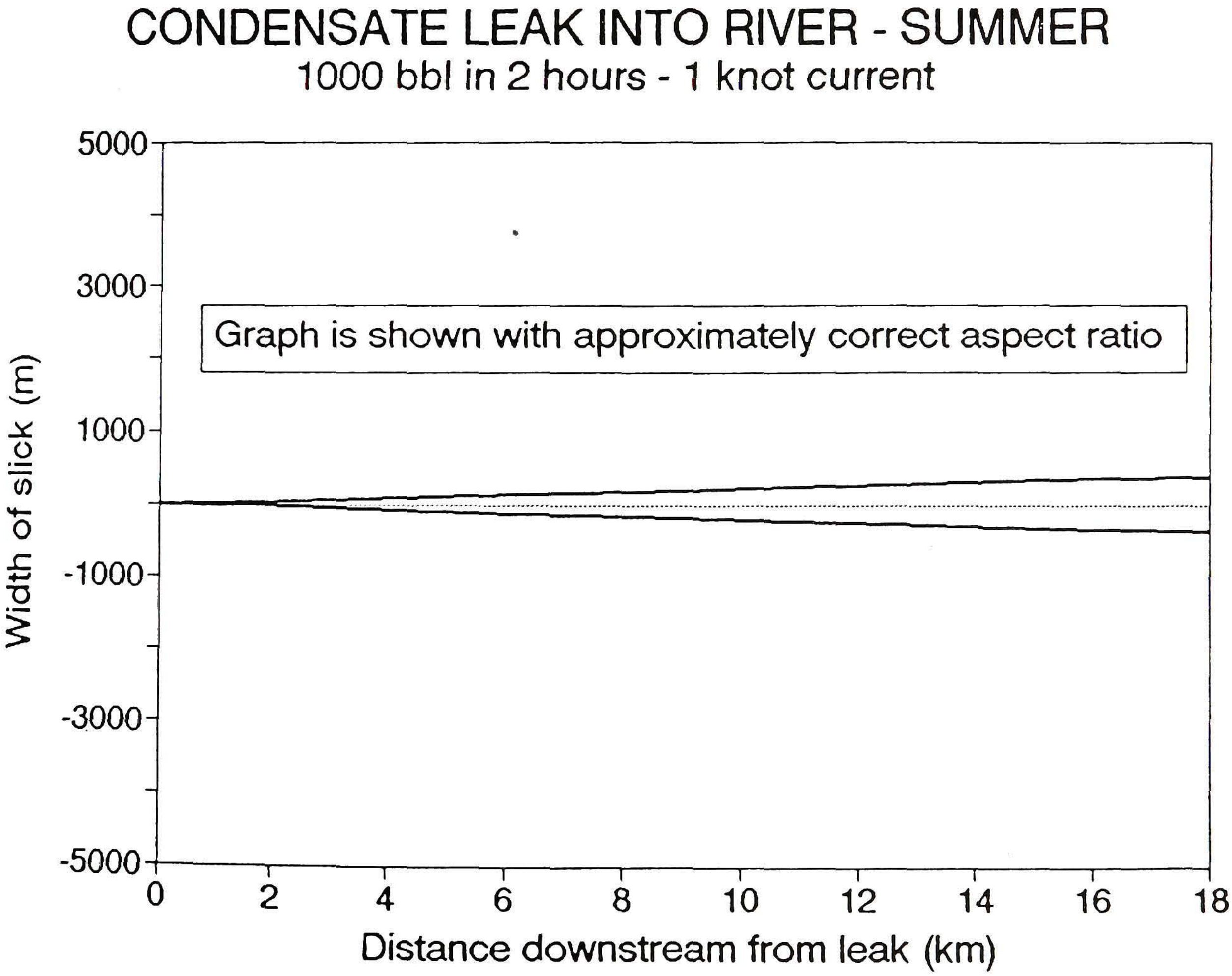

CONDENSATE LEAK INTO RIVER - SUMMER
1000 bbl in 2 hours - 1 knot current
Graph is shown with approximately correct aspect ratio
Width of slick (m)
5000
3000
1000
-1000
-3000
-5000
0
2
4
6
8
10
12
14
16
18
Distance downstream from leak (km)

Figure 6-2 illustrates the thinning of the thick portion of the slick as a function of distance downstream. Near the leak, the slick is composed of a continuous, thick stream of oil. As this stream moves down the river, it breaks up into thick patches of condensate surrounded by sheen. Further downstream, the sheen becomes discontinuous as the patches drift apart.

Figure 6-3 illustrates the fate of a portion of the condensate slick as it moves downstream, assuming no shoreline oiling. Because condensate is highly volatile, most of this portion of the slick ultimately evaporates (72%), while the remainder naturally disperses into the river (28%). Maximum-dispersed condensate concentrations would be in the order of 1 ppm beneath the slick, assuming that the dispersed condensate is evenly mixed across the width of the slick and to a depth of 5 m.

6.3.2.4 Countermeasures

It is assumed that no countermeasures can be implemented in the approximately 12 h duration of this scenario.

6.3.2.5 Shoreline Oiling

It is assumed that one riverbank is contaminated with 300 bbls of condensate over a distance of 10 km. Due to the volatile nature of this fluid, the beached condensate evaporates completely from the shoreline sediments in 1 to 5 days.

6.3.2.6 Summary

The following summarizes the fate of this hypothetical condensate leak from a buried pipeline into the Mackenzie River:

CONDENSATE RELEASED: 1000 bbls
CONDENSATE EVAPORATED: 500 bbls (plus shoreline condensate)
CONDENSATE NATURALLY DISPERSED: 200 bbls
CONDENSATE RECOVERED: 0
CONDENSATE ON SHORE: 300 bbls (evaporates in 1 to 5 days)

FIGURE 6-2

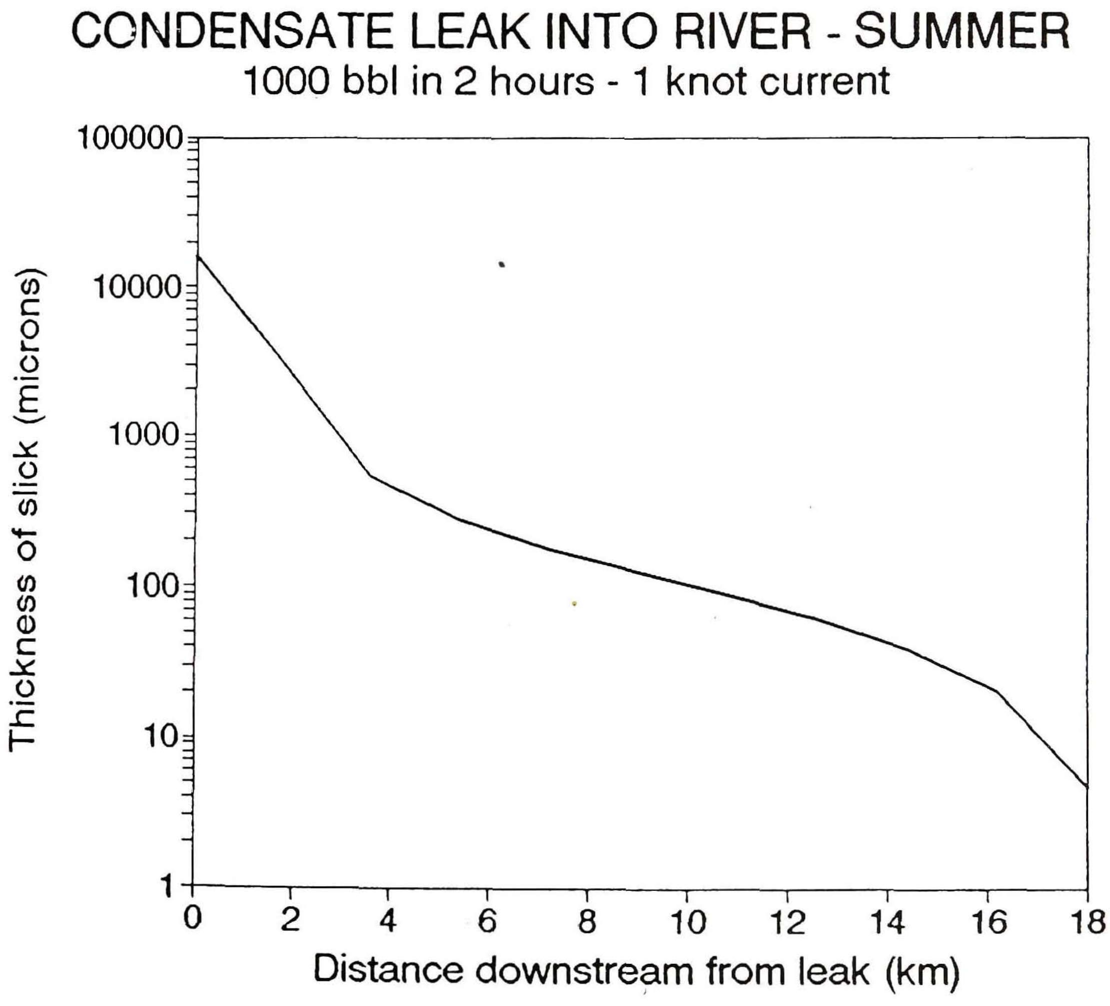
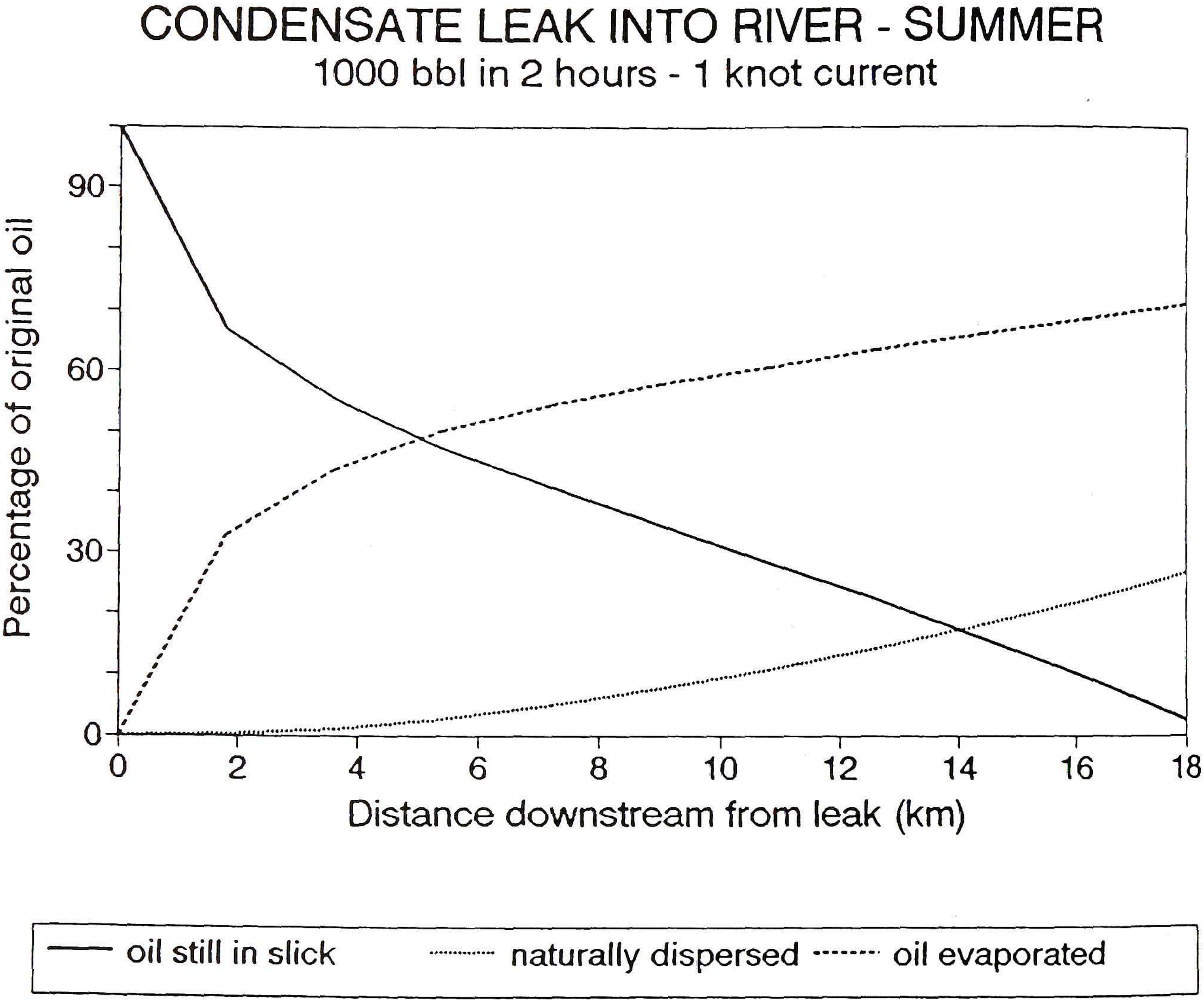

CONDENSATE LEAK INTO RIVER - SUMMER
1000 bbl in 2 hours - 1 knot current
Thickness of slick (microns)
100000
10000
1000
100
10
1
0
2
4
6
8
10
12
14
16
18
Distance downstream from leak (km)

FIGURE 6-3


CONDENSATE LEAK INTO RIVER - SUMMER
1000 bbl in 2 hours - 1 knot current
Percentage of original oil
0
30
60
90
0
2
4
6
8
10
12
14
16
18
Distance downstream from leak (km)
oil still in slick
naturally dispersed
oil evaporated

6.3.3 Oil Pipeline Break At a River Crossing in Summer

6.3.3.1 Incident Description

A catastrophic failure of a weld in a 24" oil pipeline carrying Amauligak crude oil occurs in a section buried beneath the Mackenzie River. The break is detected, the pipeline shuts down and safety valves are closed in 5 min. Prior to shutdown, 350 bbls of oil are released (5 min @ 100,000 BOPD [barrels oil per day]). Within 2 h of shutdown, another 4650 bbls of oil (the contents of 2.5 km of 24" pipe) drain out of the pipeline between the closed safety valves. The leak then stops as the pressures balance.

6.3.3.2 Environmental Conditions

The wind speed averages 3 m/s and is blowing along the length of the river. The air temperature is 15°C and the water temperature is 10°C. The current velocity in the river is 0.5 m/s.

6.3.3.3 Spill Behaviour

While the oil is still leaking out, it forms a narrow slick 1.8-km long and 400-m wide. The majority of the surface area of this slick is in the form of a sheen (85% = 0.6 km^2), while most of the total volume of oil (99%) is present in the thick slick. With time, the slick breaks up into patches of thick oil surrounded by sheen and separated by oil-free water.

Figure 6-4 shows the predicted spreading of the slick (both in area and equivalent diameter of a circular slick) as it drifts down the river. At its maximum size, the slick covers an area of 3.4 km^2 of water, although only 0.25 km^2 contains thicker portions. Figure 6-5 illustrates the thinning of the thick slick as it moves downriver. Initially the oil is not emulsified, but after 23 h of exposure to air and water (41 km downstream), it has weathered enough to begin forming an emulsion.

FIGURE 6-4

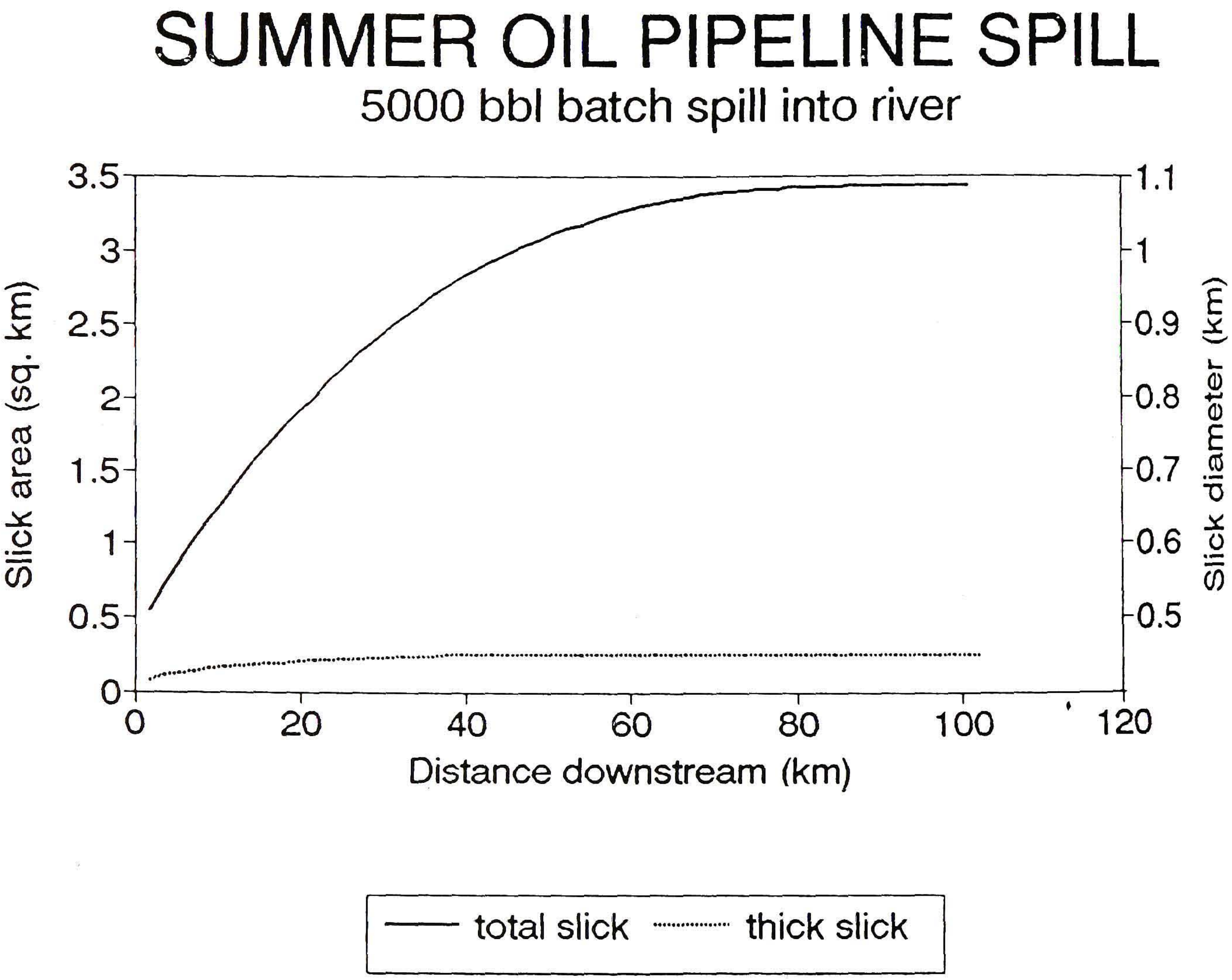

SUMMER OIL PIPELINE SPILL
5000 bbl batch spill into river
Slick area (sq. km)
Slick diameter (km)
Distance downstream (km)
0
0.5
1
1.5
2
2.5
3
3.5
0.5
0.6
0.7
0.8
0.9
1
1.1
0
20
40
60
80
100
120
total slick
thick slick

FIGURE 6-5

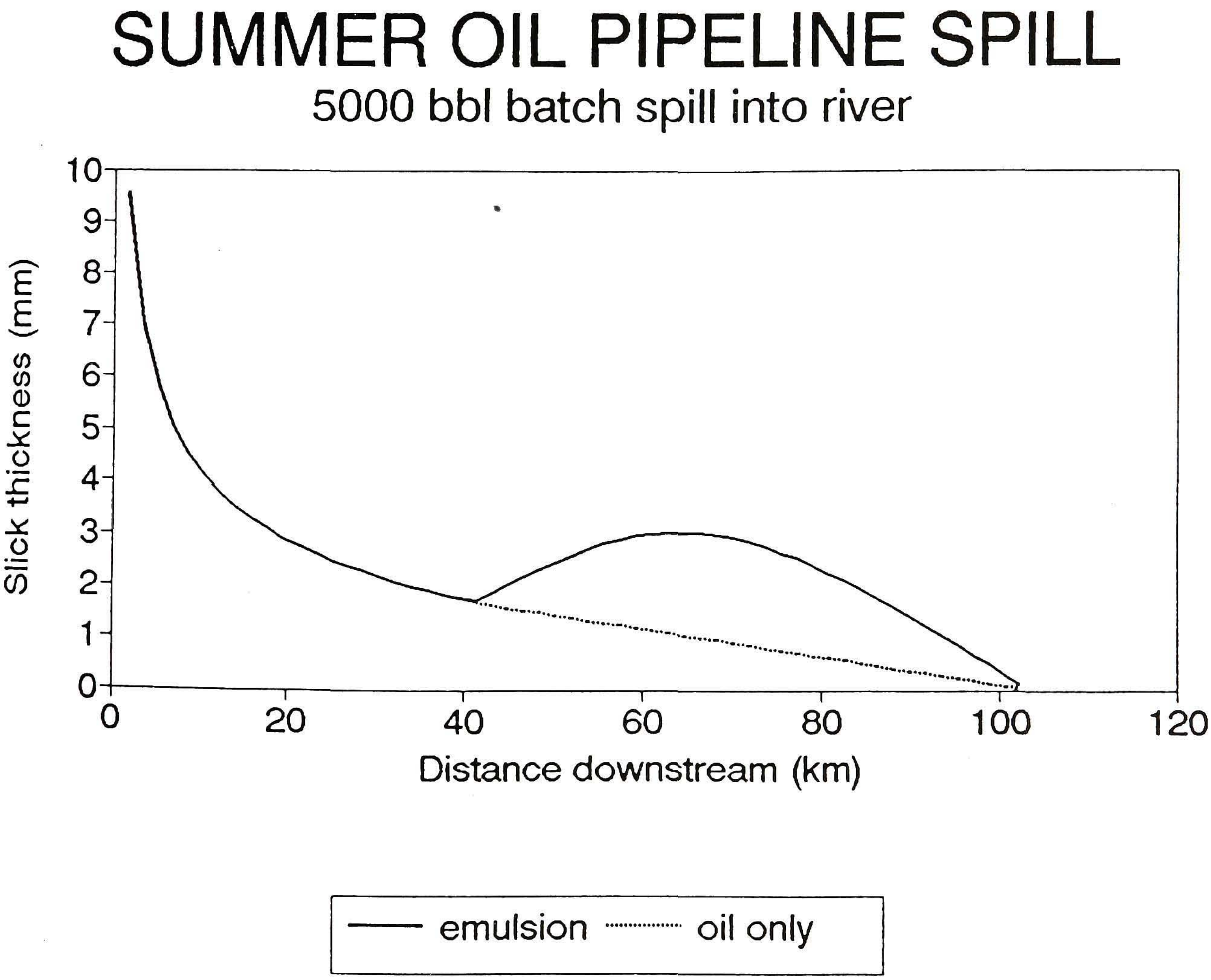

SUMMER OIL PIPELINE SPILL
5000 bbl batch spill into river
Slick thickness (mm)
10
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
Distance downstream (km)
emulsion
oil only

Figure 6-6 shows the predicted fate of the slick as it moves down the river. Overall, 70% of the slick naturally disperses and 30% evaporates over the 57-h survival time of the slick. Peak, initial dispersed oil concentrations beneath the slick (evenly mixed over the entire slick and to a depth of 5 m) remain relatively constant, declining from 1 ppm near the time of the release to 0.7 ppm near the end of the spill.

6.3.3.4 Countermeasures

For the purposes of this scenario, it is assumed that no countermeasures are implemented prior to the dissipation of the oil.

6.3.3.5 Shoreline Oiling

It is assumed that both shores of the Mackenzie River are sporadically oiled along a 100-km stretch affected by the spill. It is estimated that 1000 bbls of oil are stranded in widely-scattered areas within this affected zone.

6.3.3.6 Summary

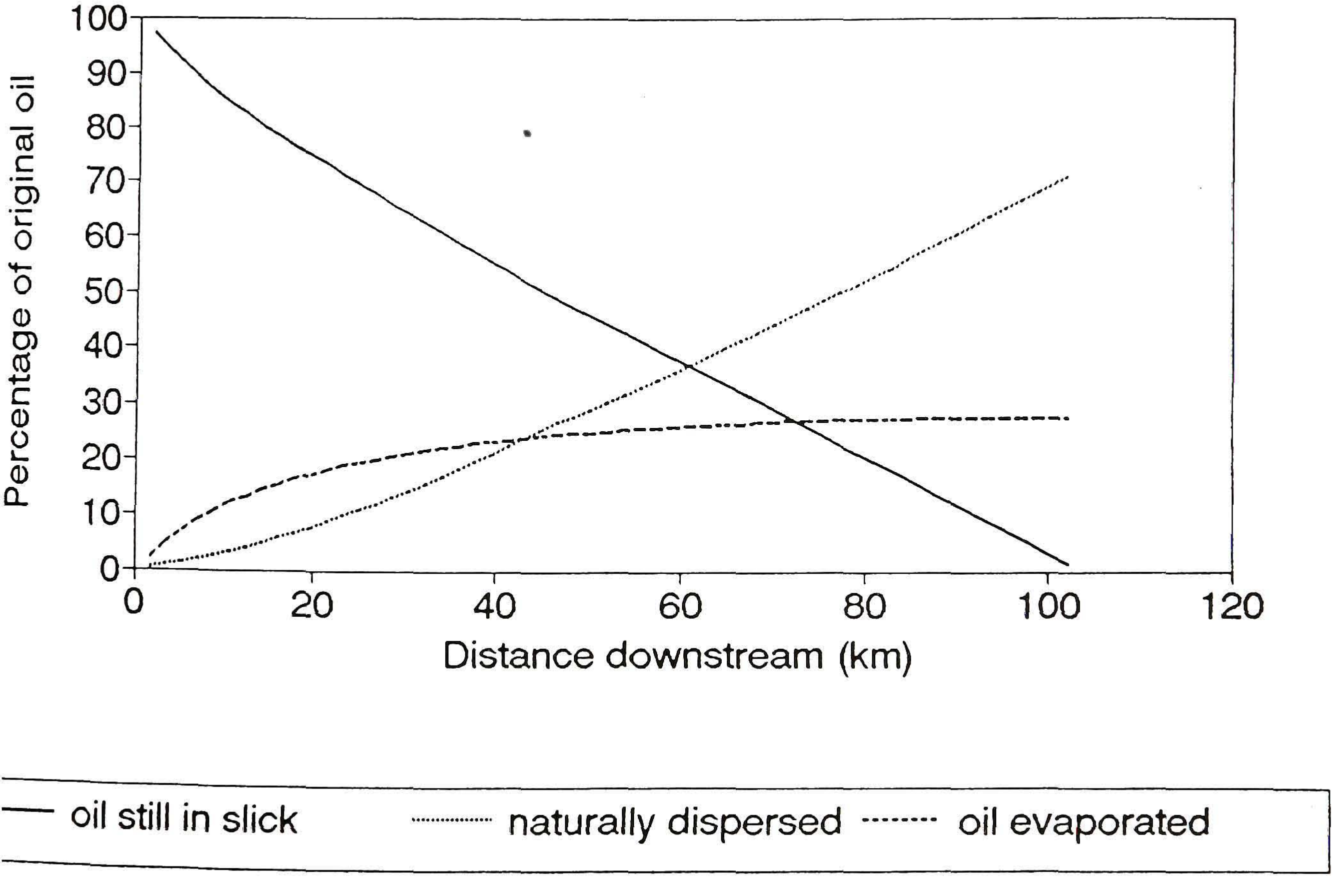
The following summarizes the fate of the oil from this scenario:

OIL SPILLED: 5000 bbls
OIL EVAPORATED: 1500 bbls
OIL NATURALLY DISPERSED: 2500 bbls
OIL ON SHORELINES: 1000 bbls
OIL RECOVERED: 0

FIGURE 6-6

SUMMER OIL PIPELINE SPILL

5000 bbl batch spill into river



6.3.4 Oil Pipeline Leak at a River Crossing in Spring

6.3.4.1 Incident Description

On May 15, a weld in a section of pipeline carrying Amauligak oil beneath the Mackenzie River cracks and begins to leak oil slowly, releasing 10,000 bbls over a 2-week period (80 L/min). The leak is discovered after 14 days, and the pipeline is shut down.

6.3.4.2 Environmental Conditions

Winds during the spill event are light (1 m/s). The air and water temperatures are both 0°C. The current velocity is 1 m/s, and the river is 50% ice covered.

6.3.4.3 Spill Behaviour

The oil released from the riverbed rises to the surface just downstream from the leak. Initially, the slick is 2-m wide and 0.8-mm thick. Half the slick is released under ice floes passing over the leak; the other half is released into areas of open water. Figure 6-7 shows the spreading of the slick on the water as it expands and moves downriver; by the time the slick extends almost 160 km down the river, it has spread to a width of 4.6 km. At this point, an ice jam is encountered and the remaining slick is dispersed into the water.

Figure 6-8 shows the predicted thinning of the thick portion of the slick on the water as it moves downstream. The oil thins rapidly at first, reaching a thickness of 10 μm after 7 h of movement (25 km) downriver from the leak. From this point, the slick thins much more slowly because the pour point of the crude oil exceeds the water temperature. The oil released under ice floes is painted on the underside of the ice to a thickness of 0.8 mm. This oil is slowly released as these floes rot.

FIGURE 6-7

PIPELINE OIL SPILL IN RIVER - BREAKUP
10,000 bbl in 2 weeks - 2 knot current

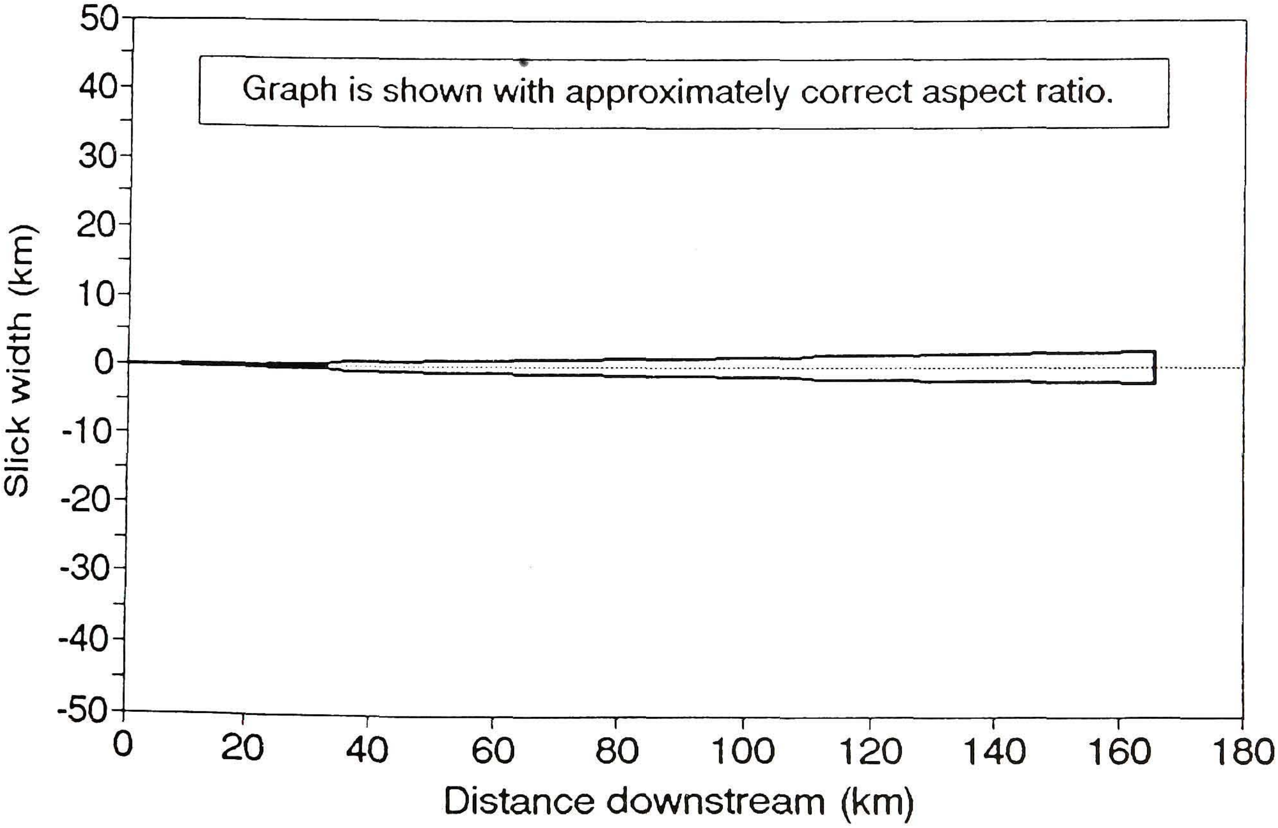


FIGURE 6-8

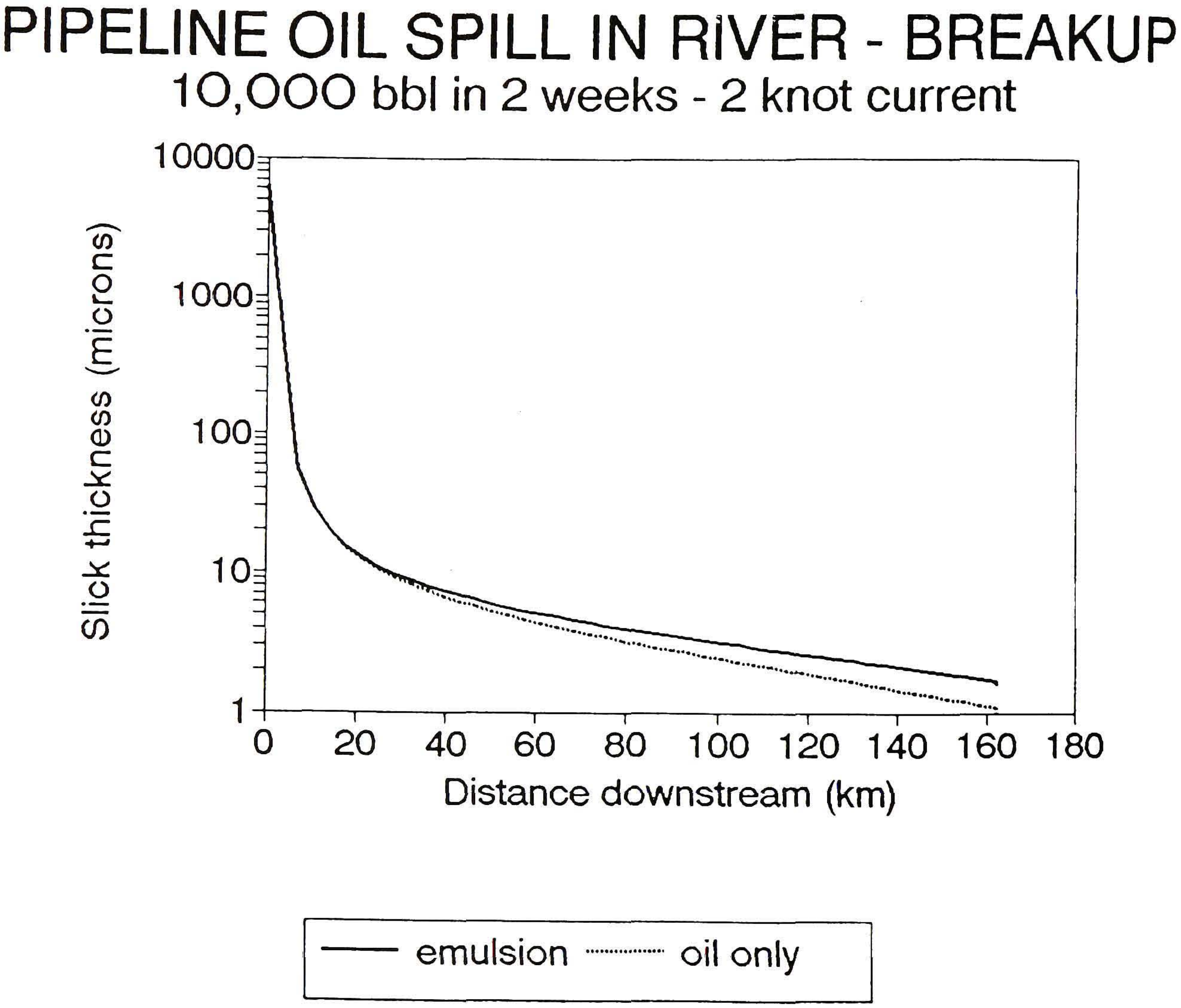

PIPELINE OIL SPILL IN RIVER - BREAKUP
10,000 bbl in 2 weeks - 2 knot current
Slick thickness (microns)
10000
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
Distance downstream (km)
emulsion
oil only

Figure 6-9 illustrates the fate of a portion of the oil slick on the water as it moves downstream from the leak location. In the relatively calm river environment (i.e. no wave action), natural dispersion is assumed to be relatively slow until the slick reaches the ice jam; at this point, the remaining oil is completely and permanently dispersed into the water. Assuming that the dispersed oil is evenly mixed over the width of the slick to a depth of 5 m, its concentration in the water would be 0.03 ppm.

6.3.4.4 Countermeasures

It is assumed that no countermeasures operations are initiated to deal with oil on the water.

6.3.4.5 Shoreline Oiling

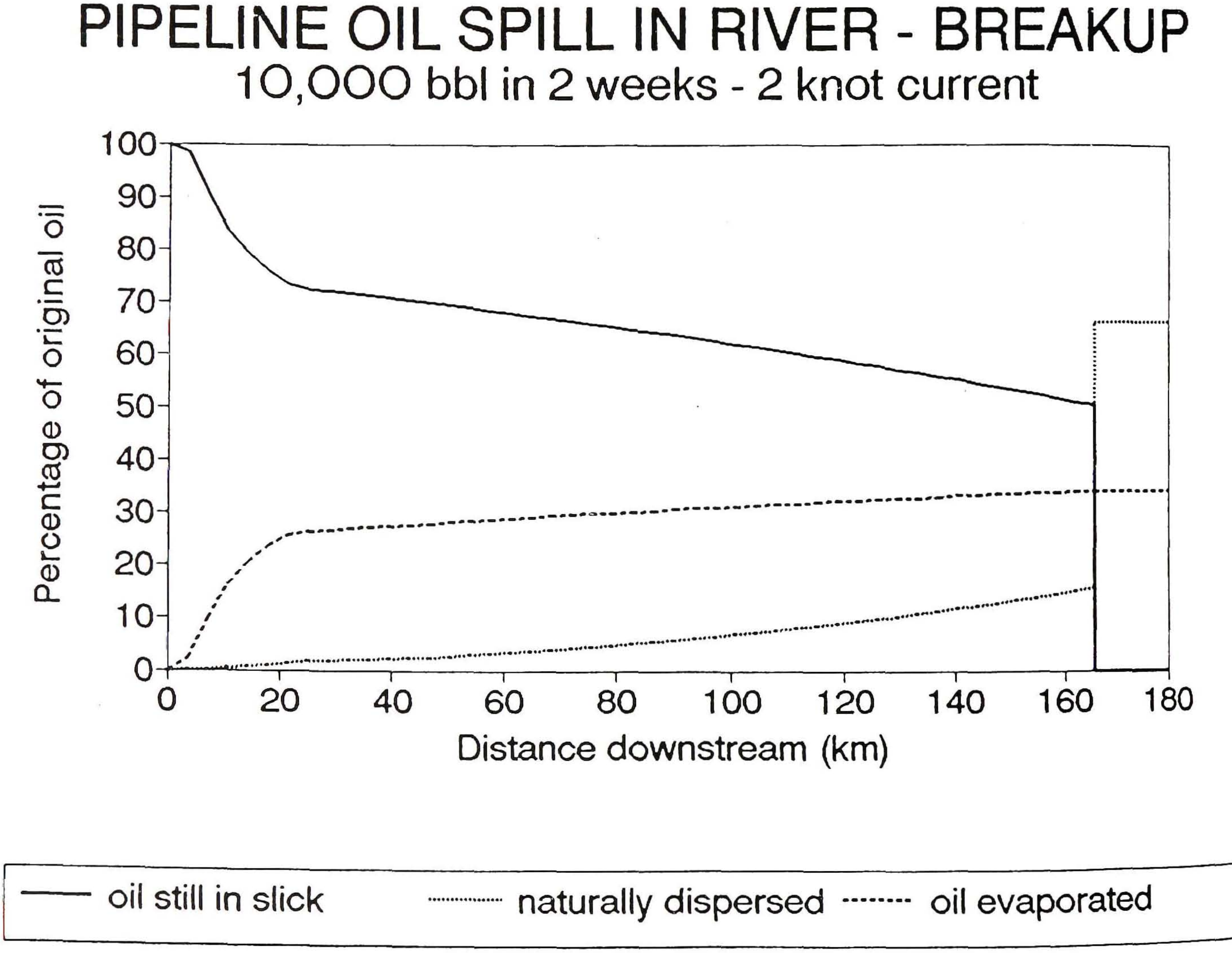
It is assumed that both shores of the river are sporadically oiled along the 160-km length from the leak site to the ice jam. It is further assumed that 2000 bbls of oil end up in widely-separated areas along the river banks.

6.3.4.6 Summary

The following summarizes the predicted fate of the oil from an oil pipeline leak during spring:

OIL SPILLED: 10,000 bbls
OIL EVAPORATED: 3400 bbls
OIL NATURALLY DISPERSED: 4600 bbls
OIL ON SHORELINES: 2000 bbls
OIL RECOVERED: 0

FIGURE 6-9


PIPELINE OIL SPILL IN RIVER - BREAKUP
10,000 bbl in 2 weeks - 2 knot current
Percentage of original oil
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
Distance downstream (km)
oil still in slick
naturally dispersed
oil evaporated

6.3.5 Island Platform Blowout Scenario

6.3.5.1 Incident Description

On August 1, while drilling a well from an artificial island located at 69°39'N, 136°00'W, a blowout occurs due to the failure of the internal BOP (blowout preventer) and the shear rams to control a flow created by swabbing gas into the hole. The blowout flows from the drillpipe remaining in the hole at 12,900 BOPD (2050 m^3/day) of Adgo oil (Bobra 1990) and 277,000 m^3/day of natural gas. The flow continues unabated for six days until killed from the surface by the installation of a valve on the drill pipe.

6.3.5.2 Environmental Conditions

During the 6-day incident, the winds average 5.5 m/s and the air and sea temperatures are both 6°C. The currents in the vicinity of the offshore platform are 0.25 m/s. Weather and sea conditions suitable for marine oil spill countermeasures exist 55% of the time.

6.3.5.3 Oil Release Conditions

The gas, exiting the drill pipe at 340 m/s, shatters the oil into droplets with a mean diameter of 175μm and shoots them to a height of 30 m above sea-level. The oil droplets rain out onto the sea surface downwind of the island in a slick that is initially 750-μm thick and 100-m wide. During their time in the air, the oil droplets lose 18% of their volume due to evaporation and also cool to ambient environmental temperatures. The oil slick drifts away from the island at 0.25 m/s.

6.3.5.4 Oil Fate Predictions

As the continuous slick drifts slowly away from the spill site, it spreads, thins, evaporates, emulsifies and naturally disperses. Figure 6-10 shows the predicted width of the continuous slick as a function of distance from the spill site; Figure 6-11 depicts the corresponding thickness of the emulsified oil in the thick portions of the slick and the equivalent oil thickness of that emulsion. Once a portion of the slick has drifted a few kilometres from the spill site, it breaks into patches of thicker emulsified oil surrounded by sheen. This eventually further breaks up into thick patches of heavily-weathered emulsion (mousse) surrounded by sheen and separated by uncontaminated water.

Figure 6-12 shows the predicted loss of oil due to evaporation and natural dispersion from a slice of the slick as it drifts away from the spill site. If the slice does not contact land, it would dissipate (99% of the oil has evaporated and naturally dispersed) in just over 200 km.

6.3.5.5 Near-Source Countermeasures

The Beaufort Sea Co-op's Response Barge is deployed and operating down drift of the blowout in 24 h. In view of the physical capabilities and limitations of this equipment and the properties of the slick, about 25,000 barrels of oil could be recovered from the sea surface near the blowout site.

6.3.5.6 Shoreline Oiling

The volumes of emulsion (containing 75% water) coming ashore are based on the following assumptions:

1. over the 6-d event, the wind blows at 5.5 m/s from the north for 2.5 d and from the north-east for 3.5 d.

FIGURE 6-10

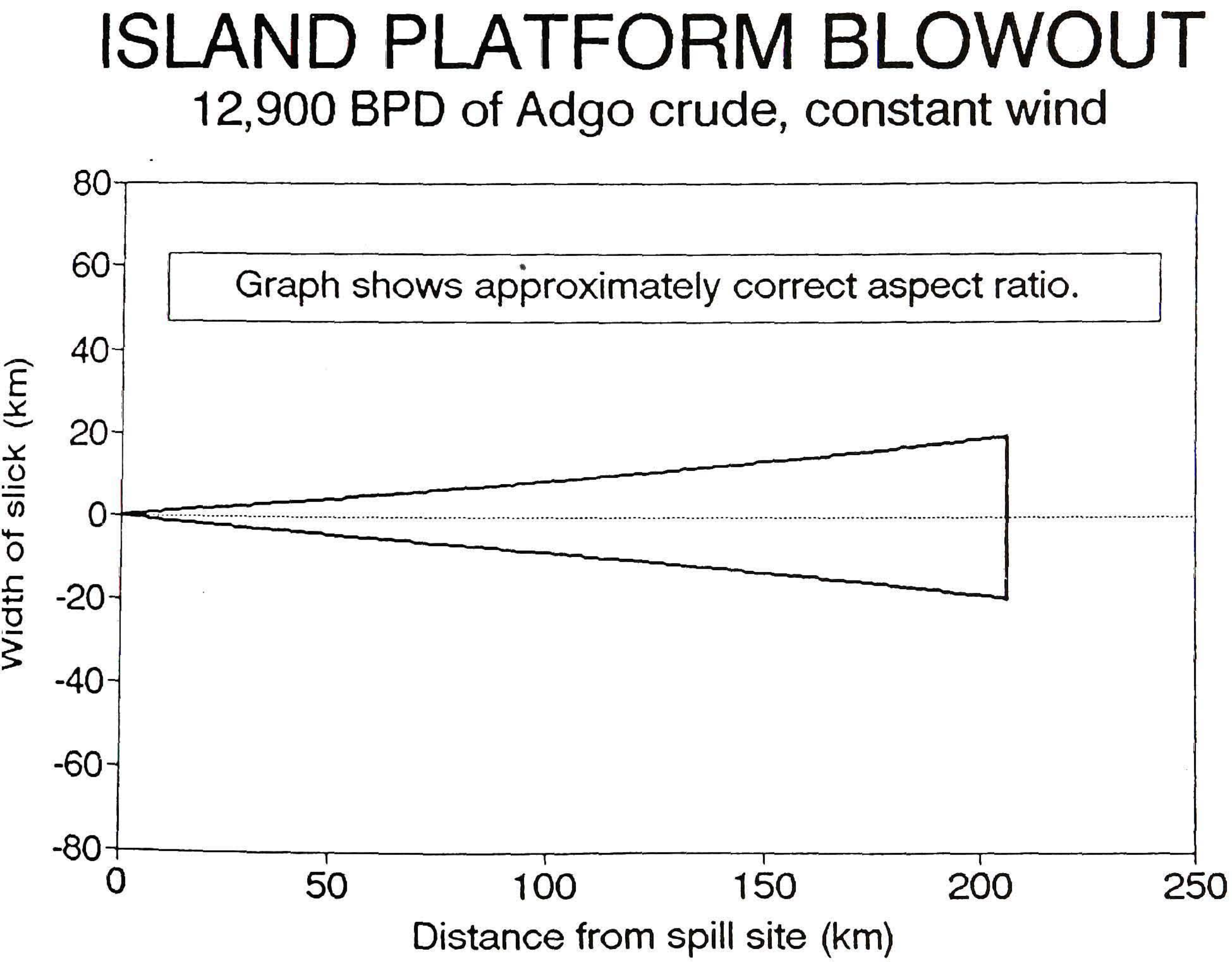

ISLAND PLATFORM BLOWOUT
12,900 BPD of Adgo crude, constant wind
Graph shows approximately correct aspect ratio.
80
60
40
20
0
-20
-40
-60
-80
Width of slick (km)
0
50
100
150
200
250
Distance from spill site (km)

FIGURE 6-11

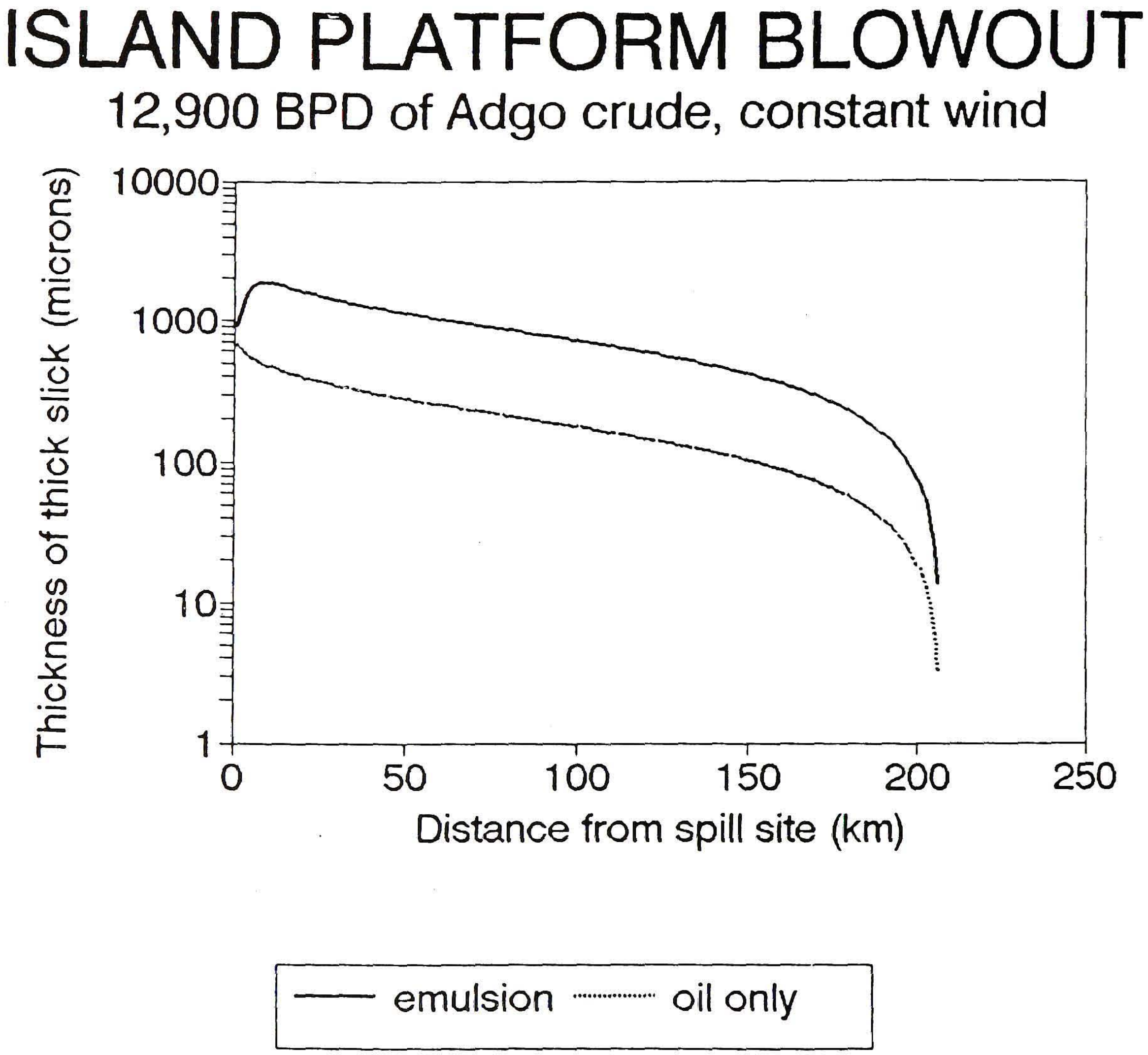
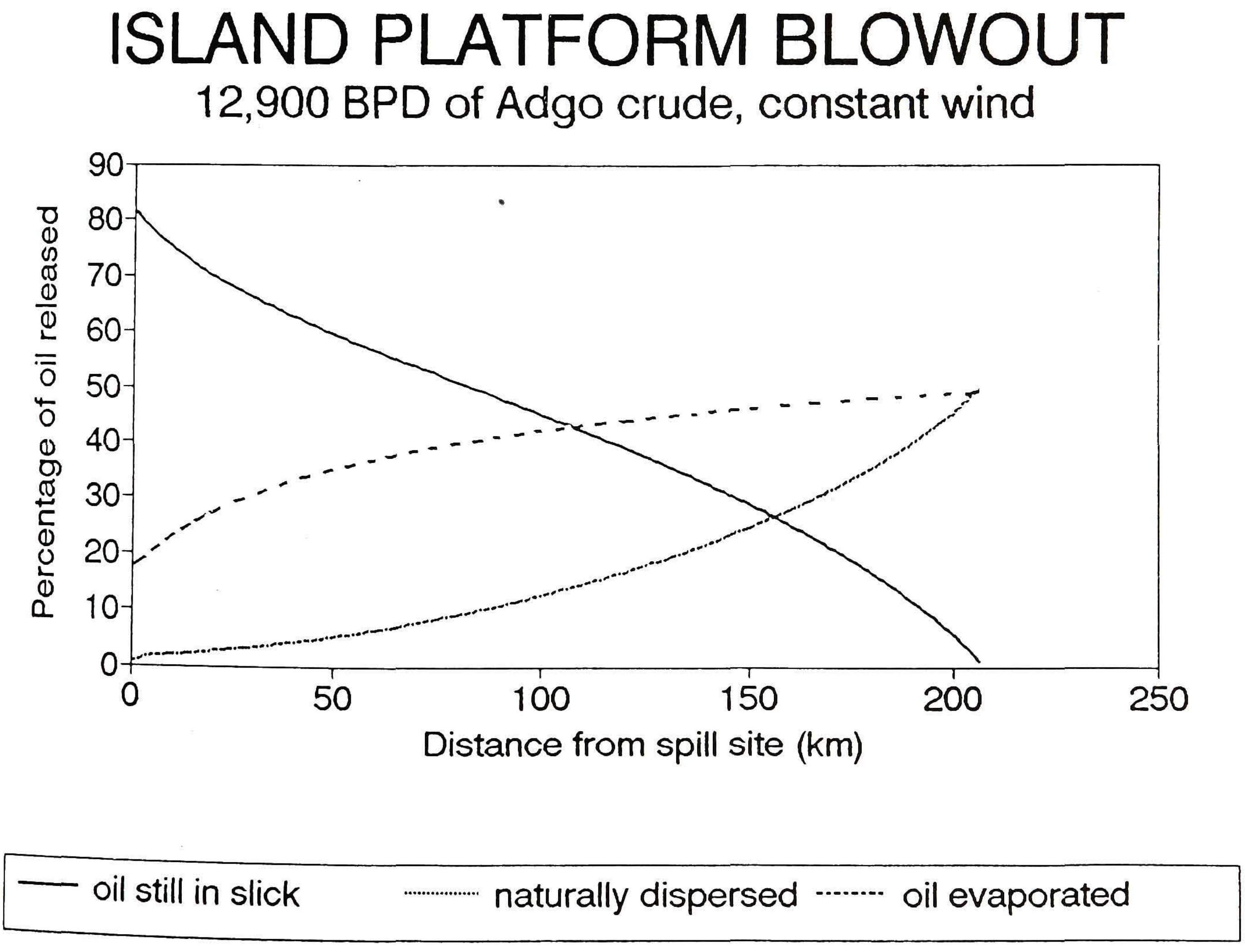

ISLAND PLATFORM BLOWOUT
12,900 BPD of Adgo crude, constant wind
Thickness of thick slick (microns)
10000
1000
100
10
1
0
50
100
150
200
250
Distance from spill site (km)
emulsion
oil only

FIGURE 6-12


ISLAND PLATFORM BLOWOUT
12,900 BPD of Adgo crude, constant wind
Percentage of oil released
0
10
20
30
40
50
60
70
80
90
0
50
100
150
200
250
Distance from spill site (km)
oil still in slick
naturally dispersed
oil evaporated

2. the average distance from the well site to the Yukon coast to the south west is 90 km (equivalent to the distance where 50% of the oil originally discharged still remains in the slick).

3. the average distance from the well site to the Mackenzie Delta coastline to the south is 40 km (65% of the slick volume remaining).

4. 33% of the oil discharged is removed near the source of the blowout by marine countermeasures.

Given these assumptions, the following extent and location of shoreline oiling is predicted to occur:

1. along the Yukon coast between Kay Pt. and Whitefish Station, some 60,000 bbls of emulsion (75% water) strand on shorelines.

2. between Whitefish Station and Avoknar Channel in the Delta, another 56,000 bbls of emulsion (75% water) are stranded.

6.3.5.7 Summary

The following summarizes the predicted fate of the oil released from the hypothetical blowout.

OIL RELEASED OVER 6 DAYS: 77,400 bbls
OIL EVAPORATED: 19,400 bbls
OIL NATURALLY DISPERSED INTO WATER-COLUMN: 4000 bbls
OIL ON SHORE: 29,000 bbls (116,000 bbls of emulsion)
OIL RECOVERED OFFSHORE: 25,000 bbls

6.3.6 Offshore Sub-Sea Blowout Scenario

6.3.6.1 Incident Description

On September 15, a blowout occurs during late-season drilling operations at an offshore wellsite (70°06'N, 134°00'W). While tripping the drill pipe out, gas is swabbed into the well and, while circulating the kick out, sand erodes a hole in the kill line access to the BOP. An attempt is made to kill the well by pumping mud from the reserve pit but it clogs the bit; hydrocarbons flow to the surface through the annulus and out of the hole in the BOP on the seabed in 24 m of water. The drillship disconnects and moves safely offsite.

Amauligak crude oil and gas flow for 6 days from the hole at rates of 12,900 BOPD (2050 m^3/day) and 277,000 m^3/day, respectively. After 6 days, the upper zones of the formation collapse into the well bore and shut off the flows of oil and gas.

6.3.6.2 Environmental Conditions

The wind speed over the 6-d scenario averages 7.7 m/s and blows continuously from the north. The air temperature is 3°C and the water temperature is 1°C. The current velocity is constant at 0.25 m/s.

6.3.6.3 Near-Source Spill Behaviour

The oil from the well head is shattered into small (1 to 2 mm) droplets by the high velocity of the escaping gas. The gas rises to the surface as a plume, drawing large volumes of water and the oil droplets with it. As the entrained water nears the surface, it turns outwards and carries the entrained oil droplets with it. The oil droplets slowly rise to the surface to form a parabola-shaped continuous slick. This slick spreads and moves downwind with the 0.25 m/s current. At a point 900 m downdrift of the blowout site, the slick is 860 m wide, 40-μm thick and consists of a 30% water-content emulsion formed with 31% evaporated crude.

6.3.6.4 Near-Source Countermeasures

Within a day, the resources of the Beaufort Sea Co-op are deployed and operating in the slick down-drift of the blowout. With cleanup operations possible 55% of the time, 11,000 barrels of oil (14,000 bbls of emulsion) could be skimmed and 8000 barrels of oil (10,000 bbls of emulsion) could be burned in fire-proof booms in the 5 days available for offshore operations.

6.3.6.5 Predicted Oil Behaviour and Fate

Because of the low-pour point and low-viscosity nature of Amauligak oil, it is highly susceptible to natural dispersion until it emulsifies. As such, in the time it takes for the slick to drift 900 m, about 44% of the oil released has dispersed into the water column. The initial concentration of oil beneath the slick at a 900-m distance from the blowout (assuming the dispersed oil is evenly distributed to a depth of 10 m) is 5 ppm. Assuming Okubo-oceanic diffusion applies, the concentration in this dispersed oil plume would drop below 1 ppm approximately 73 km downdrift of the blowout site (where the width of the slick is 4300 m).

Figure 6-13 shows the spreading of the surface slick as it drifts away from the blowout site. Ultimately, it reaches a width of about 4 km. Near the blowout site, the oil is a continuous slick. As it drifts away, however, it breaks up into patches of thicker, emulsified oil surrounded by sheen. Still further downstream, the sheen becomes discontinuous and the slick consists of emulsified oil patches surrounded by sheen separated by clean water from other patches.

Figure 6-14 shows the predicted thickness of the surface slick as a function of drift distance from the blowout. The upper curve shows the thickness of the emulsion; the lower curve shows the equivalent thickness of the oil in the emulsion. The thickness of the emulsion increases initially as the slick takes up water until it reaches its predicted maximum water content.

FIGURE 6-13

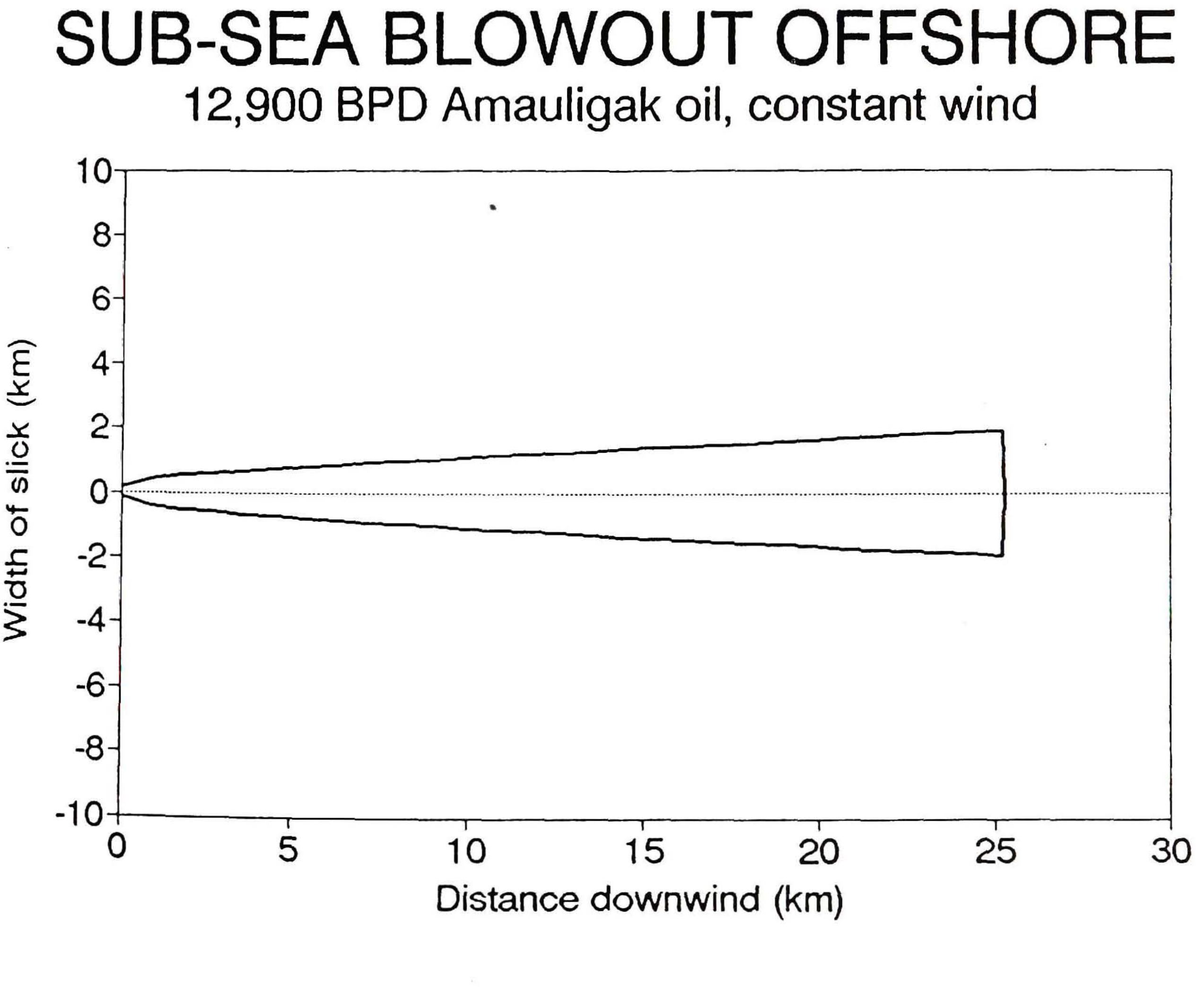

SUB-SEA BLOWOUT OFFSHORE
12,900 BPD Amauligak oil, constant wind
Width of slick (km)
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
5
10
15
20
25
30
Distance downwind (km)

FIGURE 6-14

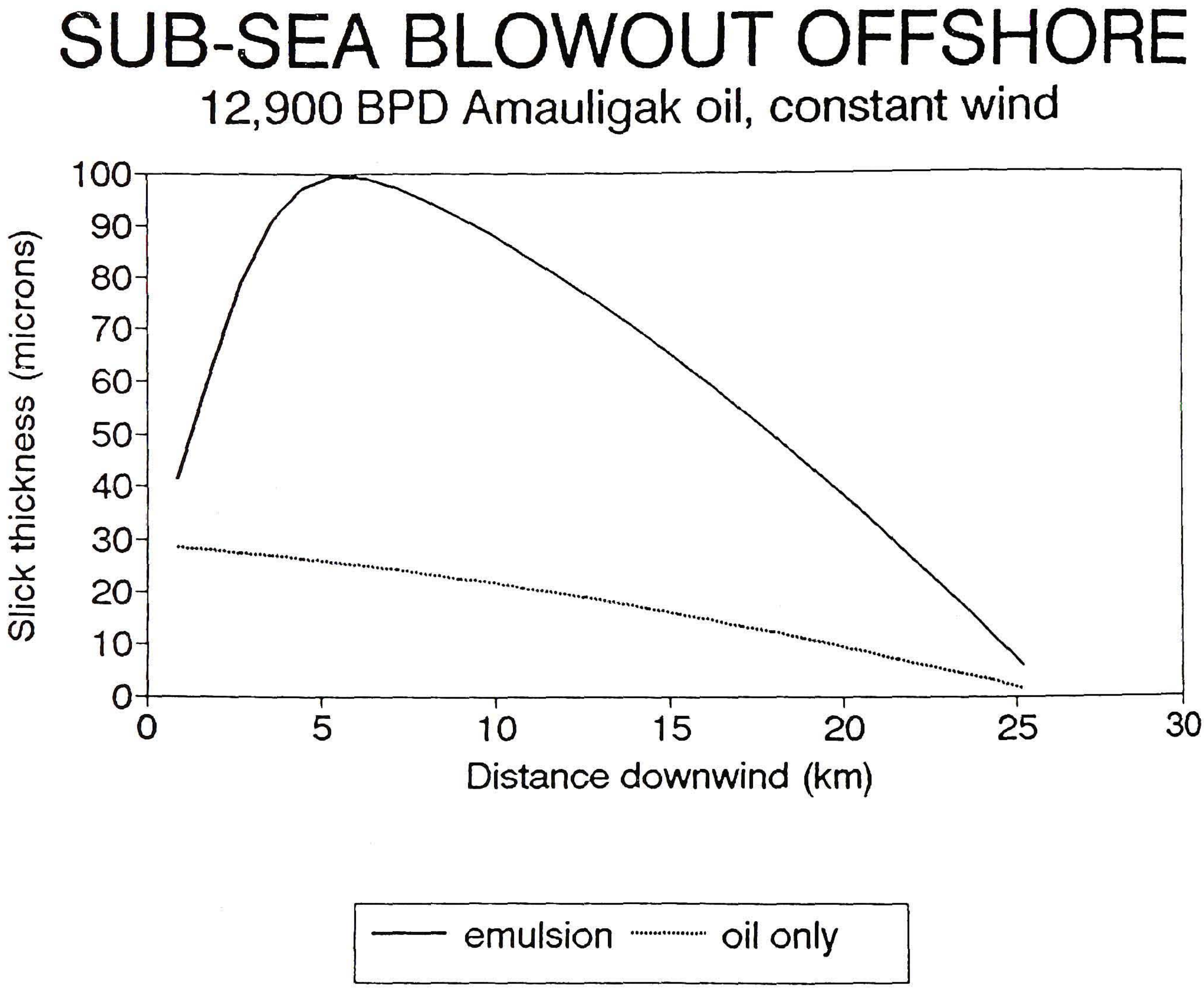

SUB-SEA BLOWOUT OFFSHORE
12,900 BPD Amauligak oil, constant wind
Slick thickness (microns)
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
25
30
Distance downwind (km)
emulsion
oil only

Figure 6-15 illustrates the fate of a portion of the slick as it drifts away from the blowout site. As noted above, much of the oil naturally disperses and evaporates near the blowout site while it is fresh, thin and has a low viscosity. The remaining surface slick is predicted to survive for a distance of some 25 km from the site until 99% of the original oil has evaporated or naturally dispersed. At this point, the thick portion of the slick has thinned to 1 µm, and only sheen remains.

6.3.6.6 Shoreline Oiling

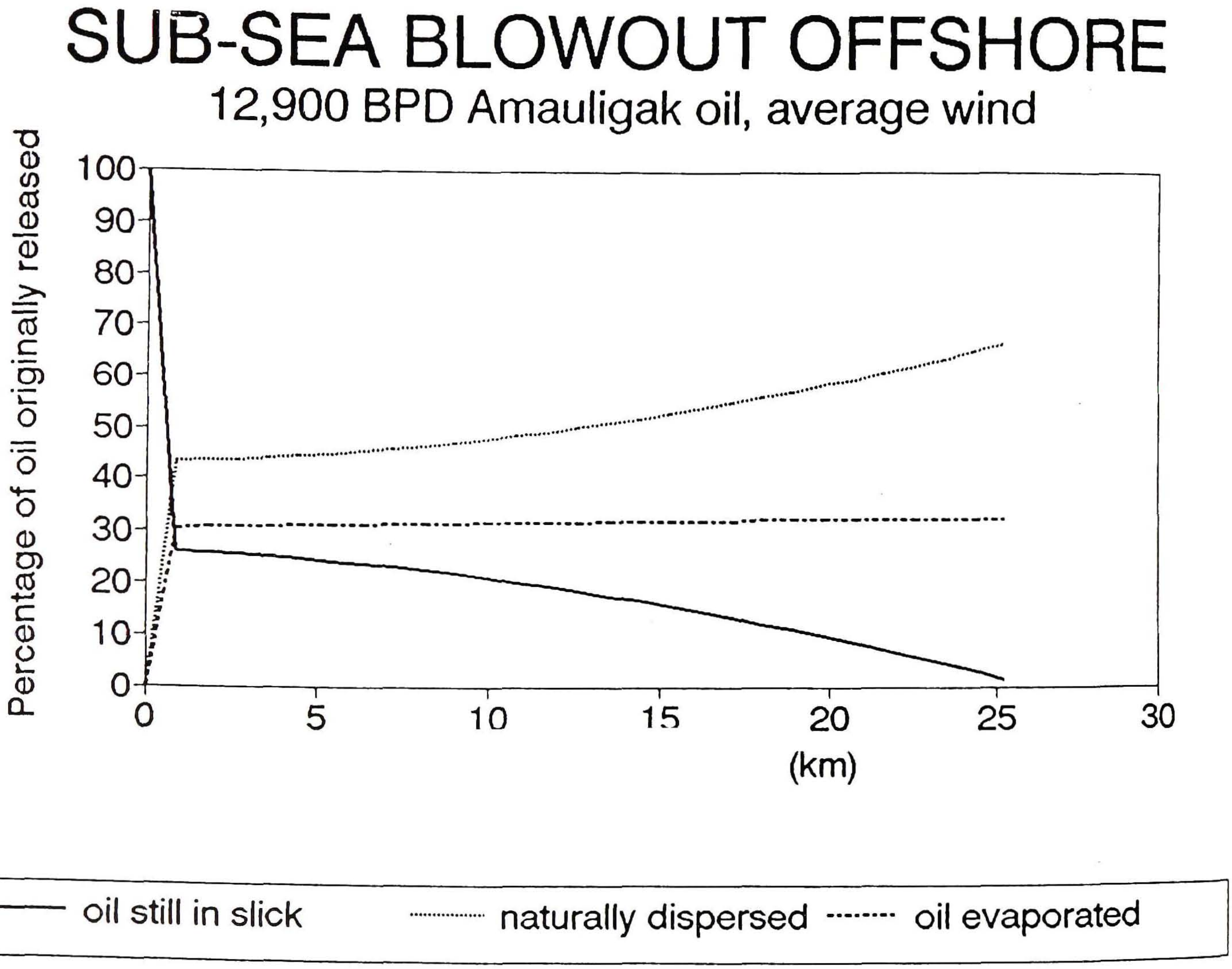
Due to the nature of the oil in this scenario, the surface slick is predicted to dissipate prior to reaching shore, and no significant shoreline oiling is assumed to occur. However, nearshore areas in the Delta, Kugmallit Bay and between Tuktoyaktuk and Tuft Point could be exposed to dispersed oil concentrations in the 1 to 5 ppm range.

6.3.6.7 Summary

The following summarizes the predicted fate of the Amauligak crude oil released in this scenario:

OIL RELEASED: 77,400 bbls
OIL EVAPORATED: 23,600 bbls
OIL NATURALLY DISPERSED: 34,800 bbls
OIL REMOVED OFFSHORE: 11,000 bbls skimmed plus; 8000 bbls burned *in situ*
OIL ON SHORE: 0

FIGURE 6-15


SUB-SEA BLOWOUT OFFSHORE
12,900 BPD Amauligak oil, average wind
Percentage of oil originally released
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
(km)
oil still in slick
naturally dispersed
oil evaporated

6.4 New Impact Hypotheses for Future Consideration

Based on the selected list of Valued Ecosystem Components (Table 6-1) and the six oil spill scenarios developed for offshore well blowouts and onshore oil pipeline ruptures, a series of new impact hypotheses were developed for evaluation at future BREAM workshops. These hypotheses were structured to include not only the direct effects of oil itself on the environment and its resources but also the indirect effects of clean-up, restoration and monitoring operations. Due to the need to review the tentative list of VECs and the possible consolidation of resource groups (Section 6.2), one impact hypothesis was formulated for each spill scenario involving marine mammals, terrestrial and semi-aquatic mammals, birds and, freshwater, marine and anadromous fish. These hypotheses will provide the framework for developing more specific hypotheses related to each VEC group or surrogate VEC, where deemed necessary.

As mentioned in Section 6.3, there will be a need to develop one or more additional scenarios around refined fuel spills. New impact hypotheses related to these scenarios should be formulated prior to any future workshop dealing with catastrophic oil spills. Two possible scenarios would be: (1) grounding of a barge on the Mackenzie River in late spring resulting in the loss of No. 2 diesel oil into surrounding waters; and (2) a transport vehicle accident on an ice road in winter resulting in spillage of diesel or gasoline onto the adjacent tundra.

6.4.1 Marine Mammals

Offshore Oil Spill - Marine Mammals

This hypothesis involves the possible effects of a substantial offshore blowout of crude oil on marine mammals. The following linkages lead from the release of oil to effects on marine mammals (i.e. VECs) and on the harvest of marine mammals (also a VEC).

Link 1: **An offshore oil blowout will lead to the presence of oil on the water surface and in the water column.**

Link 2: **Some oil will be stranded along shorelines.**

The presence of stranded oil will be dealt with in another hypothesis that examines the effects of the stranded oil on terrestrial mammals.

Link 3: **The presence of oil in the water column can have effects on important food chains.**

The effects of oil on food chains are examined in a separate hypothesis.

Link 4: **The presence of oil can lead to direct effects on marine mammals.**

Direct effects are related to the effects of the oil itself. There are also several indirect effects of an oil spill that are related to the effects of the well control and clean-up operations. The indirect effects are embodied in the following link.

Link 5: **The presence of oil can lead to indirect effects on marine mammals related to well control and oil clean-up activities.**

Link 6: **Marine mammals can become oiled by swimming or surfacing through oil slicks.**

Link 7: **Marine mammals can ingest oil directly from the water or by eating oiled prey.**

Link 8: **Certain species of marine mammals, particularly polar bears, may ingest oil while attempting to clean their own oiled fur.**

Link 9: **The ingestion of oil may have lethal and sub-lethal effects on marine mammals.**

Link 10: **Contact with oil by the skin and/or fur may have thermal and other sub-lethal effects on marine mammals.**

The ingestion and surface contact with oil has certain known and unknown effects on marine mammals. Effects range from lethal to polar bears, possibly lethal to arctic foxes, sub-lethal to seals, to possibly sub-lethal to whales.

Link 11: **Mortality to polar bear and arctic fox populations will lead to reduced populations.**

Link 12: **Reduced populations of bears and foxes will result in reduced levels of harvest.**

Link 13: **The presence of oil on fur or skin will reduce the value of the product and therefore reduce the quantity and quality of the harvest.**

In addition to the actual effects of surface contact with oil, there will be several perceived effects that will reduce the market value of the product and may even lead to regulatory closures of some hunts for one or more years.

Link 14: **Well control and clean-up activities will produce noise and will disturb marine mammals.**

Link 15: **Noise and disturbance will cause changes in the distribution of marine mammals that will lead to changes in the harvestability of the animals.**

Link 16: **Noise and disturbance will cause reductions in time available for foraging and will increase energy expenditures through increased avoidance behaviour.**

Link 17. **The energetic effects of noise and disturbance will manifest themselves through reduced reproduction by the affected animals. This will lead to reduced populations.**

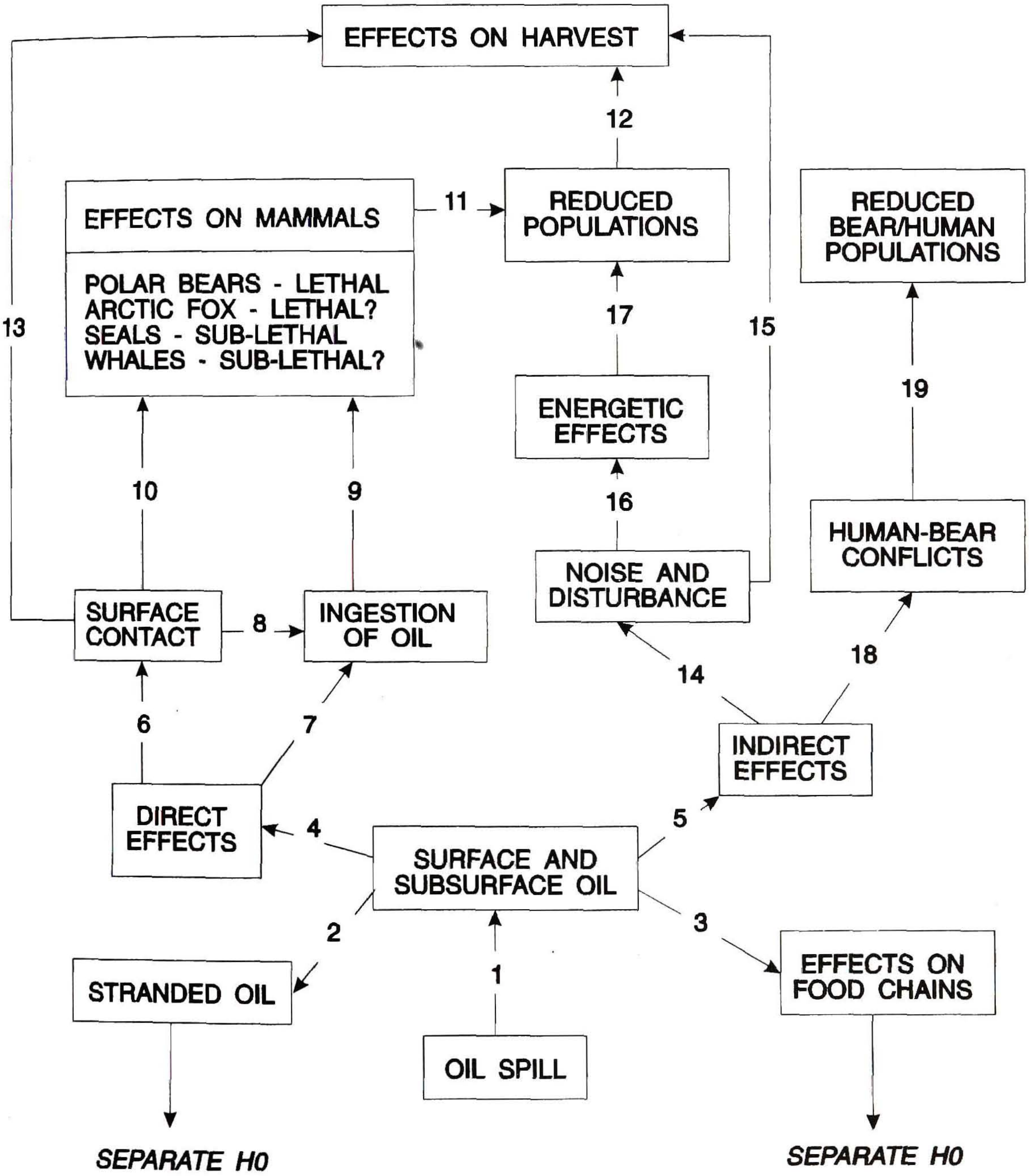
The energetic links are more extensive and complex than noted here. They are discussed explicitly in BREAM R-1.

Link 18: **The presence of humans associated with well control and clean-up activities will lead to conflicts between polar bears and humans.**

Link 19: **Man/bear conflicts will lead to the death of several bears, or possibly even humans.**

FIGURE 6-16

OFFSHORE OIL SPILL VS MARINE MAMMALS



6.4.2 Terrestrial and Semi-Aquatic Mammals

6.4.2.1 Terrestrial Mammals

Offshore Oil Spill - Terrestrial Mammals

This hypothesis addresses the effects of an offshore oil blowout on terrestrial mammals that results in substantial amounts of oil becoming stranded along the shore, in coastal lagoons and marshes, and in storm-surge zones. Thus, the initial agent of potential effects is the presence of stranded oil along shore.

Link 1: The presence of oil will damage or kill coastal vegetation that provides important habitat for terrestrial mammals.

This link is considered to be an end in itself; its significance is a function of the amounts and types of vegetation which will be affected, and the terrestrial mammals involved.

Link 2: The stranded oil will have direct effects on terrestrial mammals.

Direct effects are related to the effects of the oil itself (fouling, ingestion). Indirect effects of stranded oil, clean-up, restoration, and monitoring operations are considered in the following link.

Link 3: The presence of oil will lead to indirect effects on terrestrial mammals related to clean-up, restoration, and monitoring activities.

Link 4: The presence of stranded oil will lead to the fouling of pelage of some terrestrial mammals.

Link 5: Stranded oil will be ingested by terrestrial mammals.

Grizzly bears, polar bears, red foxes, arctic foxes and wolves are likely to be attracted by and feed on oiled carrion and ingest oil. It is also possible that caribou and musk oxen will eat oiled vegetation, thereby ingesting oil.

Link 6: **Fouled pelage will lead to a reduction in the harvest of the animals and to a reduction in the value of the animals.**

Link 7: **Fouling of the pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.**

Link 8: **Ingestion of oil by some species of terrestrial mammals (e.g., bears) while trying to clean their own fur, will change the energy balance of the individuals.**

Link 9: **Ingestion of oil will lead to the death of affected bears and perhaps, other species, leading to reduced populations.**

Link 10: **Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction that will lead to reduced populations.**

Link 11: **Shoreline clean-up, restoration, and monitoring activities will produce noise and will disturb terrestrial mammals.**

Link 12: **Noise and disturbance will cause changes in the distribution of terrestrial mammals that will lead to changes in the harvestability of the animals.**

Link 13: **Noise and disturbance will cause reductions in time available for foraging and will increase energy expenditures through increased avoidance behaviour.**

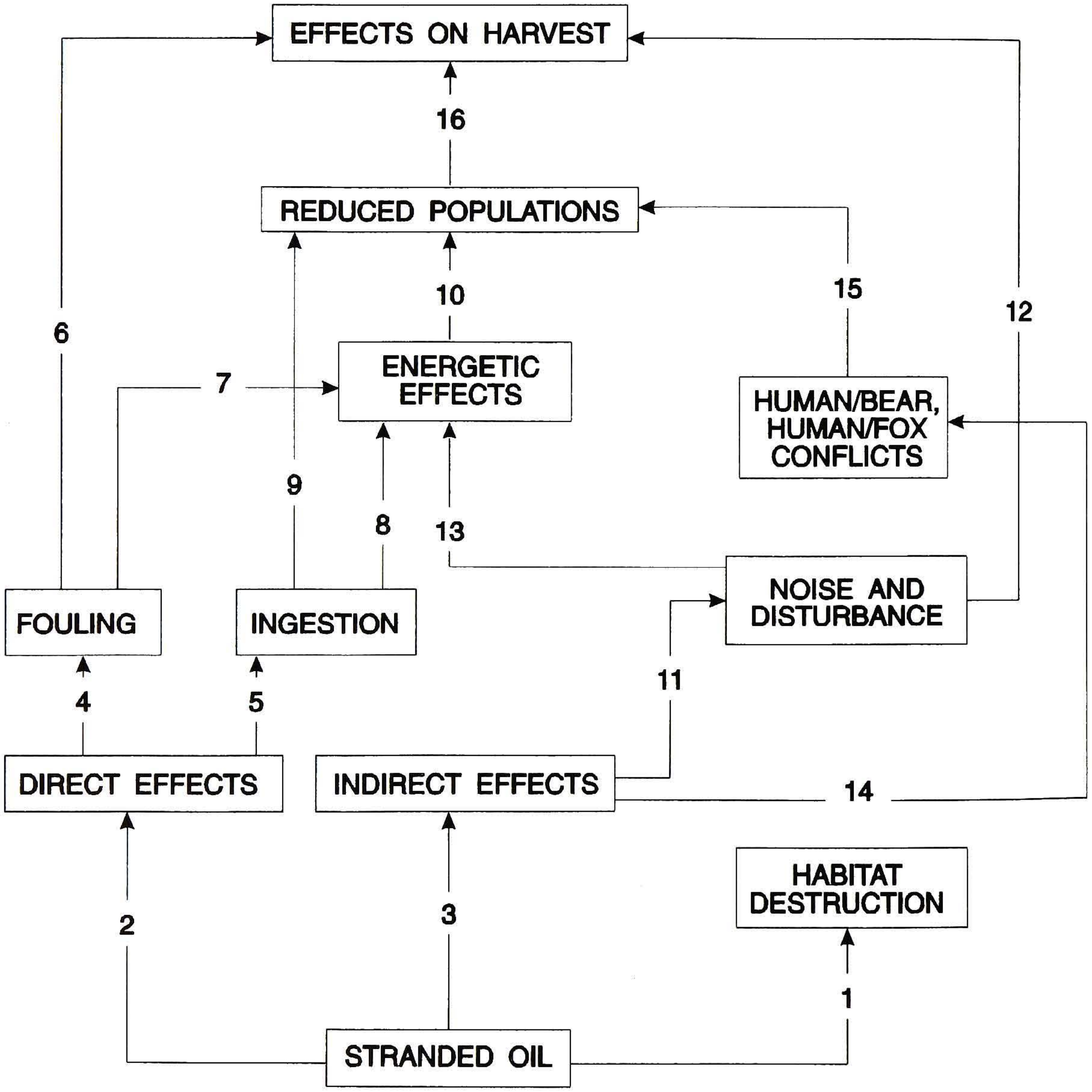
Link 14: **The presence of humans involved in shoreline clean-up, restoration, and monitoring programs will lead to increased interactions between humans and bears and humans and foxes.**

Link 15: **Interactions between humans and bears and between humans and foxes will lead to mortality of some mammals as a result of animal control, thereby reducing populations.**

Link 16: **Reduced populations of terrestrial mammals will result in reduced harvests of these mammals.**

FIGURE 6-17

OFFSHORE OIL SPILL VS TERRESTRIAL MAMMALS



Crude Oil Pipeline - River Spill - Terrestrial Mammals

In this hypothesis, a pipeline buried under a river ruptures, releasing 10,000 barrels of crude oil into the river. The release of oil will lead to a variety of direct and indirect effects on terrestrial mammals. The potential for the spilled oil to have significant effects on food chains was not considered to be part of this hypothesis.

Link 1: **Rupture of the buried pipeline will release crude oil into a river.**

Link 2: **The spilled oil will have direct effects on terrestrial mammals.**

Direct effects are related to the effects of the oil itself (ingesting, fouling). Indirect effects of spilled oil related to the effects of pipeline repair, clean-up, restoration, and monitoring operations are embodied in the following link.

Link 3: **The presence of oil can lead to indirect effects on terrestrial mammals related to repair, clean-up, restoration and monitoring activities.**

Link 4: **The presence of spilled oil will lead to the fouling of pelage of some terrestrial mammals.**

Aquatic mammals and grizzly bears may swim through areas with spilled oil on the surface.

Link 5: **Stranded oil will be ingested by terrestrial mammals.**

Grizzly bears, polar bears, red foxes, arctic foxes and wolves are likely to be attracted by, and feed on, oiled carrion, and may ingest oil. It is also possible that caribou and musk oxen will eat oiled vegetation, thereby ingesting oil.

Link 6: Fouled pelage will lead to a reduction in in the harvest of the animals and to a reduction in the value of the animals.

Link 7: Fouled pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.

Link 8: Ingestion of oil by some species of terrestrial mammals (e.g., bears) while trying to clean their own fur, will change the energy balance of the individuals.

Link 9: Ingestion of oil will lead to the death of affected bears and perhaps other species, leading to reduced populations.

Link 10: Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction, which will lead to reduced populations.

Link 11: Pipeline repair, cleanup, restoration, and monitoring activities will produce noise and will disturb terrestrial mammals.

Link 12: Noise and disturbance will cause changes in the distribution of terrestrial mammals, which will lead to changes in the harvestability of the animals.

Link 13: Noise and disturbance will cause reductions in time available for foraging and will increase energy expenditures through increased avoidance behaviour.

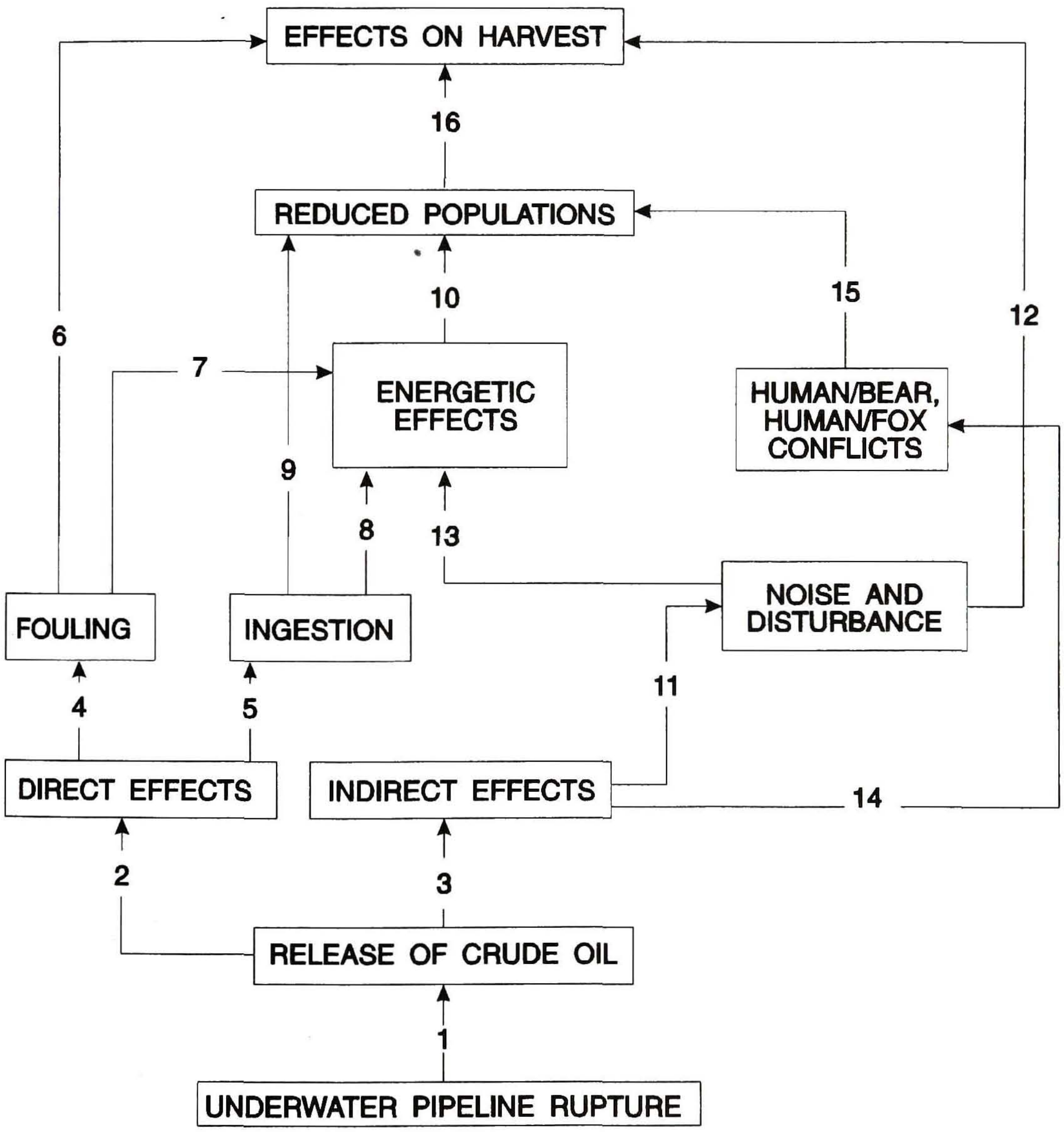
Link 14: The presence of humans involved in shoreline clean-up, restoration, and monitoring programs will lead to increased interactions between humans and bears, and between humans and foxes.

Link 15: Interactions between humans and bears and between humans and foxes will lead to mortality of some mammals as a result of animal control, thereby reducing populations.

Link 16: Reduced populations of terrestrial mammals will results in reduced harvests of these mammals.

FIGURE 6-18

CRUDE OIL PIPELINE RIVER SPILL VS TERRESTRIAL MAMMALS



Underwater Pipeline - Condensate Spill - Terrestrial Mammals

In this hypothesis, a pipeline buried under a river leaks condensate into a river. The release of the condensate will lead to a variety of direct and indirect effects on terrestrial mammals. The potential for the spilled condensate to have significant effects on food chains was not considered to be part of this hypothesis.

Link 1: Rupture of the buried pipeline will release condensate into a river.

Link 2: The condensate will have direct effects on terrestrial mammals.

Direct effects are related to the effects of the oil itself (ingestion, fouling). Indirect effects of spilled condensate related to the effects of pipeline repair, restoration, and monitoring operations are embodied in the following link.

Link 3: The presence of condensate will lead to indirect effects on terrestrial mammals related to repair, restoration, and monitoring activities.

Link 4: The presence of condensate will lead to the fouling of pelage of some terrestrial mammals.

Terrestrial mammals such as grizzly bears may swim through areas with spilled condensate on the surface.

Link 5: Spilled condensate will be ingested by terrestrial mammals, either directly or through ingestion of oiled prey.

Link 6: Fouled pelage will lead to a reduction in the harvest of the animals, and a reduction in the value of the animals.

Link 7: Fouling of the pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.

Link 8: Ingestion of condensate will lead to sub-lethal effects that will change the energy balance of the individuals.

Link 9: Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction that will lead to reduced populations.

Link 10: Pipeline repair, clean-up, restoration, and monitoring activities will produce noise and will disturb terrestrial mammals.

Link 11: Noise and disturbance will cause changes in the distribution of terrestrial mammals that will lead to changes in the harvestability of the animals.

Link 12: Noise and disturbance will cause reductions in time available for foraging and will increase energy expenditures through increased avoidance behaviour.

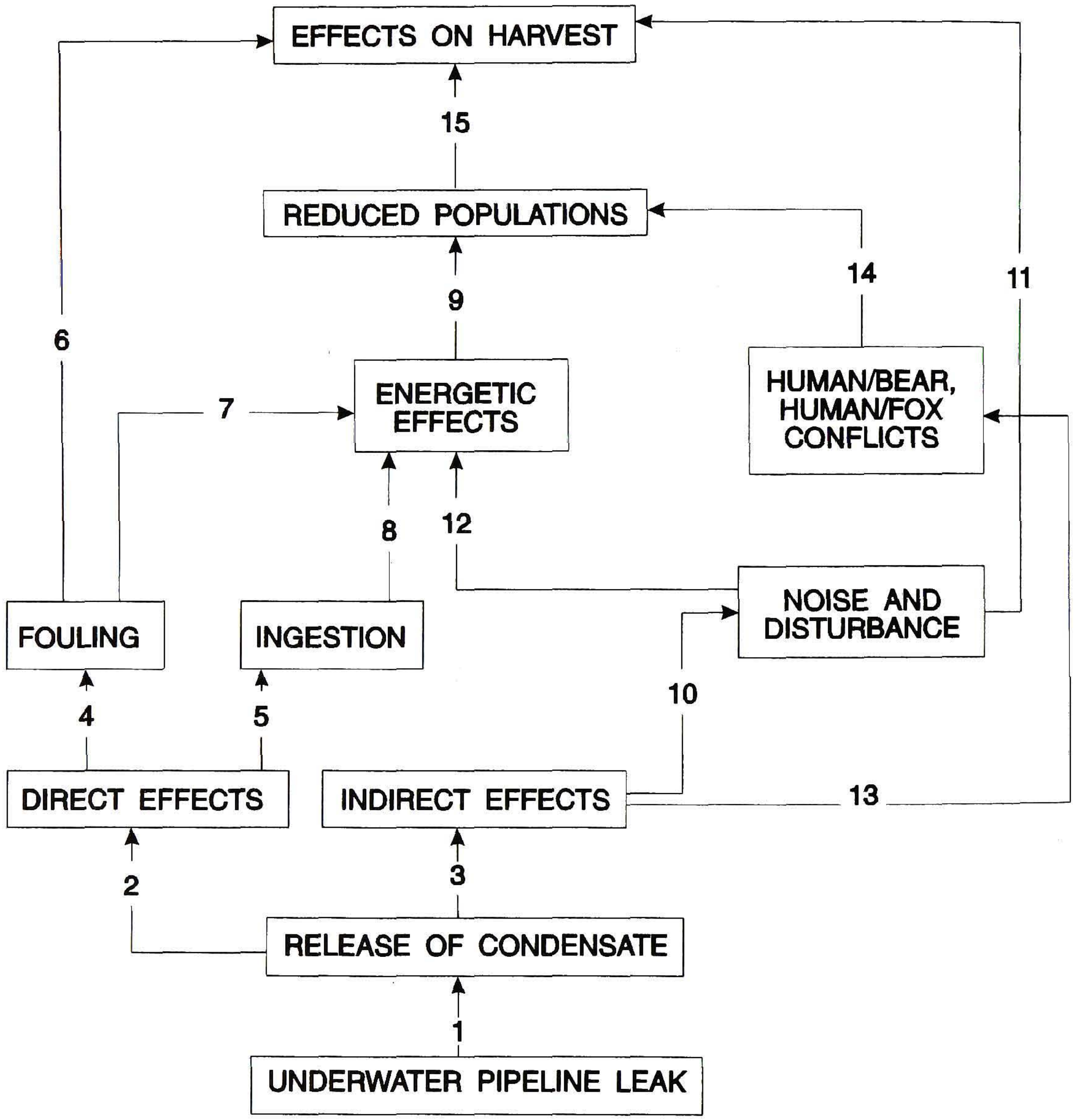
Link 13: The presence of humans involved in pipeline repair, clean-up, restoration, and monitoring programs will lead to increased interactions between humans and bears and humans and foxes.

Link 14: Interactions between humans and bears and between humans and foxes will lead to mortality of some of the mammals involved, thereby reducing populations of these species.

Link 15: Reduced populations of terrestrial mammals will results in reduced harvests of these mammals.

FIGURE 6-19

UNDERWATER PIPELINE - CONDENSATE SPILL VS TERRESTRIAL MAMMALS



6.4.2.2 Semi-Aquatic Mammals

Offshore Oil Spill - Semi-Aquatic Mammals

This hypothesis examines the potential effects of an offshore oil blowout on semi-aquatic mammals, which results in substantial amounts of oil becoming stranded along the outer margin of the Mackenzie Delta. Important impacts to semi-aquatic mammals are expected to occur only if storm surges result in the transport of oil into the wetlands along the coastal fringe of the Mackenzie Delta. Muskrat is the key species for assessment, as animals occur throughout the wetlands of the Mackenzie Delta. As beaver do not normally inhabit the outer coastal fringe of the delta, an offshore oil blowout is not expected to affect this species.

Link 1: **The presence of stranded oil will damage or kill wetland vegetation that provides important habitat for semi-aquatic mammals.**

Link 2: **The stranded oil will have direct effects on semi-aquatic mammals.**

Direct effects on semi-aquatic mammals are related to the effects of the oil itself (ingestion, fouling, chronic irritation of mucous membranes). Indirect effects of spilled stranded oil related to the effects of pipeline repair, restoration and monitoring operation are included in the following linkages.

Link 3: **The presence of stranded oil will lead to indirect effects on semi-aquatic mammals related to cleanup, restoration and monitoring activities in the affected wetlands.**

Link 4: **The presence of stranded oil in the delta wetlands will lead to fouling of pelage of semi-aquatic mammals.**

Link 5: **Stranded oil will be ingested by semi-aquatic mammals through ingestion of oiled aquatic vegetation.**

Link 6: **Fouled pelage will lead to a reduction in the harvest of semi-aquatic mammals, and a reduction in the value of the animals for fur and food.**

Link 7: **Fouling of the pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.**

Link 8: Ingestion of stranded oil will lead to sub-lethal effects that will change the energy balance of individuals.

Link 9: Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction that will lead to reduced populations.

Link 10: Chronic ingestion of stranded oil will result in direct mortality of semi-aquatic furbearers.

Link 11: Cleanup, restoration and monitoring activities will produce noise and will disturb semi-aquatic mammals.

Link 12: Cleanup, restoration and monitoring activities will result in localized destruction of wetland habitat.

Link 13: Noise and disturbance will cause changes in the distribution of semi-aquatic mammals that will lead to changes in the harvestability of the animals.

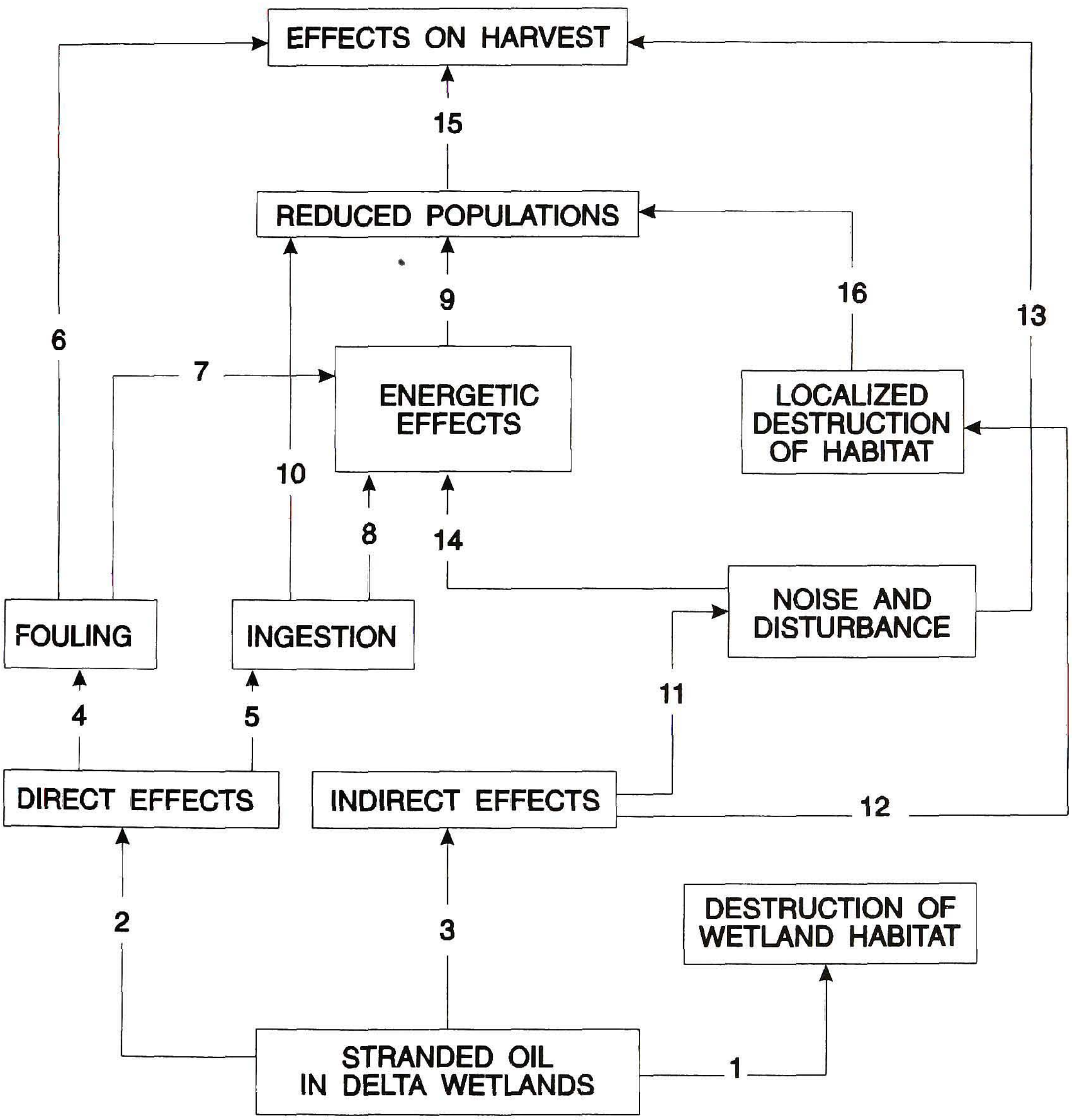
Link 14: Noise and disturbance will cause reduction in the time available for foraging and will increase energy expenditures through increased avoidance behaviour.

Link 15: Reduced populations of semi-aquatic mammals will result in reduced harvests of these animals.

Link 16: Localized losses of aquatic habitat will result in reduced populations of semi-aquatic furbearers.

FIGURE 6-20

OFFSHORE OIL SPILL VS SEMI-AQUATIC MAMMALS



Crude Oil Pipeline - River Spill - Semi-Aquatic Mammals

In this hypothesis, a crude oil pipeline under a river ruptures, releasing up to 10,000 barrels of crude oil into the river. Food chain effects are not considered. Depending on the location of the pipeline rupture, muskrat and beaver could be affected.

Link 1: **Rupture of the buried pipeline will release crude oil into a river.**

Link 2: **The spilled oil will have direct effects on semi-aquatic mammals.**

Direct effects on semi-aquatic mammals are related to the effects of the oil itself (ingestion, fouling, chronic irritation of mucous membranes). Indirect effects of spilled oil related to the effects of pipeline repair, restoration and monitoring operations are included in the following linkages.

Link 3: **The presence of spilled oil will lead to indirect effects on semi-aquatic mammals related to cleanup, restoration and monitoring activities in the affected wetlands.**

Link 4: **The presence of spilled oil will lead to fouling of pelage of semi-aquatic mammals.**

Link 5: **Spilled oil will be ingested by semi-aquatic mammals through ingestion of oiled aquatic vegetation and fouling of food caches.**

Link 6: **Fouled pelage will lead to a reduction in the harvest of semi-aquatic mammals, and a reduction in the value of the animals for fur and food.**

Link 7: **Fouling of the pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.**

Link 8: **Ingestion of spilled oil will lead to sub-lethal effects that will change the energy balance of individuals.**

Link 9: **Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction, which will lead to reduced populations.**

Link 10: **Chronic ingestion of spilled oil will result in direct mortality of semi-aquatic mammals.**

Link 11: Pipeline repair, oil cleanup, restoration and monitoring activities will produce noise and will disturb semi-aquatic mammals.

Link 12: Pipeline repair, oil cleanup, restoration and monitoring activities will result in localized disturbance of habitat for semi-aquatic mammals.

Link 13: Noise and disturbance will cause changes in the distribution of semi-aquatic mammals that will lead to changes in the harvestability of the animals.

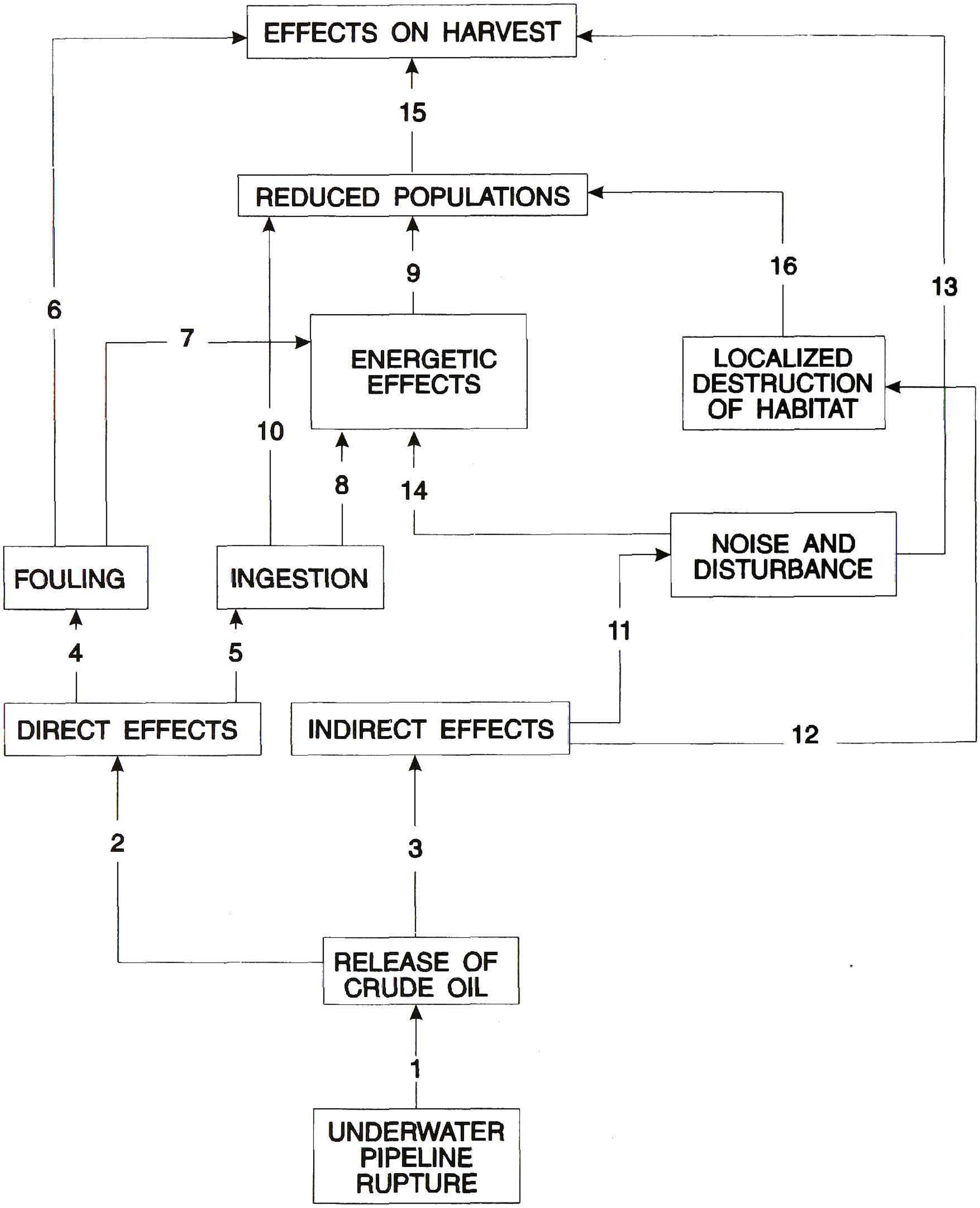
Link 14: Noise and disturbance will cause reductions in the time available for foraging and will increase energy expenditures through increased avoidance behaviour.

Link 15: Reduced populations of semi-aquatic mammals will result in reduced harvests of these animals.

Link 16: Loss of local habitat will result in reduced numbers of semi-aquatic mammals.

FIGURE 6-21

CRUDE OIL PIPELINE - RIVER SPILL VS SEMI-AQUATIC MAMMALS



Underwater Pipeline - Condensate Spill - Semi-Aquatic Mammals

The release of condensate into the river following rupture of the pipeline during either summer or early spring will lead to a variety of direct and indirect effects on semi-aquatic mammals. As for terrestrial mammals, food chain effects are not considered as part of this hypothesis.

Link 1: **Rupture of the buried pipeline will release condensate into a river.**

Link 2: **The condensate will have direct effects on semi-aquatic mammals.**

Direct effects on semi-aquatic mammals are related to the effects of the oil itself (ingestion, fouling, chronic irritation of mucous membranes). Indirect effects of spilled condensate related to the effects of pipeline repair, restoration and monitoring operation are included in the following linkages.

Link 3: **The presence of condensate will lead to indirect effects on semi-aquatic mammals related to repair, restoration and monitoring activities.**

Link 4: **The presence of condensate will lead to fouling of pelage of semi-aquatic mammals.**

Link 5: **Spilled condensate will be ingested by semi-aquatic mammals through ingestion of oiled aquatic vegetation or food caches.**

Link 6: **Fouled pelage will lead to a reduction in the harvest of semi-aquatic mammals, and a reduction in the value of the animals for fur and food.**

Link 7: **Fouling of the pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.**

Link 8: **Ingestion of condensate will lead to sub-lethal effects that will change the energy balance of individuals.**

Link 9: **Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction that will lead to reduced populations of semi-aquatic mammals.**

Link 10: **Chronic ingestion of condensate will result in direct mortality of semi-aquatic furbearers.**

Link 11: **Pipeline repair, clean-up, restoration and monitoring activities will produce noise and will disturb semi-aquatic mammals.**

Link 11: Pipeline repair, clean-up, restoration and monitoring activities will produce noise and will disturb semi-aquatic mammals.

Link 12: Pipeline repair, cleanup activities and site restoration will result in localized destruction of habitat for semi-aquatic furbearers.

Link 13: Noise and disturbance will cause changes in the distribution of semi-aquatic mammals that will lead to changes in the harvestability of the animals.

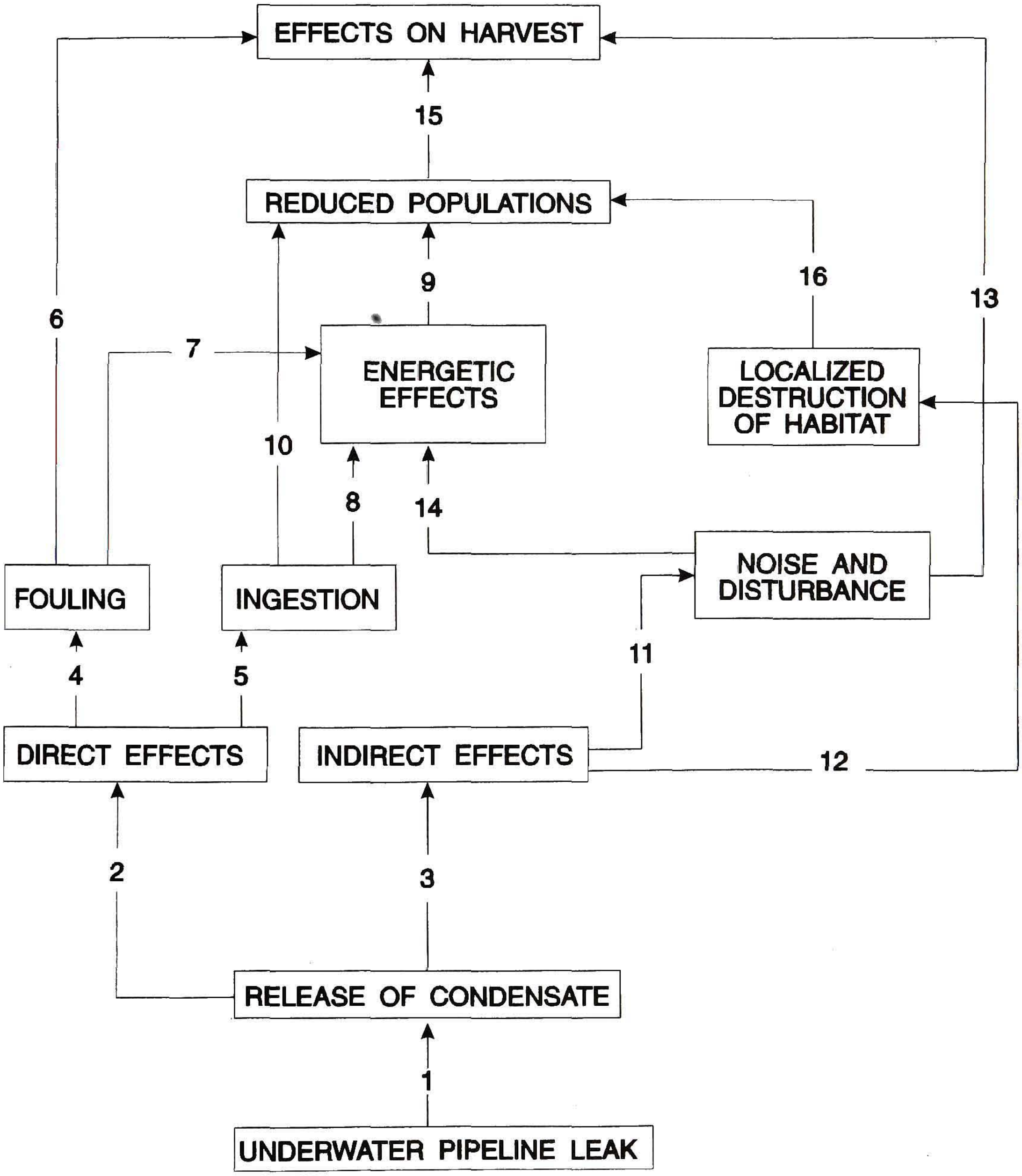
Link 14: Noise and disturbance will cause reductions in the time available for foraging and will increase energy expenditures of semi-aquatic mammals through increased avoidance behaviour.

Link 15: Reduced populations of semi-aquatic mammals will result in reduced harvests of these animals.

Link 16: Loss of local habitat will result in reduced numbers of semi-aquatic mammals.

FIGURE 6-22

UNDERWATER PIPELINE - CONDENSATE SPILL VS SEMI-AQUATIC MAMMALS



6.4.3 Birds

Oil/Condensate Spill, Leak or Blowout - Waterfowl

This hypothesis addresses the potential direct effects of waterfowl coming in contact with oil/condensate following a pipeline rupture or offshore blowout.

Link 1: **A spill, leak, or blowout will cause condensate or oil to be present on or in the water, ice, shoreline or bottom.**

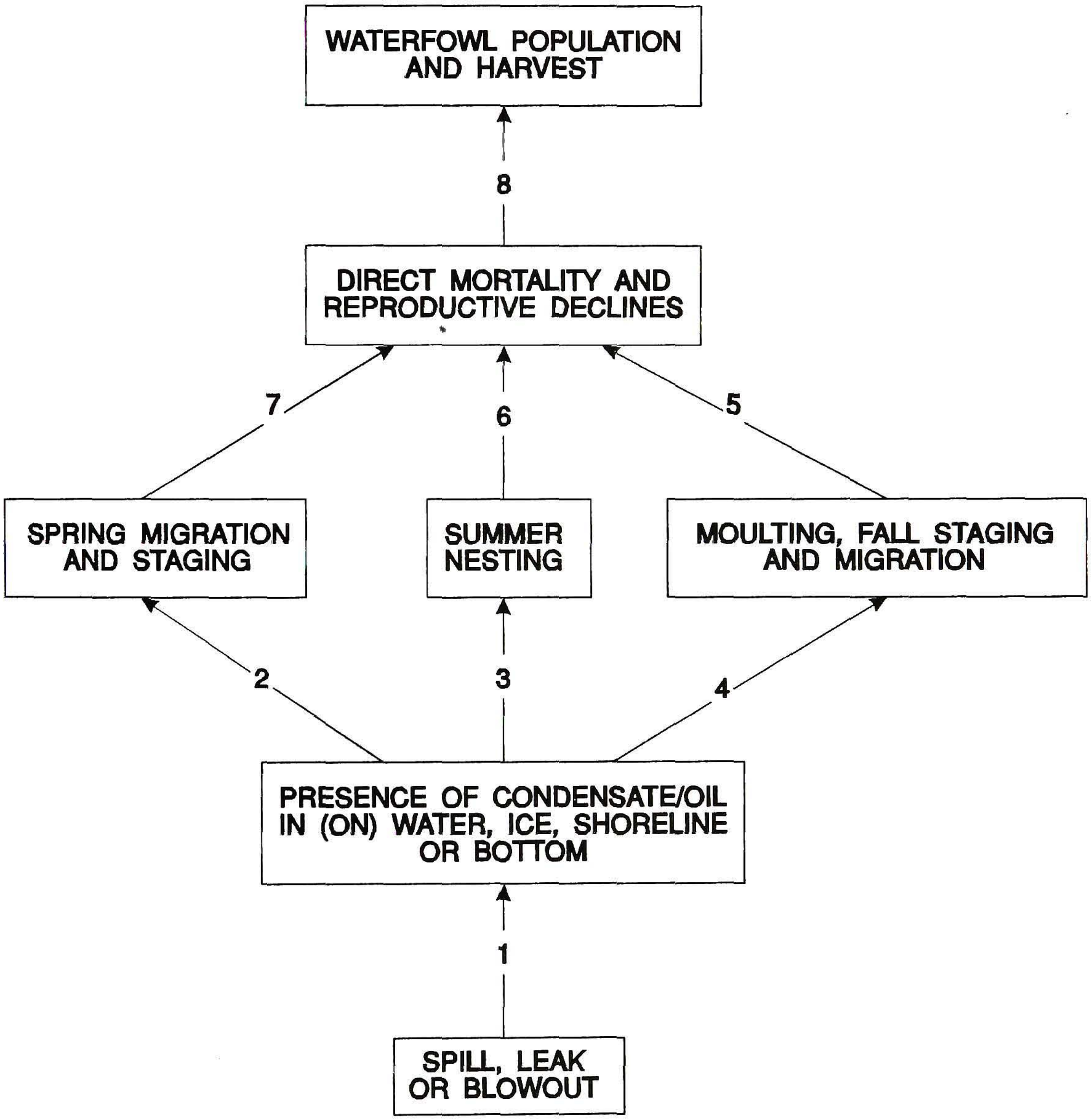
Links 2-4: **Condensate or oil in the environment will come into contact with spring migrating or staging waterfowl, summer nesting waterfowl, and moulting, fall staging and/or migrating waterfowl.**

Links 5-7: **Direct contact of oil or condensate with waterfowl will cause mortality which will result in reproductive declines.**

Link 8: **Mortality and reproductive declines will result in declines in waterfowl populations and ultimately in declines in waterfowl harvest rates.**

FIGURE 6-23

OIL/CONDENSATE SPILL, LEAK OR BLOWOUT VS WATERFOWL



Oil/Condensate Spill, Leak, or Blowout - Waterfowl

This hypothesis deals with the possible effects of a spill, leak or blowout of oil/condensate on waterfowl populations and the harvest of this resource as a result of contamination of waterfowl habitat and foods.

Link 1: **A spill, leak, or blowout will cause condensate or oil to be present on or in the water, ice, shoreline or bottom.**

Link 2: **Condensate or oil in the environment will contaminate waterfowl habitat and waterfowl foods.**

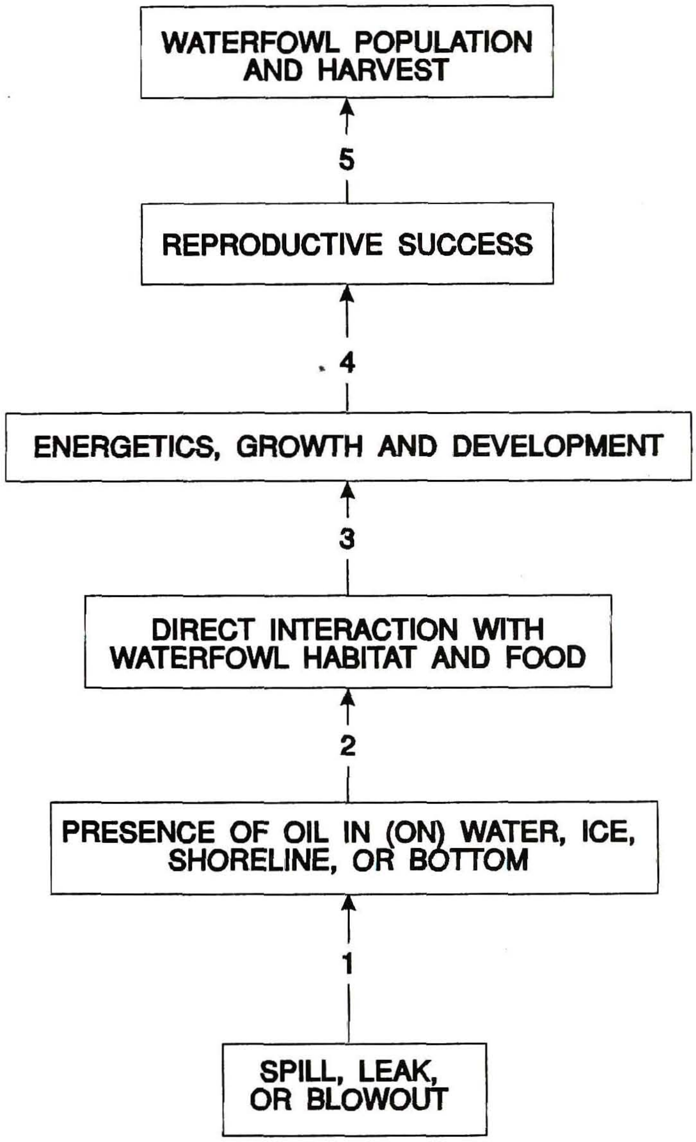
Link 3: **Oiled or contaminated foods will affect waterfowl energetics, growth and development.**

Link 4: **Alterations in energetics, growth and development will affect waterfowl reproductive success.**

Link 5: **Alterations in waterfowl reproductive success will ultimately affect waterfowl populations and harvest rates.**

FIGURE 6-24

OIL/CONDENSATE SPILL, LEAK OR BLOWOUT VS WATERFOWL



Oil/Condensate Spill, Leak, or Blowout - Scavenging Birds

This hypothesis addresses the potential effects of a pipeline rupture or blowout of oil/condensate on populations of scavenging birds. The linkages deal specifically with the effects of consumption of oiled birds by scavengers.

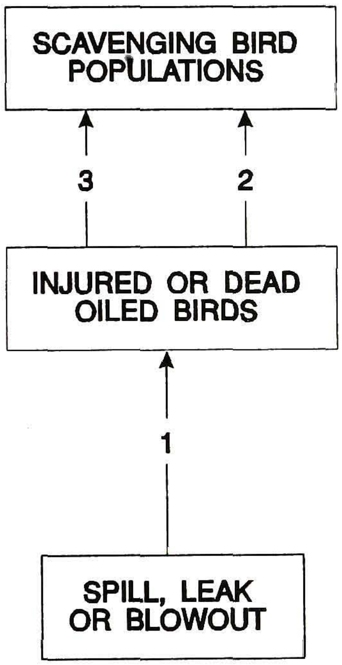
Link 1: **A spill, leak, or blowout will cause condensate or oil to be present on or in the water, ice, shoreline or bottom and will result in oiled and dead or dying birds.**

Link 2: **Scavenging birds (e.g., bald eagles) will be poisoned by eating dead and dying oiled birds and ultimately the populations of these birds will be affected.**

Link 3: **Scavenging birds will be contaminated through direct contact with oiled carcasses and ultimately populations of these birds will be affected.**

FIGURE 6-25

OIL/CONDENSATE SPILL, LEAK OR BLOWOUT VS SCAVENGING BIRDS



Oil/Condensate Spill, Leak, or Blowout - Waterfowl

This hypothesis deals specifically with the possible effects that disturbances associated with spill response activities may have on spring and fall staging and migrating waterfowl, and moulting and nesting waterfowl.

Link 1: **A spill, leak, or blowout will trigger an oilspill response plan.**

Link 2: **The response plan will involve considerable activity by people, boats, aircraft, and other equipment in habitats occupied by wildlife.**

Links 3-5: **Spill response activities in wildlife habitats will cause disturbances that will affect spring and fall staging and migrating waterfowl, and moulting and nesting waterfowl.**

Links 6-8: **Disturbances to spring and fall staging and migrating waterfowl, and moulting and nesting waterfowl will affect waterfowl energetics, growth and development.**

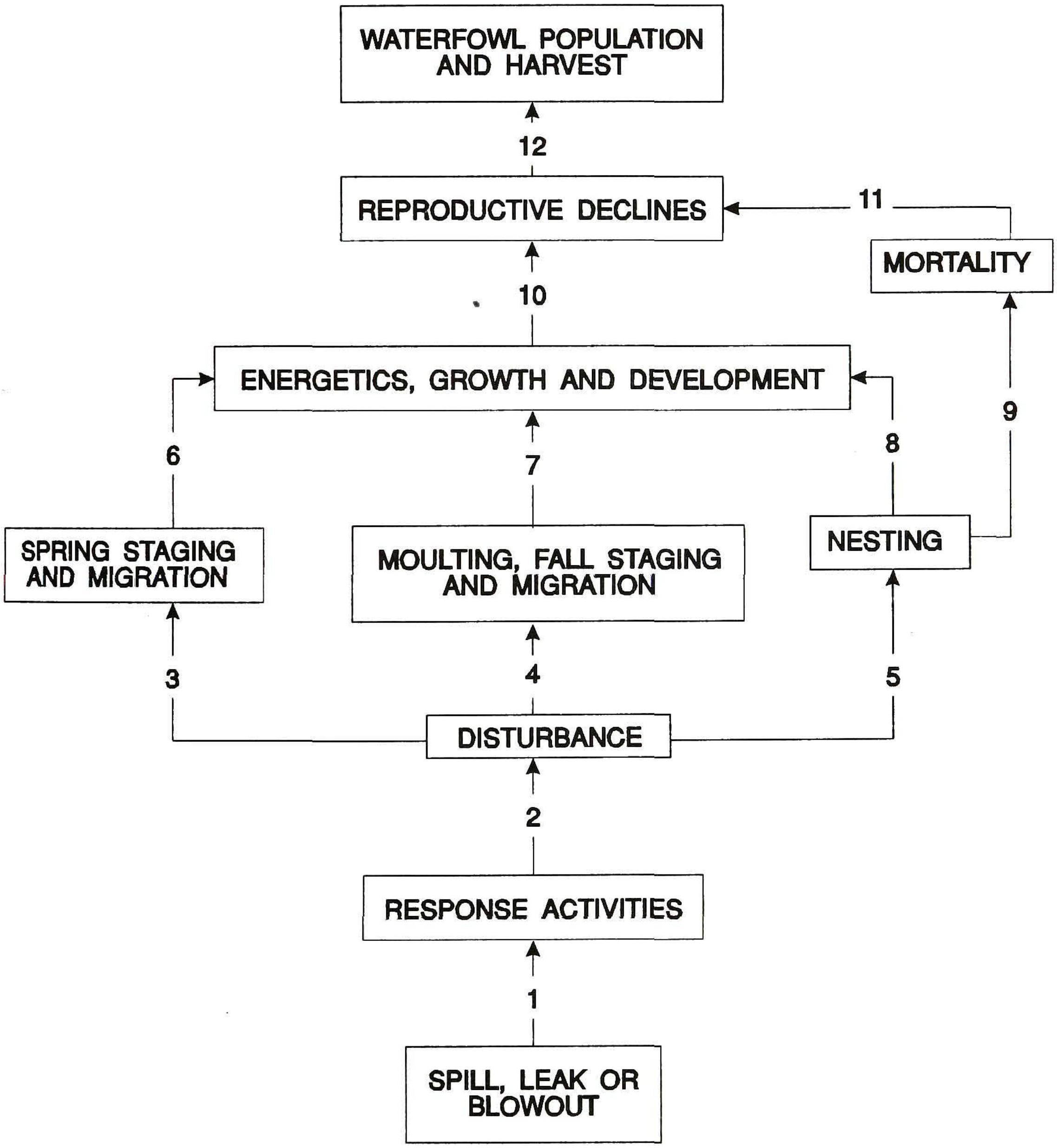
Link 9: **Disturbances to nesting waterfowl will also result in mortality through abandonment of nests with eggs or newly hatched young.**

Links 10-11: **Alterations in energetics, growth and development of waterfowl, and mortality of young will result in declines in waterfowl reproductive success.**

Link 12: **Declines in waterfowl reproductive success will ultimately affect waterfowl populations and harvest rates.**

FIGURE 6-26

OIL/CONDENSATE SPILL RESPONSE ACTIVITIES VS WATERFOWL



6.4.4 Freshwater, Marine and Anadromous Fish

Condensate Pipeline Spill Under Ice - Fish

This hypothesis involves the possible effects of a condensate leak occurring at a river crossing under ice, February 15 - May 15. It was assumed, based on the concentration of oil dissolved in water, that no lethal toxic effects would occur and that food chain effects would be inconsequential, given the concentration and the time of year.

Link 1: **A condensate spill will result in a fraction of oil being dissolved in water.**

Link 2: **A portion of oil will be encapsulated in ice.**

Link 3: **During spring melt, some portion of the still-fresh oil will be dissolved in water, extending the time during which fish will be exposed.**

Link 4: **Dissolved oil-in-water will have an effect on newly emerging fry (from fall-spawning species)**

Link 5: **Negative effects on growth and development of fry will lead to reduced populations of these fall spawners in the short term.**

Link 6: **Reduction in population size will reduce harvest levels of the affected year-class.**

Link 7: **Oil dissolved in water in the spring will affect the spawning and migratory behaviour of spring-spawning fish.**

Link 8: **Changes in spawning and migration behaviour will lead to short-term reduction in spawning success and thus in population size.**

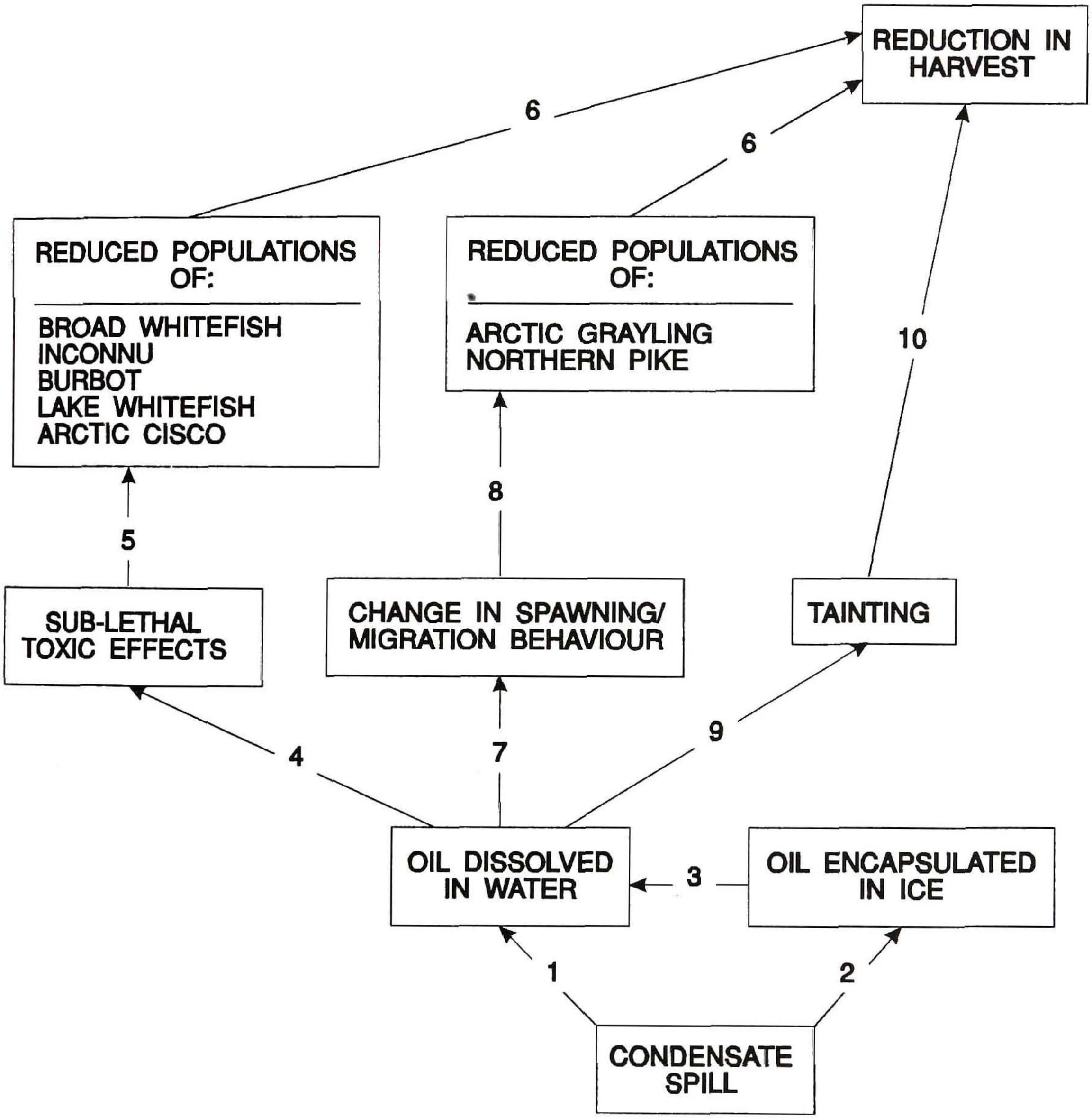
Link 9: **Dissolved oil-in-water will affect the quality of flesh and impart a "taint".**

Link 10: **The presence of taint will result in reduced desirability of fish and can result in reduced harvest levels.**

The effect of tainting on harvest levels is the subject of other BREAM hypotheses (R-11, R-15, and R-26).

FIGURE 6-27

CONDENSATE PIPELINE SPILL UNDER ICE VS FISH



Condensate Pipeline Leak at a River Crossing in Summer - Fish

This hypothesis involves the possible effects of a condensate pipeline leak occurring during summer, August 1. The essential difference between the effects of this scenario and the late winter-early spring scenario is the absence of post-larval fish and of fish engaged in spawning migrations at this time. As was the case with respect to the previous scenario, it was assumed that food chain effects would be inconsequential given the concentrations involved, and that lethal toxic effects would not occur.

Link 1: **A condensate spill will result in a fraction of oil being dissolved in water.**

Link 2: **Leaked condensate will result in oil on the river surface.**

Link 3: **Oil dissolved in water will have behavioural and sub-lethal effects on fish.**

Link 4: **Sub-lethal effects and effects on pre-spawning behaviour of VECs will result in reduced population size.**

Link 5: **Reduction in a population year class will result in a reduction in harvest in subsequent years.**

Link 6: **Dissolved oil-in-water will affect the quality of flesh and impart a "taint."**

This linkage is the subject of other BREAM hypotheses (R-11, R-15, and R-26).

Link 7: **The presence of taint will result in reduced desirability of fish and will result in reduced harvest levels.**

The effect of tainting on harvest levels is the subject of BREAM hypotheses R-11, R-15 and R-26.

Link 8: **Oil on the water's surface will result in ingestion of oil by surface-feeding fish.**

Link 9: **Ingestion of oil will result in tainting and changes of the quality of fish flesh.**

Link 10: Oil ingested with prey will have sub-lethal effects on fish.

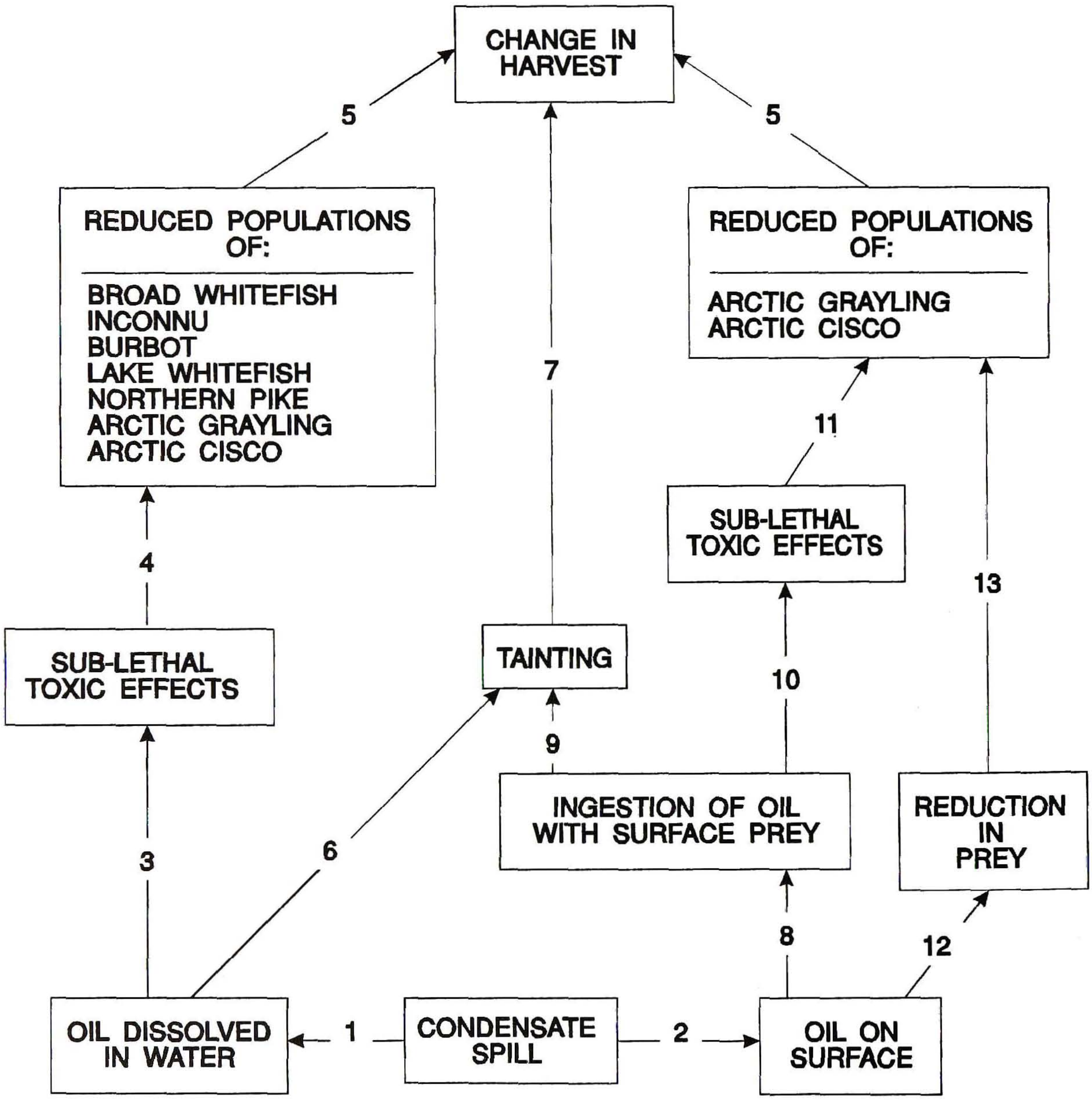
Link 11: Sub-lethal effects will result in reproductive failure or reduction in growth.

Link 12: Oil on the water's surface will result in reduced availability of food to surface-feeding fish.

Link 13: Reduced prey abundance and/or reduced availability of prey will result in reduced growth and ultimately population size.

FIGURE 6-28

CONDENSATE PIPELINE LEAK AT A RIVER CROSSING IN SUMMER VS FISH



Oil Pipeline Break at a River Crossing in Summer - Fish

This scenario results in effects that are similar to a condensate leak in summer. The major differences relate to the greater probability of oil (in emulsified form) finding its way to the river bottom -- particularly in back-eddy environments, and to inherent differences in toxicity and relative proportion and rates of dissolution in air and water.

Link 1: **A condensate spill will result in a fraction of oil being dissolved in water.**

Link 2: **Leaked condensate will result in oil on the river surface.**

Link 3: **Oil dissolved in water will have behavioural and sub-lethal effects on fish.**

Link 4: **Sub-lethal effects and effects on pre-spawning behaviour of VECs will result in reduced population size.**

Link 5: **Reduction in a population year class will result in a reduction in harvest in subsequent years.**

Link 6: **Dissolved oil-in-water will affect the quality of flesh and impart a "taint."**

This linkage is the subject of other BREAM hypotheses (R-11, R-15, and R-26)

Link 7: **The presence of taint will result in reduced desirability of fish and will result in reduced harvest levels.**

The effect of tainting on harvest levels is the subject of BREAM hypotheses R-11, R-15 and R-26.

Link 8: **Oil on the water's surface will result in ingestion of oil by surface-feeding fish.**

Link 9: **Ingestion of oil will result in tainting and changes in the quality of fish flesh.**

Link 10: **Oil ingested with prey will have sub-lethal effects on fish.**

Link 11: **Sub-lethal effects will result in reproductive failure or reduction in growth.**

Link 12: Oil on the water's surface will result in reduced availability of food to surface-feeding fish.

Link 13: Reduced prey abundance and/or reduced availability will result in reduced growth.

Link 14: A pipeline break will result in oil being stranded on the shoreline, some of which may subsequently re-enter the water.

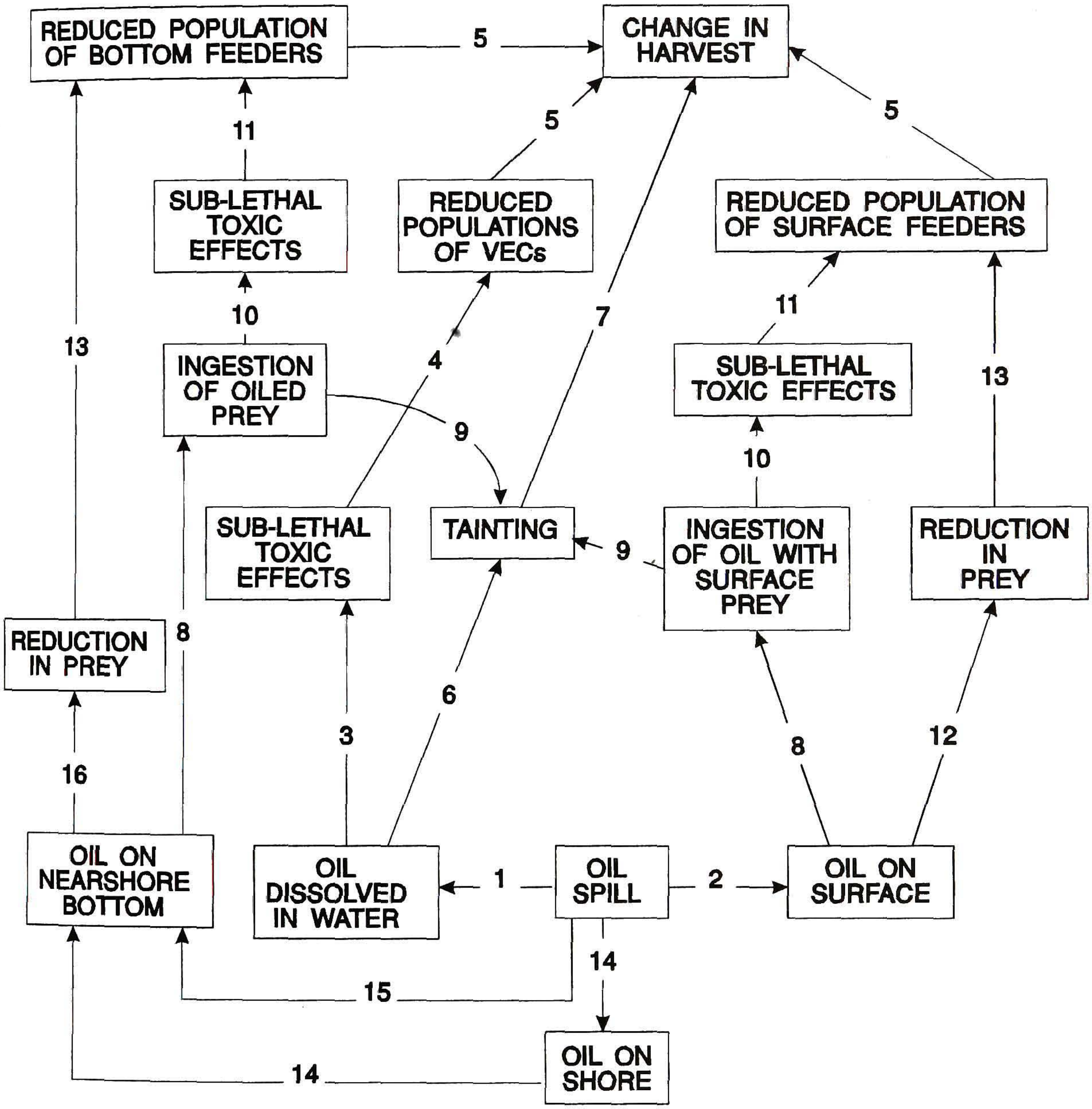
Link 15: Oil from the spill will find its way to the bottom substrate. This oil will be in emulsified form and will not contain lighter (i.e. more toxic) fractions of oil.

Link 16: Oil on the bottom will result in the smothering of benthic invertebrates and result in reduced prey availability to benthic feeders.

Note: Links 8, 9, 10 and 11 stemming from "oil on the nearshore bottom" would be expected to result in minimal, if any, toxic or taint effects, because of the weathered nature of the oil.

FIGURE 6-29

OIL PIPELINE BREAK AT A RIVER CROSSING IN SUMMER VS FISH



Oil Pipeline Leak at a River Crossing in Spring - Fish

The effects that result from this scenario differ from the condensate spill with respect to the potential for oiling of some bottom substrates and the potential for oil on the surface of the water. However, unlike the summer oil spill scenario, it is less likely that oil on the surface will have a significant effect on fish, as few fish would be surface feeding at that time.

Link 1: Oil spilled in the water will result in oil spreading on the water surface between moving ice floes.

Link 2: A portion of the oil spilled will be dissolved in the water column.

Link 3: Emulsified oil will sink to the bottom in some low-energy habitats (e.g., back-eddies).

Link 4: Oil stranded on shore will subsequently re-enter the water and settle on the bottom.

Link 5: Oil on the bottom will smother benthic invertebrates.

Link 6: Oil on the bottom will be ingested by fish consuming oiled or oil-contaminated prey.

Link 7: Reduction in prey of bottom feeders will result in a reduction in their growth and population size.

Link 8: Ingestion of oiled prey will lead to sub-lethal toxic effects (albeit reduced, because of the weathered nature of the oil).

Link 9: Sub-lethal effects (stress, reproductive failure) will lead to reduced population of bottom-feeding fish species.

Link 10: Ingestion of oil will lead to tainting and reduction in the quality of flesh.

Link 11: Reductions in population size will lead to reduced harvest.

Link 12: Tainting will result in change in harvest levels.

Link 13: Fish exposed to oil dissolved in water will become tainted.

Link 14: Oil dissolved in water will affect behaviour of fish and result in changes in spawning/migration behaviour.

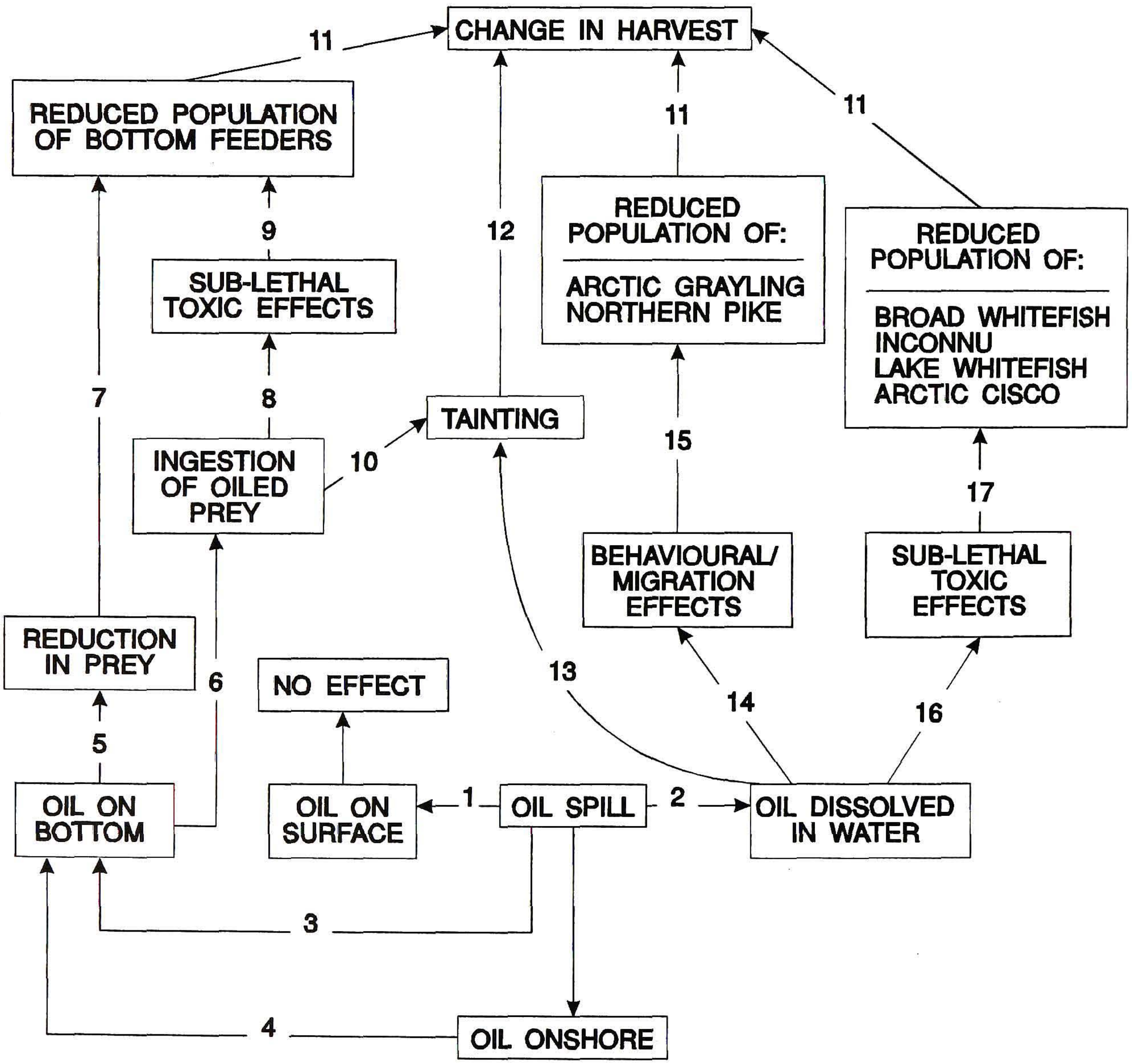
Link 15: Reduced spawning success will result in a reduction in next year's population.

Link 16: Oil dissolved in water will manifest sub-lethal effects that cause reduced growth and reproduction.

Link 17: Reduced reproduction and growth will result in reduction of an ensuing year's population size.

FIGURE 6-30

OIL PIPELINE LEAK AT A RIVER CROSSING IN SPRING VS FISH



Offshore Sub-Sea Blowout Scenario - Fish

This hypothesis reflects potential effects to fish that can result from an offshore sub-sea blowout occurring in early fall.

Link 1: Sub-sea blowout will result in oil being dissolved in the water in a range of concentrations depending on proximity to the source.

Link 2: A portion of the oil will emulsify in the water and eventually sink; residue from countermeasures burning will disperse and sink to the bottom.

Link 3: Oil dissolved in water near to the blowout site will be in concentration sufficient to cause lethal toxic effects on arctic cod and pacific herring.

Link 4: Mortality will result in reduced population size.

Link 5: Reduced population size will cause a change in harvest.

Link 6: Oil dissolved in water near to the blowout site will have sub-lethal effects. The range of these effects will extend shoreward to habitat occupied by Arctic cisco at this time of year.

Link 7: Sub-lethal toxic effects including reductions in growth and spawning success will result in reduced population size.

Links 8 & 9: Oil dissolved in water will reduce water column prey, resulting in reductions in growth and population size of fish, particularly young-of-the-year Arctic cod and Pacific herring that are in the vicinity of the blowout.

Link 10: Oil dissolved in water will be in concentrations sufficient to cause tainting of broad whitefish that inhabit the nearshore coast of the Tuktoyaktuk Peninsula.

Link 11: Tainting of broad whitefish will cause changes in harvest levels.

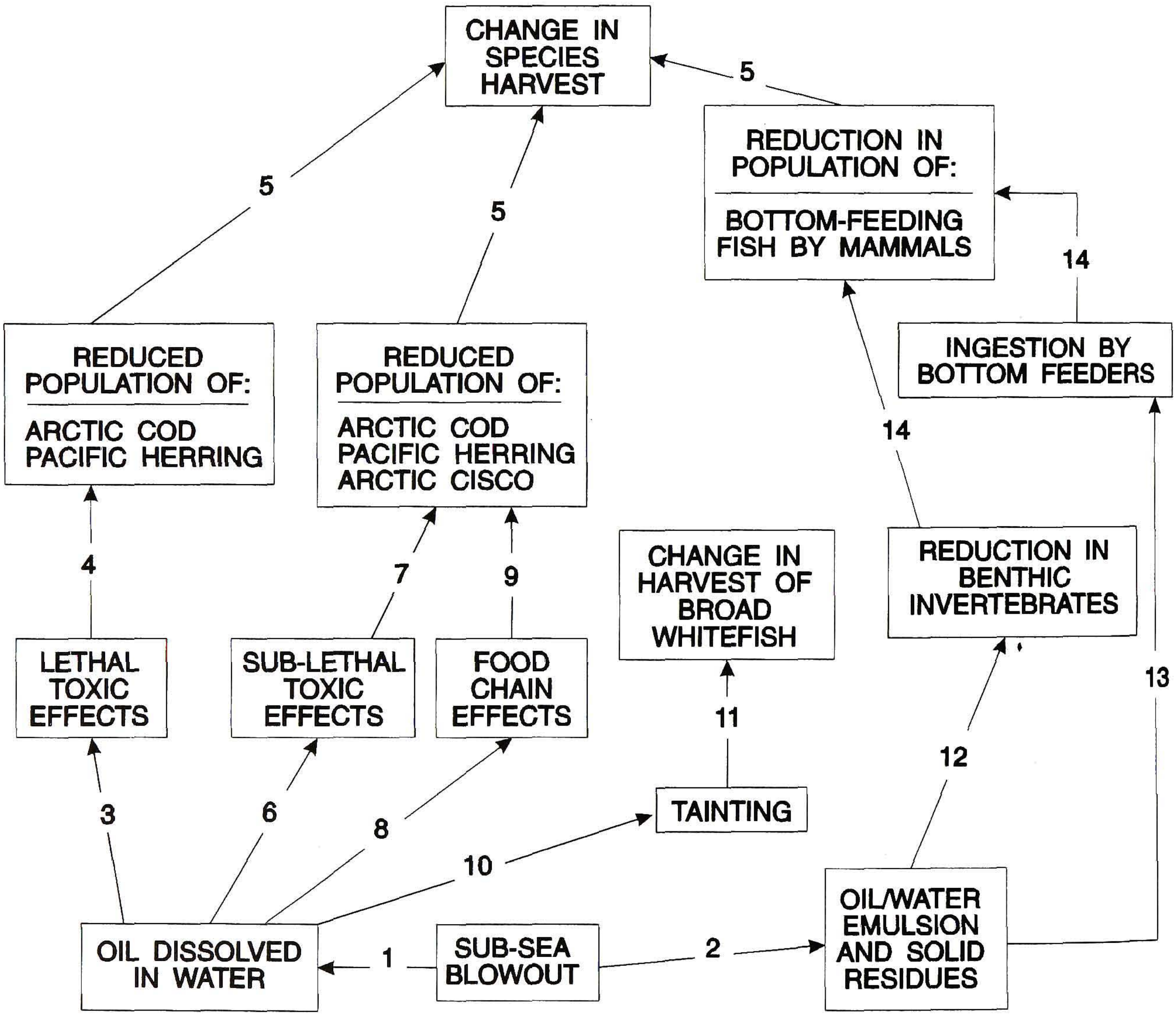
Link 12: Oil emulsion and solids on the bottom substrate will reduce invertebrate population size.

Link 13: Oil will be ingested by bottom-feeding fish (and marine mammals - subject of another hypothesis).

Link 14: Reduction in the availability of bottom prey and ingestion of contaminated prey will cause a reduction in population size.

FIGURE 6-31

OFFSHORE SUB-SEA BLOWOUT VS FISH



Island Platform Blowout - Fish

The potential effects in the offshore would be similar to those described in the previous hypothesis related to an offshore sub-sea blowout. Additional linkages shown below relate to the greater proportion of oil reaching the nearshore and stranding on shore.

Link 1: **A sub-sea blowout will result in oil being dissolved in the water in a range of concentrations depending on proximity of the source.**

Link 2: **A portion of the oil will emulsify in the water and eventually sink; residue from countermeasures burning will disperse and sink to the bottom.**

Link 3: **Oil from the sub-sea blowout will be stranded on shore along portions of the Yukon coast and western Delta.**

Link 4: **Oil stranded onshore will subsequently be re-introduced into the water.**

Species could also include Arctic charr and whitefishes. Although tainting of flesh may not result from exposure to this weathered component, the harvest of species in the area could be affected.

Link 5: **Oil dissolved in water near to the blowout site will be in concentration sufficient to cause lethal toxic effects on arctic cod and pacific herring.**

Link 6: **Mortality will result in reduced population size.**

Link 7: **Reduced population size will cause a change in harvest.**

Link 8: **Oil dissolved in water near to the blowout site will have sub-lethal effects. The range of these effects will extend shoreward to habitat occupied by Arctic cisco at this time of year.**

Link 9: **Sub-lethal toxic effects including reductions in growth and spawning success will result in reduced population size.**

Links 10,11: **Oil dissolved in water will reduce water column prey, resulting in reductions in growth and population size of fish, particularly young-of-the-year Arctic cod and Pacific herring that are in the vicinity of the blowout.**

Link 12: Oil dissolved in water will be in concentrations sufficient to cause tainting of broad whitefish that inhabit the nearshore coast of the Tuktoyaktuk Peninsula.

Link 13: Tainting of broad whitefish will cause changes in harvest levels.

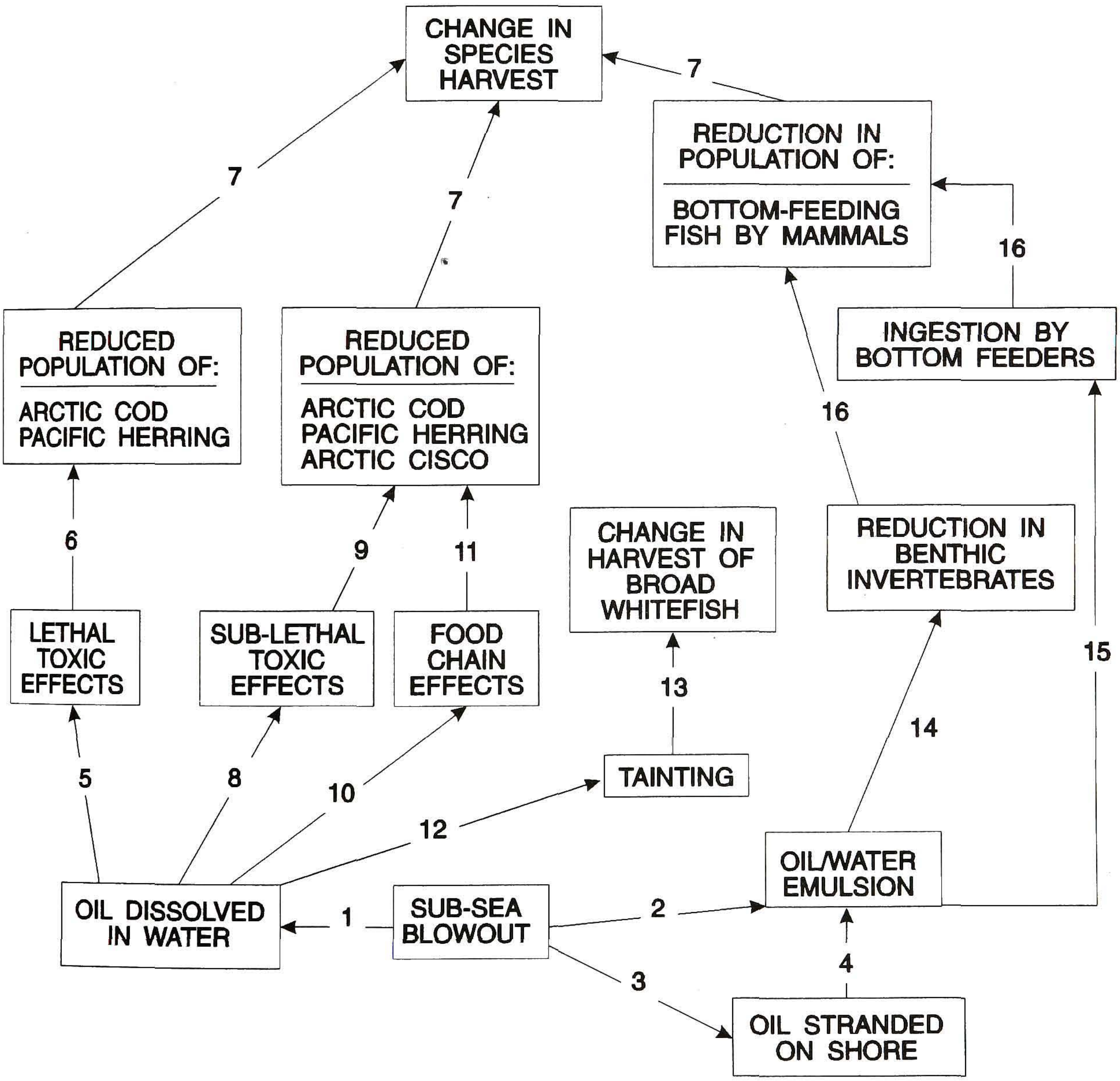
Link 14: Oil emulsion and solids on the bottom substrate will reduce invertebrate population size.

Link 15: Oil will be ingested by bottom-feeding fish (and marine mammals).

Link 16: Reduction in the availability of bottom prey and ingestion of contaminated prey will cause a reduction in population size.

FIGURE 6-32

ISLAND PLATFORM BLOWOUT VS FISH



7. FUTURE ACTIVITIES OF BREAM

7.1 Environmental Assessment Methodology

During this year's interdisciplinary workshop, two assessment procedures (ESSA, ESL) were used to determine the significance of potential impacts evaluated in each of the BREAM hypotheses (Section 4.2). While this is unlikely to have any serious consequences to the outcome of the workshop, these procedures need to be re-evaluated for use in BREAM to determine the most appropriate assessment method(s) for all impact hypotheses, including those dealing with catastrophic oil spills and community-based concerns. While most of the difficulties experienced with both procedures was due to the lack of detailed project information, it is clear that some methods lend themselves better to the assessment of population VEC issues than resource use (VSC) and non-species VEC issues.

In response to recommendations of the Beaufort Sea Steering Committee, the ESL assessment procedure (Duval and Vonk 1991) is currently being reviewed to determine its suitability for EIRB and government reviews of future development proposals. Following this review, an assessment procedure will be established for this purpose. While it is important that environmental assessment be an integral part of BREAM and play a role in future project workshops, it is equally important that the methodology selected for this program be consistent with the requirements of the EIRB and government agencies to ensure its usefulness in the review of future project applications. For this reason, it is recommended that the results of the review be considered during selection of an assessment methodology for BREAM. A report is scheduled to be completed by year end.

Due to the timing of the EIRB report, selection/development of an assessment methodology for BREAM could not occur prior to the 1992/1993 workshop. However, it is important that a procedure be developed as part of future work of the program. The Chairpersons of the Technical Working Groups should meet to examine the methodology established for the EIRB and select a procedure for BREAM that will satisfy the needs of all the groups. The EIRB methodology as well as possibly two other assessment procedures should be examined as potential candidates for BREAM. The strengths and weaknesses of each of the assessment methods can be determined by working through 2-3 BREAM hypotheses (preferably those dealing with resource harvesting and non-species VEC issues as well as population VEC issues). The outcome of this task may be the selection of one or possibly two assessment procedures which are best compatible with the impact hypothesis concept or may involve the development of a new assessment procedure based on the strengths of those evaluated. Nevertheless, it is important that the assessment method(s) selected for BREAM be: (1) relatively efficient and practical to use in a workshop environment; (2) semi-quantitative and lead to defensible conclusions on the significance of potential impacts; and (3) comply with any legislative requirements considered appropriate by those agencies that will be involved in the review of future project approvals.

7.2 Community-based Concerns

During the first meeting of the Community-based Concerns Working Group, representatives from northern communities identified a number of ecological concerns and issues that they believe should be considered in environmental assessments of future hydrocarbon development in the Beaufort Sea/Mackenzie Valley region. Central to all of these issues was harvestable food resources and the overall quality of the northern environment. As stated in Section 5.6, many of these concerns (i.e. fish quality, increased ambient noise and traffic, cumulative effects of industrial developments) are either reflected in existing BREAM impact hypotheses related to routine aspects of development or have now been addressed through the addition of new linkages to these hypotheses. While there may be additional community-based environmental concerns that need to be addressed through BREAM, it will be necessary to have one or two more meetings of the Technical Working Group prior to any full workshop to clearly define these concerns, and refine the process by which traditional and local knowledge is accessed and incorporated into the process. The Working Group should review the issues and concerns (e.g., related to food quality, contaminants and downstream effects of pulp mills) discussed in the Phase I BREAM report (INAC 1991) and addressed during their planning meeting to ensure that they have been brought forward and adequately incorporated into the BREAM impact hypotheses presented in this year's report. The conceptual model developed by the Working Group is a notable step towards ensuring adequate participation of northerners in the program. However, this process has yet to be thoroughly evaluated. It is important that the Working Group evaluate the model and achieve consensus that it will work before the group can proceed further.

One of the primary concerns of northern communities that has yet to be addressed through BREAM is catastrophic oil spills and its potential impact on harvestable resources (i.e. fish, marine mammals, polar bears, seabirds) and their habitat. While some social issues related to oil spills are outside the scope of BREAM, concerns related to the effects of spills and cleanup on resource harvesting will be addressed through impact hypotheses that have been developed around spill scenarios involving offshore well blowouts and onshore pipeline ruptures (Section 6). The Community-based Working Group should review these hypotheses to ensure that they adequately address community environmental concerns (e.g., effects of cleanup operations on access to resource harvesting areas) as well as scientific concerns. This task should be completed in advance of the Catastrophic Oil Spill Workshop, which is discussed in more detail in Section 7.3.

Members of the Working Group identified the need to establish a parallel process to address social issues and concerns of northern communities related to future hydrocarbon development activities. While this is outside the scope of BREAM, establishment of such a process is strongly endorsed by the BREAM study team.

7.3 Catastrophic Oil Spills

Catastrophic oil spills have been and continue to be one of the primary concerns of northerners related to future hydrocarbon development in the region. For this reason, the primary emphasis for 1992/1993 BREAM activities should be placed in this direction. Considerable work has been accomplished by the Oil Spill Working Group this year, and BREAM is now in a better position to deal with the topic through an interdisciplinary workshop approach. Preliminary impact hypotheses related to offshore well blowouts and onshore pipeline ruptures have been formulated, and a substantial amount of information is available as a result of the Exxon Valdez oil spill and activities of the BSSC. However, several tasks need to be undertaken by the Working Group prior to a workshop dealing with oil spills. These tasks should include the following:

(1) compile all literature related to the Exxon Valdez spill;

(2) identify key studies relevant to the new impact hypotheses, which will be evaluated at the interdisciplinary workshop;

(3) finalize the list of VECs adopted for the catastrophic oil spill component of BREAM, and refine the impact hypotheses accordingly;

(4) review the oil spill scenario involving offshore well blowouts to ensure it is consistent with those scenarios developed under the BSSC;

(5) modify the impact hypotheses to include any community-based environmental concerns not already addressed in the linkages (see Section 7.2);

(6) develop two or more scenarios involving spills of refined petroleum products as a result of increased winter road travel and barge traffic; and

(7) formulate new impact hypotheses related to the above spill scenarios.

A planning meeting should occur at the outset of the 1992/1993 BREAM program to: (1) discuss specific tasks to be completed by the Working Group and any background documents that must be prepared in advance of future meetings and workshops; (2) select key participants for the interdisciplinary workshop; and (3) discuss the details of the scope of the workshop.

7.4 Routine Aspects of Hydrocarbon Development and Transportation

As a result of activities of the Impact Hypothesis Working Group this year and the success of the interdisciplinary workshop in achieving its objectives, there is no need for the Working Group to conduct any further work during the 1992/1993 BREAM program. However, it may be appropriate for the BREAM Steering Committee and the funding agencies to followup on the recommendations related to research and monitoring priorities identified during this year's project workshop.

8. LITERATURE CITED

Beaufort Sea Steering Committee (BSSC). 1991. Issues arising from the Environmental Impact Review Board Reviews of the Isserk and Kulluk Drilling Program Applications. Volume 1, April. 44 pp.

Canadian Petroleum Association. 1989. Land use requirements for anticipated hydrocarbon development in the Mackenzie Delta - Beaufort Sea Land Use Planning Region. Report prepared by R.A. Owens Environmental Services Ltd. for the Canadian Petroleum Association. 73 pp. + appendices.

Duval, W. and P. Vonk. 1991. A semi-quantitative procedure for preparation of initial environmental evaluations and assessment of potential impact significance. Seakem Group Ltd., Vancouver, B.C.

Indian and Northern Affairs Canada (INAC). 1991. Beaufort Region Environmental Assessment and Monitoring (BREAM) Program Final Report for 1990/1991, Environmental Studies No. 67, March. 416 pp.

Polar Gas. 1991. Project Overview - Mackenzie Valley Pipeline. Polar Gas, Mackenzie Delta Pipeline Project, Calgary, Alberta.

APPENDIX A

DISCUSSION PAPER ON GLOBAL WARMING
(David Thomas, Axys Group Ltd.)

GLOBAL WARMING AND IMPLICATIONS FOR THE ARCTIC: A BRIEF BACKGROUND

by D.J. Thomas

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of the

BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROJECT

VANCOUVER

January 28, 1992

GLOBAL WARMING AND IMPLICATIONS FOR THE ARCTIC: A BRIEF BACKGROUND

1. OVERVIEW

A variety of human activities, such as the burning of fossil fuels and deforestation, have increased the atmosphere's ability to retain heat by enhancing the natural greenhouse effect. Carbon dioxide is the greenhouse gas of greatest concern because the world's demand for energy is steadily increasing. The climate models used to forecast global temperature and precipitation patterns that will accompany a doubling of carbon dioxide in the atmosphere predict that the greatest changes will occur in high latitude zones, and especially the Arctic. Over the next 50 years, mean global equilibrium surface temperatures are anticipated to increase by 1.5° to 4.5°C (Environment Canada, 1989). In the Arctic, the warming is expected to be less than the global average during the summer, perhaps as little as 0.5°C; during winter, however, a dramatic increase in temperature is anticipated, perhaps as much as 8-10°C, which would be at least twice the global average. Although such temperature increases do not seem large relative to daily or seasonal fluctuations that we accept as part of normal weather patterns, they are very large on a global or Arctic-wide scale, where even a rise of 1.0°C in average temperature could have major impacts. During the last ice age, for example, average global temperatures were only 5 to 7°C cooler than today. During the last century, the global mean equilibrium surface temperature has increased by about 0.5°C (International Panel on Climate Change, 1990), and there is direct evidence of warming in the Arctic. Temperature profiles measured in Alaskan permafrost indicate a regional warming of 2-4°C during the same period, or at least four times the global average. The warming trend is also evident on Baffin Island, where the extent of year-round snow cover around existing ice-caps has decreased significantly during the last century.

Several factors present in the Arctic are expected to enhance the warming effect. These include:

1. Thawing of Permafrost
   The warming and thawing of permafrost, particularly subsea permafrost, will release methane (stored as clathrate hydrates), thus increasing further the abundance of atmospheric greenhouse gases.

2. Warming of Peat Bogs
   Peatlands and muskeg of the Arctic currently contain the largest surface reservoir of biologically fixed non-oxidised carbon in the world. Increased soil and air temperatures and changes in the water table brought about by global warming are expected to result in the release of methane and carbon dioxide from the bogs to the atmosphere.

3. Arctic Haze
   Air pollution produced from industries in the Northern Hemisphere is transported by global atmospheric circulation to the Arctic. This Haze contains low concentrations of sooty particulates and acidic material that absorb solar

radiation and warm the atmosphere. Solid particles deposited on snow and ice reduce the surface albedo slightly. This sets into motion the cyclical increase of solar radiation followed by a slight increase in air and ground temperature followed by a further decrease in albedo followed by another incremental increase in air and ground temperature etc.

It is important to note that feedback mechanisms might enhance the greenhouse effects by factors ranging from 0.8 - 2.6 (Bolin *et al.* 1987).

2. POTENTIAL EFFECTS OF GLOBAL WARMING ON THE ARCTIC

The prospect of long-term warming of the Arctic has led to intense concern over the possible physical, biological, and socio-economic impacts that might accompany it. The most likely impacts are summarized below and illustrated in Figures 1 and 2.

<u>Physical impacts</u>

- virtually all of the Arctic is underlain with perennially frozen ground, or permafrost, some of which would melt, releasing methane, one of the gases that contribute to global warming, thus further enhancing the greenhouse effect;

- lakes would experience a longer ice-free season of up to 20 days in the fall and 15 days in the spring;

- many regions would experience significant change in water availability as precipitation patterns change;

- thermal expansion of the oceans and melting of glacial ice could elevate mean sea level 0.5 m or more; the Beaufort Sea coast, which is characterized by unconsolidated, ice-rich ground with a gentle regional slope, would be drastically affected by beach erosion and flooding by storm surges;

- arctic coastlines would experience more fog and snow;

- the extent of sea-ice would diminish; an ice-free Arctic Ocean is considered a possibility, perhaps within 30-50 years (Flohn, 1982). As a consequence, polynyas would gradually decrease in frequency, duration and extent; and

- changes would occur in the occurrence of river ice, timing of river breakup, and river and delta routing.

<u>Biological impacts</u>

- the tree line would gradually shift north — by up to 750 km in the District of Keewatin — and the Arctic Ecoclimatic Province would be reduced by 15-20%

(Anderson and Reid, 1991), such that arctic tundra vegetative communities would be restricted mainly to the Arctic Islands;

- a northward shift of treeline would increase competition amongst the mainland barren-ground caribou herds for preferred tundra calving territory, with potential negative consequences for herd populations (Anderson and Reid, 1991);

- increased snowfalls would bury the sparse tundra vegetation beyond the reach of caribou and muskox, such that populations of these animals would be decimated, as has happened during previous episodes of heavy snowfall accumulation (Gates *et al.*, 1986);

- increases in the extent and duration of open water between the Arctic Islands would limit the movements of caribou, Arctic fox, wolves, and other land animals, thereby reducing their opportunity to find suitable habitat and new sources of food (Sheehy and Chouinard, 1989);

- Arctic charr and other cold-water fish species would be affected as lake temperatures increase resulting in the northward expansion of southern fish species, such as brook trout, which compete with the current population (Hammar, 1989);

- ocean warming and ice-pack recession may increase the range and numbers of some marine mammals such as beluga, bowhead whale, harbour seal, and harp seal, and walrus, but polar bear, ringed seal, and bearded seal require expanses of ice cover for breeding, feeding, and other habitat functions, and may suffer population decline (Harrington, 1986);

- the Arctic is the primary western hemisphere breeding and moulting ground for shorebirds and waterfowl (see for example, Chapter 6). Their low-lying coastal habitat could be affected by permafrost degradation and sea-level rise, which would lead to saltwater intrusion; and

- change in vegetation in Mackenzie and Athabasca River deltas.

Productivity of arctic soils.

- A warmer Arctic would have significant effects on the productivity of arctic soils. Indeed, the shores of the Arctic Ocean could be forested again as they were about two million years ago (Cooper, 1982). The most important restriction on arctic agriculture today is the length of the growing season. Summer temperatures are normally sufficient for good crop growth everywhere away from the direct influence of the Arctic Ocean, but there is insufficient time for crops to ripen between the frosts of spring and fall. Global greenhouse warming and an ice-free Arctic Ocean would significantly prolong the arctic growing season. Two factors, however, are obstacles to an agriculturally productive Arctic — precipitation and soils. The Arctic is now essentially a polar desert. Although an increase in precipitation is anticipated along with the general shift in arctic climate, whether the increase would be sufficient to support meaningful agriculture is unknown (Cooper, 1982). Soils are a more critical problem. Most of the Arctic is covered by only thin soils, in most cases insufficient for even marginally productive agriculture. An exception is the Mackenzie River Delta area. Nevertheless, increased agricultural production in the Arctic would not be expected to be significant.

Socio-economic impacts

- the existing tourism values which centre on wilderness and wildlife could be altered, as will be the strategies to protect them (Anderson and Reid, 1991);

- melting of permafrost could damage roads, buildings, and other man-made structures, and onshore oil and gas development could become more difficult and expensive (Maxwell and Barrie, 1989);

- climate change could alter fish and wildlife habitats upon which the intensity of hunting and trapping in an area is now largely determined by accessibility from communities (Anderson and Reid, 1989);

- a rise in sea level of 0.4 m would have serious implications for over one-half of the arctic communities (Egginton and Andrews, 1989), such as Tuktoyaktuk, which are located on the coast essentially on flat land at or near sea level; extensive and expensive remedial protection measures would be necessary to protect them from flood damage; and

- reduction in the extent and duration of sea ice could economically benefit offshore hydrocarbon development, tourism, recreation, and marine transport as the shipping season is expected to lengthen by six to eight weeks (Maxwell and Barrie, 1989); the Northwest Passage could become a viable shipping route during the summer months, although rougher seas, increased fog occurrence, and more icebergs may occur with changes to the ocean environment (Intergovernmental Panel on Climate Change, 1990).

Impacts specifically relevant to hydrocarbon development

- Offshore drilling in the Delta and the Beaufort Sea should benefit from warmer temperatures; there will be fewer problems with ice and extreme cold. Some of the drilling is conducted on ice islands, however, and changing river ice flows could also pose problems. The design of liquid natural gas plants, such as the one proposed by ESSO for the Mackenzie Delta, is very sensitive to temperature extremes, as gas must be cooled for liquification and then cooled again as it enters the pipeline. One of the greatest impacts may be on the pipelines, as changing permafrost conditions will affect pipelines in certain locations. Other problems include changes to river and sea levels and increased storm effects.

3. SUMMARY

Although a warmer climate would at first appear to be beneficial to the Arctic because of a less harsh climate to live and work in and improved accessibility, the potential negative impacts described above could result in the loss of the very characteristics that make the Arctic unique. The harsh climate has helped to isolate the Arctic, preserving its wildlife and allowing its native peoples and their culture to endure. By "softening" the Arctic's natural barriers, climatic warming could lead to a reduction in this isolation, jeopardizing these important features of the Arctic. It is also important to recognise the following aspects of global warming:

(1) scientists agree that it is occurring;

(2) scientists agree that the effects on the Arctic will be substantial, but lack of data at the present time prevents quantification of the impacts; and

(3) whatever changes do occur, these will occur on time scales of decades, not years. Significant greenhouse effect related changes to precipitation patterns, the hydrological regime, animal migration patterns, ice regimes etc. are not likely to occur for 30 to 100 years.

4. LITERATURE CITED

Anderson, J.C. and J.R. Reid. 1991. (in preparation). Northern resources at risk to climate change. Environment Canada, State of the Environment Reporting.

Bolin, B., B.R. Döös, J. Jäger and R.A. Warrick (eds). 1987. The Greenhouse Effect, Climate Change and Ecosystems. Scope 29. The Scientific Committee on Problems of the Environment. John Wiley and Sons. U.K.

Cooper, C.F. 1982. Food and fibre in a world of increasing carbon dioxide. (In) Carbon Dioxide Review 1982. W.C. Clark (ed). Clarendon Press. pp. 297-319.

Egginton, P.A. and J.T. Andrews. 1989. Sea-levels are changing. Geos 18(2):15-22.

Environment Canada. 1989. The greenhouse effect: impacts on the Arctic. Changing Atmosphere Fact Sheet. Atmospheric Environment Service. Downsview, Ontario.

Flohn, H. 1982. Climate change and an ice-free Arctic Ocean. (In) Carbon Dioxide Review 1982. W.C. Clark (ed). Clarendon Press. pp. 143-129.

Gates, C.C., J. Adamczewski, and R. Mulders. 1986. Population dynamics, winter ecology and social organization of Coats Island caribou. Arctic 38(3):216-222.

Hammar, J. 1989. Freshwater ecosystems of polar regions. Arctic 18(1).

Harrington, C.R. 1986. The impact of changing climate on some vertebrates in the Canadian Arctic. pp. 100-13 (in) Proceedings of the Canadian Climate Program Workshop on Climate Change Impacts in the Canadian Arctic. Orillia, Ontario, March 1986.

Intergovernmental Panel on Climate Change. 1990. IPPC First Assessment Report, Overview.

Maxwell, B. and L.A. Barrie. 1989. Atmospheric and climate change in the Arctic and Antarctic. Ambio 18(1):42-49.

Sheehy, G. and J. Chouinard. 1989. Environmental and socio-economic impacts of climate change on wildlife. Prepared for the Intergovernmental Panel on Climate Change. Draft.

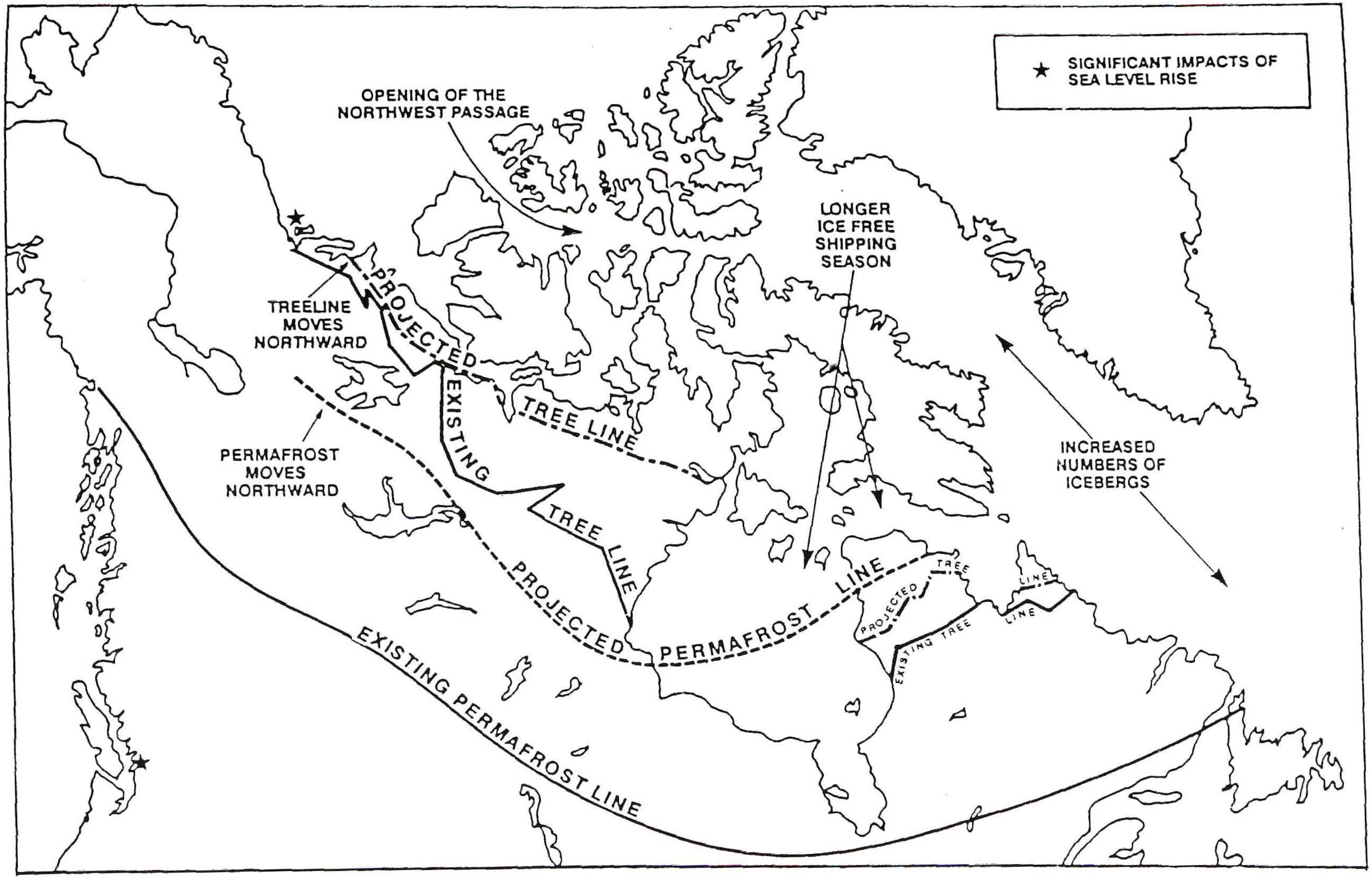

Figure 1. Predicted changes to location of tree line and permafrost line and extent of sea ice associated with a change in arctic mean equilibrium surface temperatures of 0.5 C° (summer) to approx. 8 C° (winter).

Figure 2. Coastlines that are currently submerging and would be very susceptible to a rise in sea level.

APPENDIX B

AN OVERVIEW OF THE BEAUFORT REGIONAL ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

AN OVERVIEW OF THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM (BREAM)

This paper:

1. gives some background on BREAM,
2. identifies the principal players in BREAM,
3. describes the BREAM process,
4. identifies how BREAM differs from past programs with similar objectives, and
5. describes future oil and gas development scenarios.

1. BACKGROUND TO BREAM

There continues to be concern that oil and gas development activities in the Beaufort Sea, Mackenzie Delta, and Mackenzie Valley may affect the natural environment. What these effects may be, and how they can be assessed have been matters that northern communities, oil and gas industry representatives, governments and scientists have wrestled with since the 1970s. All of these groups agree that broadening the understanding of the northern environment through research and monitoring programs, can enable better decisions to be made about oil and gas developments and improve environmental assessments of these activities. These were the main reasons for creating the Beaufort Region Environmental Assessment and Monitoring Program (BREAM).

BREAM has evolved from years of effort to identify and understand the effects that oil and gas exploration, production and/or transportation activities might have on the natural environment and harvest of wildlife resources. Two earlier programs also had these goals:

1) the Beaufort Environmental Monitoring Project (BEMP), started by Indian and Northern Affairs Canada and Environment Canada in 1983 to guide monitoring in the offshore marine environment; and

2) the Mackenzie Environmental Monitoring Program (MEMP), begun in 1985 by the Federal and Territorial Governments in Yukon and the NWT to guide monitoring of the terrestrial and freshwater environment of the Mackenzie Valley and Delta.

The research and monitoring programs carried out as a result of BEMP and MEMP recommendations have created a better understanding of the environmental impact of some oil and gas development activities on the natural environment. The work accomplished by BEMP and MEMP provides much of the foundation upon which BREAM is built.

BEMP and MEMP have been inactive since 1986. In the last five years, a number of events have occurred:

- joint management structures legislated in the Inuvialuit Final Agreement (IFA) ensure that the Inuvialuit's concerns are reflected in environmental assessments and hydrocarbon development decisions;

- Federal Government approval of the Gwich'in Final Agreement (GFA) and a potential land settlement in the Sahtu Region will provide these same guarantees for the Dene/Metis from Fort Norman to Inuvik;

- new oil and gas development issues were identified by the Beaufort Sea Steering Committee (BSSC), the Environmental Impact Review Board (EIRB) established under the IFA, and the Mackenzie Delta-Beaufort Sea Regional Land Use Planning Commission;

- New information on oil spill behaviour, clean-up, biodegradation and impacts have been identified as a result of oil spills in British Columbia and Alaska; and,

- planning by six major oil and gas producing and pipeline companies toward the construction of a Mackenzie Delta/Valley natural gas or oil pipeline by the end of the 1990s, continues.

Important events such as these have influenced our understanding of the impacts of oil and gas developments or how these impacts can be assessed, and have demonstrated a need for further environmental research, monitoring and assessment. To meet these needs, BEMP and MEMP were combined in 1990/91 to form BREAM. BREAM will reflect new information and recent changes in environmental assessment responsibilities/processes, and will better coordinate and link efforts in the Beaufort region and the Mackenzie Delta/Valley.

2. BREAM PLAYERS

BREAM is funded through the Federal Government's Northern Oil and Gas Action Program (NOGAP). During 1990/91, the Federal agencies of Indian and Northern Affairs Canada, Environment Canada, and the Department of Fisheries and Oceans participated in BREAM. Other participants in BREAM were:

- Fisheries Joint Management Committee
- Government of the N.W.T.
- Government of Yukon
- Esso Resources Canada
- Gulf Canada Resources
- Amoco Canada Petroleum
- Chevron Canada Resources
- Polar Gas
- Foothills Pipeline
- the scientific community in northern and southern Canada

An even greater number of agencies and individuals will be involved in BREAM in 1992. For example, the Community-Based Concerns Working Group will add representatives from communities/ regions from the Alberta-NWT border to the Beaufort Sea.

3. THE BREAM PROCESS

BREAM is a process for identifying research that must be done to fill important information/data gaps; however, unlike earlier programs, it also has an environmental assessment component.

There are four BREAM objectives:

1) to review and evaluate assessment needs for decision-making, the state of knowledge related to scientific and community-based concerns, and the hydrocarbon development and transportation scenario for the region;

2) to establish the necessary lines of communication, consultation and participation between BREAM, government, industry and local communities;

3) to provide the focus for what needs to be known for assessment purposes and to make decisions through establishment of a prioritized list of necessary research and monitoring activities; and

4) to create the iterative process and framework to achieve the above objectives.

Because BREAM is an extension of BEMP and MEMP, it uses the same basic framework and methodology. Impact hypotheses are at the heart of BREAM. An impact hypothesis is a set of statements that link hydrocarbon development activities with their potential environmental effects. An impact hypothesis is created by developing conceptual models or assumptions about the effects of oil and gas developments on the people and environmental resources of the area. Every impact hypothesis has three parts:

1. the action: that which is the potential cause of an effect;
2. the valued ecosystem component (VEC): that which is the measure of effect; and

Valued Ecosystem Components (VECs) are activities, resources or environmental features that (i) 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. Examples of VECs include populations, harvests and quality of a number of species of birds, fish and mammals.

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

Through MEMP, 25 impact hypotheses were developed and evaluated in interdisciplinary workshops. BEMP produced and examined another 21 impact hypotheses focusing on the offshore Beaufort Sea.

The BREAM process also provides the framework for testing each impact hypothesis. This is done through research and monitoring, both of which are designed to:

- measure environmental impacts, and
- analyse cause-effect relationships.

Monitoring is the repetitive measurement of those VECs that are likely to change, due to direct or indirect effects of development activity, rather than as a result of natural variability.

BREAM is an iterative process, meaning that BREAM players regularly meet to discuss research and monitoring activities and results, and to make recommendations for the future including directions for the process itself. In this way, new information can be taken into account and the understanding of all the players can be improved.

4. BREAM DIFFERS FROM PAST PROCESSES

BREAM will differ from BEMP and MEMP in four ways. First, BREAM will consider new VECs (e.g., coastlines were not a VEC in BEMP). Due to the Exxon Valdez spill in Alaska and other events, BREAM will consider research and monitoring programs related to a major well blow-out from an offshore-drilling program, and an oil pipeline rupture that affects the Mackenzie River. A Catastrophic Oil Spills Working Group has been struck to look at the research and monitoring programs necessary to understand major oil spills.

Secondly, BREAM will look at ways that community-based ecological concerns can be better reflected in the process. For example, in the past some community concerns may not have been included because they didn't readily fit into an impact hypothesis or could not easily be tested through scientific research and monitoring processes. A Community-Based Concerns Working Group has been struck to consider how these concerns can be better understood, communicated and reflected in BREAM. Even though social issues are important, this Working Group will not deal with community-based social concerns; they are beyond the scope of BREAM.

Thirdly, while BEMP and MEMP both attempted to use traditional and local knowledge in the evaluation of some impact hypotheses, even greater effort will be made to understand and include this knowledge in the BREAM process. The Community-Based Concerns Working Group will address this priority.

Definitions developed by the NWT Working Group on Traditional Knowledge may help in this work. "Traditional knowledge is knowledge that derives from, or is rooted in the traditional way of life of aboriginal people. Traditional knowledge is the accumulated knowledge and understanding of the human place in relation to the universe. This encompasses spiritual relationships, relationships with the natural environment and the use of natural resources, relationships between people, and, is reflected in language, social organization, values, institutions and laws. Local knowledge is a body of knowledge specific to a geographic location or period of time and may be intertwined with traditional knowledge."

Fourthly, BREAM will deal with research and monitoring as well as environmental assessment in contrast to MEMP and BEMP which dealt only with research and monitoring. Broadening the focus of BREAM will enable research and monitoring information to be strongly linked to environmental assessment processes and information requirements. As a result, the quality and efficiency of environmental assessments should be improved.

BREAM can identify the information needed to enable northern residents, oil and gas companies, and public and aboriginal government agencies to make better decisions about hydrocarbon development.

5. FUTURE OIL AND GAS DEVELOPMENT SCENARIOS

Excerpts from the 1990/91 Beaufort Region Environmental Assessment and Monitoring Project report describing future oil and gas exploration, and production and transportation scenarios are attached for information purposes. These scenarios may change, but updates are part of the BREAM process.

COMMUNITY-BASED CONCERNS WORKING GROUP PARTICIPANTS

The following organizations have been invited to participate in the Community-Based Concerns Working Group Meeting in Yellowknife, February 19 and 20 (if required), at the Northern Frontier Visitors Centre Boardroom across from the Explorer Hotel.

- Gwich'in Tribal Council
- Joint Secretariat
- Inuvialuit Game Council
- Beaufort Mackenzie Delta DIZ Society

- Sahtu DIZ/Shihta Regional Council
- Deh Cho Regional Council
- GNWT Dept. of Renewable Resources
- GNWT Dept. of Energy, Mines & Petroleum Resources
- Oil and Gas Industry Representative
- Indian and Northern Affairs Canada
- Environment Canada
- Fisheries and Oceans Canada
- Axys Environmental Consultants
- ESSA Environmental & Social Systems Analysts
- North/South Consultants
- Lutra Associates

Meetings of the other technical working groups are scheduled as follows:

*Impact Hypothesis Working Group: January 28-30, 1992
*Catastrophic Oil Spill Working Group: January 30,1992
*Impact Hypothesis Interdisciplinary Workshop: February 26-28, 1992

APPENDIX C

COMMUNITY-BASED CONCERNS WORKING GROUP: TERMS OF REFERENCE

BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM (BREAM)

COMMUNITY-BASED CONCERNS WORKING GROUP: TERMS OF REFERENCE

What is BREAM?

BREAM is a process for identifying research that will broaden our understanding of the impacts of oil and gas developments on the northern environment (see Overview paper on BREAM).

What is the Community-Based Concerns Working Group?

The Community-Based Concerns Working Group is one of three (3) technical groups involved in the Beaufort Region Environmental Assessment and Monitoring (BREAM) program. The other two groups are: the Impact Hypothesis Working Group and the Catastrophic Oil Spill Working Group.

In February 1992, the Community-Based Concerns Working Group will meet for the first time. The Working Group will be made up of representatives from six regional organizations from the NWT-Alberta border to the Beaufort Sea. Representatives will be familiar with hydrocarbon development activities and their relationship to the ecology of their region. Federal government, Government of the NWT, and oil and gas industry representatives with similar interests will also join the Working Group. The Community-Based Concerns Working Group will be supported by consultants from northern and southern Canada. In total, the size of the Working Group should not exceed 15 people to ensure that it operates efficiently.

The work of each of the three technical working groups will have the same end result -- to broaden the understanding of the northern environment through the identification of research and monitoring programs to improve future environmental assessments of oil and gas activities in the western NWT. Each of the three technical working groups will contribute to this goal in a different way. As its name suggests, the Community-Based Concerns Working Group will identify ecological issues and concerns that NWT community/regional people believe should be included in future environmental assessments of hydrocarbon activities (ecological should be understood as the relationship of living things/organisms to their natural environment and to each other).

The Work of the Community-Based Concerns Working Group in 1991/92

The Community-Based Concerns Working Group will have an important role in both the immediate and longer term. In the longer term, the Working Group will contribute to the development of a comprehensive environmental information database that will enable thorough environmental assessments of future hydrocarbon development activities in the NWT. This will be accomplished through research and monitoring projects, and the strengthening of processes for communicating and discussing research and monitoring results and activities.

The immediate tasks of the Community-Based Concerns Working Group will be completed before March 31, 1992. Over the next few weeks, the Working Group will:

1. develop a good understanding of the BREAM process and its role in environmental assessment(s) of future oil and gas developments;

2. explore the types of and the extent of community-based ecological issues and concerns which should be considered in future environmental assessments of oil and gas developments in the region;

3. identify work priorities for the Community-Based Concerns Working Group for 1992/93; and,

4. enable representatives of the Community-Based Concerns Working Group to participate in an Impact Hypothesis Interdisciplinary Workshop in Vancouver, February 26-28, 1992.

How the Work of the Community-Based Concerns Working Group Will Be Accomplished.

TASK 1: Develop a good understanding of the BREAM process and its role in environmental assessment(s) of future oil and gas developments.
TIMEFRAME: Prior to February 19-20, 1992

Regional/organizational representatives should familiarize themselves with BREAM prior to attending the first meeting of the Community-Based Concerns Working Group in Yellowknife on February 19-20, 1992. An overview paper of the BREAM program is attached for this purpose. The paper provides a background to BREAM, identifies BREAM's players, describes the BREAM process, identifies how BREAM differs from its predecessors, BEMP and MEMP, and provides information on future oil and gas development scenarios. Matters arising from the overview paper requiring clarification and/or further discussion will be addressed at the February meeting.

In the meantime, regional/organizational representatives can contact Lois Little at Lutra in Yellowknife (phone 873-8903: fax 873-8368) or Wayne Duval at Axys in Vancouver (phone 604-687-3385: fax 687-0171) to get further information or clarification.

TASK 2: Explore the types of and the extent of community-based ecological issues and concerns which should be considered in future environmental assessments of oil and gas developments in the region.
TIMEFRAME: Ongoing

Each member of the Community-Based Concerns Working Group should be prepared to discuss, with some confidence, those ecological issues/concerns of importance to the people they represent. This discussion will take place at the Working Group's first meeting in February in Yellowknife and will continue at the Interdisciplinary Workshop in Vancouver. Community-based ecological issues/concerns related to future oil and gas developments could include:

- changes to/loss of wildlife/fisheries habitat,
- disturbances to/displacement of wildlife/fisheries,
- changes in wildlife/fisheries harvesting, or
- loss of/changes to water quality.

While many issues of this type have been the focus of previous environmental reviews, they remain a concern. These issues and the reasoning behind them will be discussed during the February workshop.

In addition to the issues identified above, community-based ecological concerns may relate to:

- how traditional knowledge is recognized in ecological research and monitoring projects,

- how northern people are involved in research and monitoring projects, and in environmental assessments, or

- how ecological research and monitoring activities are communicated to and among northern people.

Prior to attending the February meeting in Yellowknife, Working Group members should speak with knowledgeable people in their regions to identify ecological issues/concerns that should be considered as part of BREAM. A one page, written summary of these discussions should be available for distribution to other Working Group members.

This written summary should identify:

1. the agencies/individuals contacted in your region/organization,
2. the main ecological concerns/issues related to future hydrocarbon developments in the Beaufort and Mackenzie Delta/Valley, and
3. suggestions for improving future environmental research and monitoring activities.

TASK 3: Identify work priorities for the Community-Based Concerns Working Group for 1992/93.

TIMEFRAME: at the Community-Based Working Group meeting, Yellowknife February 19-20, 1992 (session will be extended to the 20th if required)

Emphasis this year (1991/92) on BREAM has been placed on careful planning of the focus of activities in subsequent years. The knowledge that representatives bring to the Community-Based Concerns Working Group meeting in Yellowknife is critical to determining work priorities for 1992/93. Future community-based meetings and workshops will be necessary to ensure the success of BREAM.

TASK 4: Enable representatives of the Community-Based Concerns Working Group to participate in an Impact Hypothesis Interdisciplinary Workshop in Vancouver, February 26-28,1992.

TIMEFRAME: at the Impact Hypothesis Interdisciplinary Workshop, Vancouver, February 26-28, 1992

A three-day Interdisciplinary Workshop this year will involve representatives from each of the three technical working groups - the Community-Based Concerns Working Group, the Impact Hypothesis Working Group, and the Catastrophic Oil Spill Working Group. The purpose of the Workshop will be to re-evaluate existing impact hypotheses and examine new hypotheses that have been developed by the Impact Hypothesis Working Group. This work will enable research and monitoring needs for the next few years to be identified.

Representatives from the Community-Based Concerns Working Group will actively participate in this workshop, bringing forth the ecological issues/concerns, and research and monitoring priorities that the Group has identified. In preparation for the Interdisciplinary Workshop, Community-Based Concerns Working Group members will be asked to review a summary of existing and new impact hypotheses.

COMMUNITY-BASED CONCERNS WORKING GROUP - PLANNING MEETING

April 16,1992.

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ATTACHMENTS

COMMUNITY-BASED CONCERNS WORKING GROUP - PLANNING MEETING HIGHLIGHTS

The first meeting of the Community-Based Concerns Working Group served to broaden the understanding of and participation in BREAM. The Working Group dealt with specific community-based ecological concerns, and northern involvement in addressing these issues and generally in the BREAM Program. The main highlights of the day and a half long meeting are:

- *Food sources (i.e. harvestable resources) and overall quality of the northern environment are central to all community-based concerns.*
- *BREAM Hypothesis R-26 related to decreased acceptability of fish as a food source due to uptake of contaminants should be re-evaluated.*
- *There is a need to place priority on developing baseline data and reliable monitoring programs for harvestable resources.*
- *Like global warming, other industrial developments such as upstream pulp mill developments should be reflected in new impact hypotheses linkages if there is a potential for cumulative impacts or interactions with effects resulting from hydrocarbon developments.*
- *Solid waste disposal sites and associated contamination is a concern, but one that is currently being addressed through the Arctic Environmental Strategy.*
- *Northern people have difficulty separating the potential socio-economic and environmental impacts of a catastrophic oil spill in the Beaufort Sea.*
- *Increased traffic on winter roads is creating concerns about potential spills of refined petroleum products.*
- *Reflecting traditional knowledge, new northern environmental monitoring and assessment authorities (i.e. Inuvialuit and Gwich'in structures), and better communications of research and monitoring results, were three themes which underlie most community-based issues.*
- *Working Group members agree that traditional knowledge is different than scientific knowledge but is nonetheless important and useful to improving the understanding of the northern environment and enabling better decisions to be made about future hydrocarbon developments.*

- *Members of the Community-Based Concerns Working Group have put forth a model for accessing and incorporating traditional and local knowledge into decisions related to environmental research and monitoring.*
- *Members of the Community-Based Concerns Working Group agree that the involvement of northerners in all stages of research, monitoring and assessment will be essential to maximize the acceptance of BREAM to northern communities.*
- *Working Group members agree that existing documentation related to community-based concerns should be stored in and accessible from a central location in the Northwest Territories. The nature of the information that does exist should be communicated to the various interests.*
- *Working Group members stressed that because socio-economic matters are outside the scope of BREAM, a parallel process should be established to address those concerns associated with hydrocarbon development.*

INTRODUCTION

The objectives of this the second year of BREAM included the establishment of three technical working groups and meetings among members of each of these groups *"to define the scope of future BREAM workshops and the Background Documents that should be prepared in advance of such interdisciplinary meetings"*. This document summarizes the discussions that occurred during the first meeting of one of these technical working groups, the Community-Based Concerns Working Group. The meeting was held in Yellowknife, N.W.T. on February 19-20,1992.

The main role of the Community-Based Concerns Working Group is to identify ecological issues and concerns that northern community/regional people believe should be included in environmental assessments of future hydrocarbon activities. During the 1991/92 BREAM Program, activities of this Working Group focused on:

1) introducing the BREAM process to northern communities and,

2) identifying some of the environmental issues of importance to northerners.

The geographic extent of BREAM corresponds to the proposed hydrocarbon development scenario, which assumes exploration and production activities in the Mackenzie Delta/Beaufort region and a pipeline along the Mackenzie Valley to southern Canada. The western N.W.T. regions potentially concerned about these activities include the Inuvialuit Settlement and the Gwich'in Settlement regions and the Sahtu or Great Bear and Deh Cho regions. Each of these regions is represented in the Community-Based Concerns Working Group.

MEETING PREPARATION

Following the BREAM Project Initiation Meeting (held in Vancouver in November, 1991), regional organizations in the Mackenzie Valley and Beaufort Sea regions were invited to attend a meeting of the Community-Based Concerns Working Group. These organizations were asked to select a representative familiar with hydrocarbon developments and the relationship of these activities to the region's ecology that would participate in this Working Group. It was emphasized that

BREAM focuses on environmental concerns of northern communities and that it is outside the scope of the program to deal with social issues associated with hydrocarbon development.

In preparation for the technical meeting, an overview of BREAM and the Terms of Reference for the Community-Based Concerns Working Group (Attachments A and B) were distributed to the regional organizations to:

- *familiarize these individuals with the BREAM process;*
- *outline the work of the Community-Based Concerns Working Group, and*
- *detail the specific responsibilities of the Working Group members.*

Four specific tasks of the Community-Based Concerns Working Group for 1991/92 were identified during the Project Initiation Meeting. These were as follows:

1. to develop a good understanding of the BREAM process and its role in environmental assessment(s) of future oil and gas developments;

2. to identify the types and extent of community-based ecological issues and concerns that environmental assessments of future oil and gas developments should consider;

3. to determine priorities for 1992/93 activities of the Community-Based Concerns Working Group; and

4. to ensure representatives of the regional organizations participate in the Impact Hypothesis Interdisciplinary Workshop in Vancouver in May, 1992.

COMMUNITY-BASED CONCERNS WORKING GROUP MEMBERS

The Community-Based Concerns Working Group consists of representatives from the federal and territorial governments, the oil and gas industry and northern communities. The northern communities were represented by the:

-Inuvialuit Game Council, Inuvialuit Settlement Region;
-Joint Secretariat, Inuvialuit Settlement Region;
-Gwich'in Tribal Council, Gwich'in Settlement Region;
-Shihta Regional Council/Development Impact Zone Committee, Sahtu Region; and
-Deh Cho Regional Council, Deh Cho Region.

At this first meeting of the Community-Based Concerns Working Group, all groups were represented except the Deh Cho Regional Council (see Attachment C). The designated representative of the latter organization was unable to attend due to a scheduling conflict, although the Deh Cho Regional Council intends to be involved in the BREAM Program during the future.

PLANNING MEETING OBJECTIVES

The primary objective of the Community-Based Concerns Planning Meeting was to respond to the tasks outlined in the Terms of Reference for the Working Group. Specifically, the meeting was intended to:

- *ensure that Working Group members understand the BREAM Program and its role in the environmental assessment(s) of future oil and gas developments;*
- *identify the types and extent of community-based ecological issues and concerns that environmental assessments of future oil and gas developments should consider; and*
- *explore processes for addressing community-based ecological issues and concerns.*

COMMUNITY/REGIONAL UNDERSTANDING OF BREAM

Most participants had some familiarity with the Beaufort Environmental Monitoring Program (BEMP) or the Mackenzie Environmental Monitoring Program (MEMP), the predecessors of BREAM. The history of community/regional involvement in past environmental monitoring programs enabled both the Inuvialuit Game Council (IGC) and the Government of the Northwest Territories (Department of Renewable Resources) to express support for BREAM. Support was expressed in part because local interests and concerns would be reflected in the BREAM process.

The role of BREAM in assisting the decision-making processes related to industrial development was discussed in light of the often competing socio-cultural, political and economic agendas of various northern and national interest groups. Some participants sought clarification of this role, particularly in relation to other government-sponsored environmental initiatives in the North and concerns related to possible overlapping objectives of different programs. However, the objectives of BREAM are quite distinct from these other programs and relate specifically to research and monitoring needs associated with hydrocarbon development in the region.

Members of the Community-Based Concerns Working Group expressed a general familiarity with the structure of BREAM impact hypotheses. During the Planning Meeting, participants were informed that the Impact Hypothesis Working Group has screened the existing 32 BREAM hypotheses and identified 10 hypotheses that require further attention. Based on new information and/or restructuring of the hypothesis, it was recommended that eight of these require a detailed evaluation, while two need to be briefly examined. The Impact Hypothesis Working Group also considered the cumulative effect of global warming and concluded that it would be adequately addressed by the addition of new linkages to existing impact hypotheses, where necessary. The evaluation of existing and new BREAM hypotheses will be the focus of an interdisciplinary workshop scheduled for May, 1992, in Vancouver, B.C.

COMMUNITY-BASED CONCERNS WORKING GROUP - ISSUES AND CONCERNS

This section presents the issues and concerns raised by members of the Community-Based Concerns Working Group at the Planning Meeting on February 19-20,1992. The agenda for the meeting is provided in Attachment D, while the community concerns are summarized in Attachment E of this report.

i) Ecological Concerns and Issues

Food sources (i.e. harvestable resources) and the overall quality of the northern environment are the fundamental ecological concerns that must be addressed by BREAM through the activities of the Community-Based Concerns Working Group. In particular, these concerns are related to: (1) baseline data collection and monitoring; (2) fish quality; (3) solid waste disposal and associated contamination; (4) catastrophic oil spills; (5) refined oil spills; (6) pipelines - east-west route; (7) effects of increased ambient noise and traffic; and (8) cumulative effects of industrial developments.

***Baseline Data Collection and Monitoring**

Representatives from the Inuvialuit Settlement Region expressed concern that BREAM must develop *"adequate and agreed upon baseline data for harvestable resource populations"*. Baseline data should include information on resource populations, harvest locations, harvester effort, and habitat requirements for major harvestable resource populations. The extent of information collected on polar bears is an example of the level of baseline data that is required. Existing data on Arctic cisco and herring was cited as an example of where this baseline information is incomplete.

Similarly, representatives from the Inuvialuit Settlement Region identified a need to establish relevant monitoring programs *"which will reliably assess the effects of any industrial activities"* on harvestable resource populations. Monitoring programs should enable harvesters to identify and assess changes in the resource, as well as the impacts of these changes.

The need to place priority on developing baseline data and reliable monitoring programs is considered important by residents of the Inuvialuit Settlement

Region .... "*there have been no major problems in the Beaufort as a result of hydrocarbon activities, and we want to keep it that way.*"

***Fish Quality**

Residents of the Sahtu Region, particularly communities north of Norman Wells, continue to be concerned about the tainting and texture of whitefish and the appearance of loche (burbot) livers (i.e. spotted, shrunken livers) harvested in the Mackenzie River. This has been an issue since the construction of the Norman Wells pipeline in the mid 1980s. Research conducted by the Department of Fisheries and Oceans (DFO) has not been able to establish cause-effect relationships between hydrocarbon activities and fish quality. The results of this research, however, have not been readily understandable to members of northern communities. Working Group members recommended that the fish quality hypothesis (BREAM Impact Hypothesis R-26) should be re-evaluated to underscore the importance of fish resources to community residents, and to promote a better local understanding of fisheries research that has occurred.

If hydrocarbon activities are not the cause of poor fish quality, community residents speculated that pulp mill discharges upstream of the Mackenzie River may be responsible for these changes. Community residents recommended that cumulative impacts associated with upstream (of the Mackenzie River) effluents discharged by pulp mills be reflected in new linkages of BREAM Impact Hypothesis R-26.

***Solid Waste Disposal Sites and Associated Contaminants**

Representatives from both the Sahtu Region and the Gwich'in Settlement Region expressed concerns related to buried and abandoned solid waste (i.e. drums). Communities are uncertain about the location and toxic nature of these materials, and the potential for leakage into streams and creeks. These concerns were most strongly expressed by the Sahtu Region, which has experienced some 70 years of oil and gas development activity.

Efforts to identify and cleanup hazardous waste sites are currently being undertaken through the Arctic Environmental Strategy, a program under the federal government's Green Plan.

*Catastrophic Oil Spills

Northern communities, particularly those in the Inuvialuit Settlement Region, are concerned about the potential impacts of a catastrophic oil spill (i.e. uncontrolled well blow-out) in the Beaufort Sea on harvestable resources (i.e. fish, marine mammals, polar bears, seabirds) and their habitat.

Northern residents find it difficult to categorize the range of potential impacts that may result from a catastrophic oil spill. Because BREAM does not address socio-economic concerns, members of the Working Group recommended that a parallel process be established to research and monitor needs related to these issues. While some social and economic issues related to catastrophic oil spills are outside the scope of BREAM, concerns related to effects of spills and their cleanup on resource harvesting activities and opportunities will be addressed through new impact hypotheses that will be developed for future BREAM workshops.

Working Group members identified a need to broaden the existing information base on impacts of catastrophic oil spills in order to develop effective wildlife compensation and/or species rehabilitation plans. Over 100 studies were initiated in response to the Exxon Valdez spill in Prince William Sound, Alaska. The results of many of these research programs are expected to augment the existing database on the impacts of large oil spills.

*Refined Oil Spills

The potential for oil spills from the InterProvincial Pipeline at Norman Wells is not a major concern of residents in the Sahtu Region because of ongoing monitoring of the pipeline and a good "track record" to date. However, there is concern in this and other regions related to possible spills of refined petroleum products as a result of increased winter road travel and the potential impacts of these spills on rivers and lakes. Working Group members agreed that there is increased awareness of the impacts of crude oil spills to offshore and onshore northern ecosystems but refined oil spills have received little attention in the N.W.T.

***Pipelines - East-West Route**

There is concern within the Inuvialuit Settlement Region that an east-west pipeline tying the North Slope or adjacent and subsequent feeder lines to a Mackenzie Valley pipeline may have an impact on beluga calving areas in Shallow Bay, west of Tuktoyaktuk.

Current oil and gas transportation scenarios presented by the industry representative at the Planning Meeting suggest that a north-south pipeline may be anticipated in 10-15 years, but an east-west pipeline would not be constructed for 20-30 years, if at all. It was also suggested that any east-west pipeline development scenario would recognize critical beluga calving areas and efforts would be made to minimize potential impacts on the resource and its habitat.

***Effects of Increased Ambient Noise and Traffic**

Communities in the Inuvialuit Settlement Region are concerned about the overall effects of increased ambient noise and traffic, both air and sea, on harvestable resources. Two hypotheses, BREAM R-1 and BREAM R-2, consider the impacts of ships/icebreakers on bowhead whale populations and the white whale harvest. These hypotheses are considered valid and will be re-evaluated at the 1992 Interdisciplinary Workshop in Vancouver.

***Cumulative Effects of Industrial Developments**

The cumulative effects of atmospheric deposition and other inputs of contaminants on the northern ecosystem is an area of concern to northern communities. There is a need to improve our understanding of the cumulative effects of industrial developments on air and water quality and harvestable resources. The concerns of northern residents are heightened by a lack of information on the effects on the northern ecosystem of pulp mill developments upstream of the Mackenzie River, potential Bear and Liard River hydroelectric developments, logging in the upper Liard Valley, and agricultural waste (i.e. pesticides and herbicides) entering the Mackenzie River watershed. It was recommended that, where appropriate, additional linkages be added to the existing BREAM hypotheses to help address the concerns related to cumulative impacts.

ii) Process-Related Issues and Concerns

Members of the Community-Based Concerns Working Group discussed how communities should be more involved in addressing ecological issues and concerns, and in the BREAM process itself. Reflecting traditional knowledge, new northern environmental monitoring and assessment authorities (i.e. Inuvialuit and Gwich'in structures), and better communication of research and monitoring results, were three themes which underlie most process-related issues and concerns.

***Accessing and Incorporating Traditional Knowledge into BREAM**

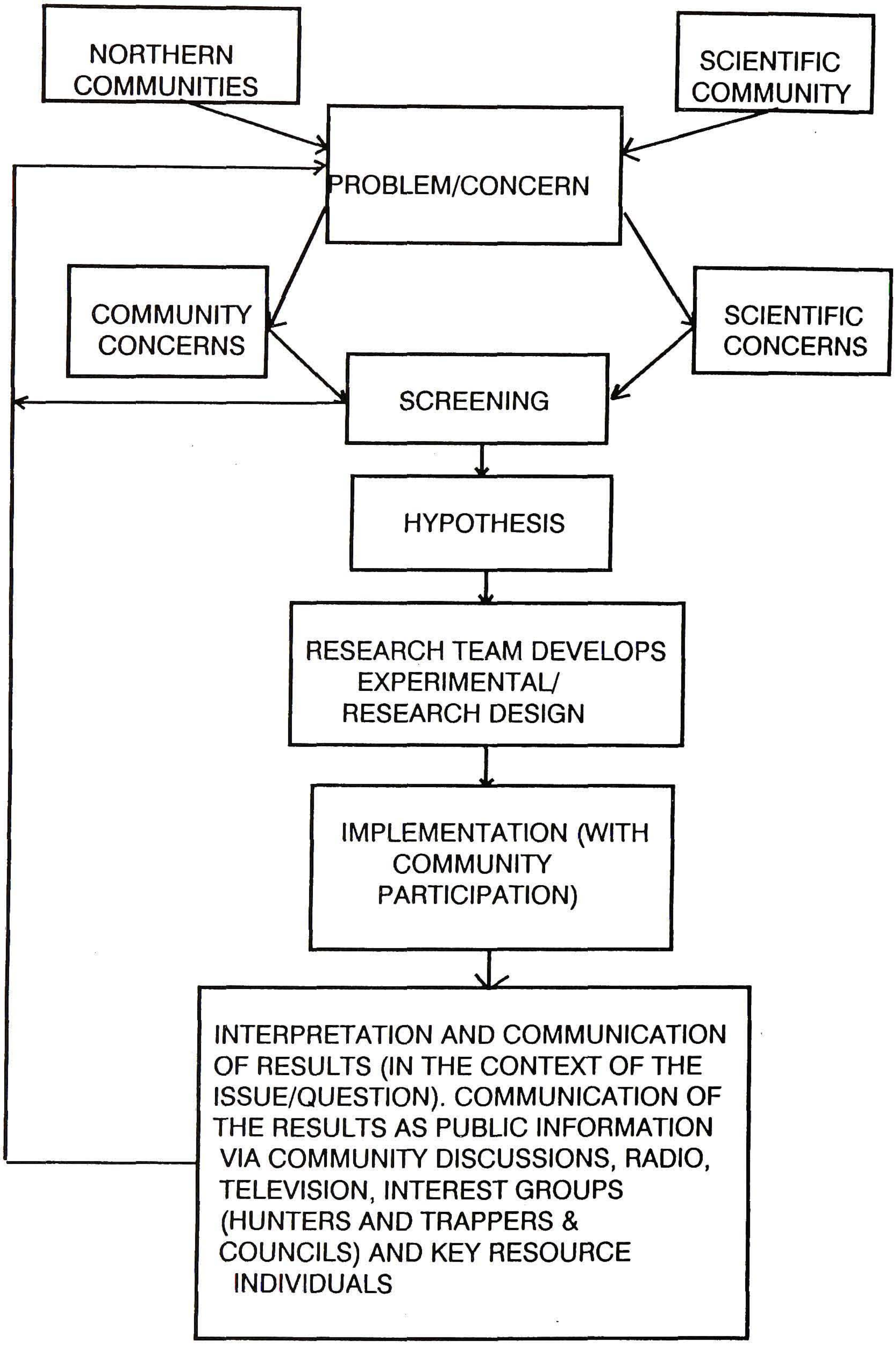
Working Group members agreed that traditional knowledge is different than scientific knowledge but is both important and useful to improving the understanding of the northern environment and enabling better decisions to be made about future hydrocarbon developments. Traditional knowledge can be incorporated into ecological research and monitoring to:

- *improve the design of research and monitoring programs;*
- *provide additional perspectives on the nature of the problem/concern or in the interpretation of research and monitoring results; and*
- *give logistical and practical guidance during the design and conduct of research and monitoring programs.*

Working Group members cited the Beaufort Regional Land Use Plan and Polar Bear Management Agreements as examples of processes that have successfully accessed and incorporated traditional and local knowledge. (Local knowledge is generally defined to be geographic-specific information.) Their success was a result of the high level of trust that was built among the traditional knowledge holders, resource users, researchers/scientists, and resource managers. Trust and consensus are developed over time and with a commitment to involve resource users and traditional knowledge holders at critical stages in agreement negotiations or planning. Polar Bear Management Agreements that have been developed in the Inuvialuit Settlement Region provide a model for similar agreements elsewhere in the N.W.T.

Members of the Community-Based Concerns Working Group developed a model for accessing and incorporating traditional and local knowledge into

A MODEL FOR ACCESSING AND INCORPORATING TRADITIONAL AND LOCAL KNOWLEDGE AND COMMUNITY CONCERNS INTO THE BREAM PROGRAM



decisions related to environmental research and monitoring. The main elements of this model are described in the attached figure and include:

- *recognizing that regional communities and the scientific community can contribute jointly to problem/concern identification;*
- *assurance that problems/concerns are cooperatively considered and screened by northern communities and the scientific community;*
- *a cooperative community and scientific effort in the formulation of the hypothesis/question to be answered;*
- *a cooperative approach between the scientific community and northern communities in developing the experimental/research design;*
- *community participation in the scientific experiment, research study or monitoring activity, and where appropriate, in the interpretation of the results; and*
- *a communications plan which ensures that communities receive and understand the results of the experiment/research.*

***Northern Community Participation**

Members of the Community-Based Concerns Working Group agreed that involvement of northerners in all stages of research, monitoring and assessment will be essential to maximize the acceptance of BREAM. The development of new northern authorities for environmental monitoring and assessment provides the mechanisms for this involvement to occur.

Working Group members also agreed that northern participation in environmental research, monitoring and assessment can be improved through better information sharing at all stages of a research or monitoring project, and by better communicating the results of research and monitoring to the community. When information is obtained from community members during the conduct of scientific research, it is very important that the results of this research be brought back to the community in a readily understandable form, even to the extent of personal communication with the information sources.

Working Group members reiterated that community people, particularly elders and resource harvesters, think about the environment and its resources in holistic terms. It is difficult for community people to communicate their ecological concerns in the absence of social and economic issues. While BREAM does not address social and economic concerns associated with hydrocarbon development, Working Group members believe that there should be a linkage to those processes which do address these issues to ensure complete communication with northern communities.

***Existing Sources of Community-Based Ecological Concerns**

Members of the Working Group identified a number of information sources that list and/or discuss community-based ecological concerns related to hydrocarbon activity. The most recent documentation of these concerns includes:

-Inuvialuit Game Council Harvest Studies;
-Community Conservation Plans for communities in the Inuvialuit Settlement Region (completed and draft documents are available for Paulatuk, Sachs Harbour and Tuktoyaktuk);
-the Land Use Plan for the Mackenzie Delta-Beaufort Sea Region;
-the Mackenzie Delta-Beaufort Sea Land Use Issues Document;
-preliminary Sahtu Region Land Use Issues Document; and
-the Environmental Atlas for Beaufort Sea Oil Spill Response.

Working Group members concluded that documentation of community-based ecological concerns is relatively comprehensive for the Beaufort, Mackenzie Delta and Mackenzie Valley Regions (Beaufort Sea south to Norman Wells). However, very few concerns have been documented for the south Mackenzie Valley regions of Deh Cho, North Slave and South Slave. Efforts to centralize and manage resource and land use data are ongoing by Indian and Northern Affairs Canada (INAC) and the Department of Renewable Resources, G.N.W.T. Much of the data has been digitized/computerized and is available through these government agencies. Working Group members suggested that existing documentation related to community-based concerns should be stored and accessible in a central location in the Northwest Territories. The nature of the information that does exist should be communicated to the various interests.

iii) Social and Economic Concerns

While the scope of BREAM is limited to environmental concerns associated with hydrocarbon development, members of the Working Group emphasized that northern people do not necessarily categorize their concerns by discipline. This was demonstrated throughout the meeting, as socio-cultural and economic issues and concerns were part of most discussions. Particular socio-economic concerns raised by the Working Group include:

- *a need to train and employ more northerners in all aspects of scientific and traditional knowledge research occurring in the community, and*
- *a need to continue research and monitoring related to the cumulative impact of increased populations associated with the development of infrastructure (i.e. temporary or permanent roads, pipeline corridors facilitating improved access to harvest areas, improved level of harvest effort and subsequent resource loss).*

Working Group members stressed that because socio-economic matters are outside the scope of BREAM, a parallel process should be established to address these concerns.

SUGGESTED FOLLOW-UP

Members of the Community-Based Concerns Working Group suggested follow-up to the first meeting of this technical group. The following actions were suggested.

1. Confirm northern participants for the Interdisciplinary Workshop (responsibility - Lutra Associates Ltd.)

2. Continue efforts to prepare and involve the Deh Cho region in the Community-Based Concerns Working Group and other aspects of BREAM (responsibility - Lutra).

3. Pursue discussions to identify and link BREAM with a parallel process to address social and economic concerns associated with hydrocarbon development (responsibility - INAC and territorial governments).

4. Complete a review of existing publications to assess the extent of documented community-based ecological concerns (responsibility - Lutra).

5. Improve communications with communities by expanding the distribution of BREAM project updates (responsibility-INAC).

ATTACHMENT A:

AN OVERVIEW OF THE BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM (BREAM)

This paper:

1. gives some background on BREAM,
2. identifies the players in BREAM,
3. describes the BREAM process,
4. identifies how BREAM differs from past programs with similar objectives, and
5. describes future oil and gas development scenarios.

1. BACKGROUND TO BREAM

There continues to be concern that oil and gas development activities in the Beaufort Sea, Mackenzie Delta, and Mackenzie Valley may effect the natural environment. What these effects may be and how they can be assessed have been matters that northern communities, oil and gas industry representatives, governments and scientists have wrestled with since the 1970s. All of these groups agree that broadening the understanding of the northern environment through research and monitoring programs, can:

- **enable better decisions to be made about oil and gas developments, and**
- **improve environmental assessments of these activities.**

These were the main reasons for creating the Beaufort Region Environmental Assessment and Monitoring Program (BREAM).

BREAM has evolved from years of effort to identify and understand the effects that oil and gas exploration, production and/or transportation activities might have on the natural environment and harvest of wildlife resources. Two earlier programs also had these goals:

- **1) the Beaufort Environmental Monitoring Project (BEMP) started by Indian and Northern Affairs Canada and Environment Canada in 1983 to guide monitoring in the off-shore marine environment; and**
- **2) the Mackenzie Environmental Monitoring Program (MEMP) begun in 1985 by the Federal and Territorial Governments in Yukon and the NWT to guide monitoring of the terrestrial and freshwater environment of the Mackenzie Valley and Delta.**

The research and monitoring programs carried out as a result of BEMP and MEMP recommendations have created a better understanding of the environmental impact of some oil and gas development activities on the natural environment. The work accomplished by BEMP and MEMP provides much of the foundation upon which BREAM is built.

BEMP and MEMP have been inactive since 1986. In the last five years, a number of events have occurred:

- **joint management structures legislated in the Inuvialuit Final Agreement (IFA) ensure that the Inuvialuit's concerns are reflected in environmental assessments and hydrocarbon development decisions. Federal Government approval of the Gwich'in Final Agreement (GFA) and a potential land settlement in the Sahtu Region will provide these same guarantees for the Dene/Metis from Fort Norman to Inuvik.**

- **new oil and gas development issues were identified by the Beaufort Sea Steering Committee (BSSC), the Environmental Impact Review Board (EIRB) established under the IFA, and the Mackenzie Delta-Beaufort Sea Regional Land Use Planning Commission.**

- **new information on oil spill behaviour, clean-up, biodegradation and impacts have been identified as a result of oil spills in British Columbia and Alaska.**

- **planning by six major oil and gas producing and pipeline companies toward the construction of a Mackenzie Delta /Valley natural gas or oil pipeline by the end of the 1990s, continues.**

Important events such as these have influenced our understanding of the impacts of oil and gas developments or how these impacts can be assessed, and demonstrated a need for further environmental research, monitoring and assessment. To meet these needs, BEMP and MEMP were combined in 1990/91 to form BREAM. BREAM will reflect new information and recent changes in environmental assessment responsibilities/processes, and better coordinate and link efforts in the Beaufort and the Mackenzie Delta/ Valley.

2. BREAM PLAYERS

BREAM is funded through the Federal Government's Northern Oil and Gas Action Program (NOGAP). During 1990/91, the Federal agencies of Indian and Northern Affairs Canada, Environment Canada, and the Department of Fisheries and Oceans participated in BREAM. Other participants in BREAM were:

-Fisheries Joint Management Committee
-Government of the N.W.T.
-Government of Yukon
-Esso Resources Canada
-Gulf Canada Resources
-Amoco Canada Petroleum
-Chevron Canada Resources
-Polar Gas
-Foothills Pipeline
-the scientific community in northern and southern Canada.

An even greater number of agencies and individuals will be involved in BREAM in 1992. For example, the Community-Based Concerns Working Group will add representatives from communities/ regions from the Alberta-NWT border to the Beaufort Sea.

3. THE BREAM PROCESS

BREAM is a process for identifying research that must be done to fill important information/data gaps; unlike earlier programs, it also has an environmental assessment component.

There are four BREAM objectives:
"1) to review and evaluate assessment needs for decision-making, the state of knowledge related to scientific and community-based concerns, and the hydrocarbon development and transportation scenario for the region,
2) to establish the necessary lines of communication, consultation and participation between BREAM, government, industry and local communities,
3) to provide the focus for what needs to be known for assessment purposes and to make decisions through establishment of a prioritized list of necessary research and monitoring activities, and
4) to create the iterative process and framework to achieve the above objectives."

Because BREAM is an extension of BEMP and MEMP, it uses the same basic framework and methodology. Impact hypotheses are at the heart of BREAM. An impact hypothesis is a set of statements that link hydrocarbon development activities with their potential environmental effects. An impact hypothesis is created by developing conceptual models or assumptions about the effects of oil and gas developments on the people and environmental resources of the area. Every impact hypothesis has three parts:

- **1. the action: that which is the potential cause of an effect;**
- **2. the valued ecosystem component (VEC): that which is the measure of effect; and**

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. Examples of VECs include populations, harvests and quality of a number of species of birds, fish and mammals.

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

Through MEMP, 25 impact hypotheses were developed and evaluated in interdisciplinary workshops. BEMP produced and examined another 21 impact hypotheses focusing on the offshore Beaufort Sea.

The BREAM process also provides the framework for testing each impact hypothesis. This is done through research and monitoring, both of which are designed to:

- **measure environmental impacts, and**
- **analyse cause-effect relationships.**

Monitoring is the repetitive measurement of those VECs that are likely to change due to direct or indirect effects of development activity rather than as a result of natural variability.

BREAM is an iterative process, meaning that BREAM players regularly meet to discuss research and monitoring activities and results, and to make recommendations for the future including directions for the process itself. In this way, new information can be taken into account and the understanding of all the players can be improved.

4. BREAM DIFFERS FROM PAST PROCESSES

BREAM will differ from BEMP and MEMP in four ways.

First, BREAM will consider new VECs. For example, coastlines were not a VEC in BEMP. But due to the Exxon Valdez spill in Alaska and other events, BREAM will consider research and monitoring programs related to a major well blowout from an offshore drilling program, and an oil pipeline rupture that effects the Mackenzie River. A Catastrophic Oil Spills Working Group has been struck to look at the research and monitoring programs necessary to understand major oil spills.

Secondly, BREAM will look at ways that community-based ecological concerns can be better reflected in the process. For example, in the past some community concerns may not have been included because they didn't readily fit into an impact hypothesis or could not easily be tested through scientific research and monitoring processes. A Community-Based Concerns Working Group has been struck to consider how these concerns can be better understood, communicated and reflected in BREAM. Even though social issues are important, this Working Group will **not** deal with community-based social concerns. Social concerns are beyond the scope of BREAM.

Thirdly, while BEMP and MEMP both attempted to use traditional and local knowledge in the evaluation of some impact hypotheses, even greater effort will be made to understand and include this knowledge in the BREAM process. The Community-Based Concerns Working Group will address this priority.

> Definitions developed by the NWT Working Group on Traditional Knowledge may help in this work. "*Traditional knowledge is knowledge that derives from, or is rooted in the traditional way of life of aboriginal people. Traditional knowledge is the accumulated knowledge and understanding of the human place in relation to the universe. This encompasses spiritual relationships, relationships with the natural environment and the use of natural resources, relationships between people, and, is reflected in language, social organization, values, institutions and laws. Local knowledge is a body of knowledge specific to a geographic location or period of time and may be intertwined with traditional knowledge.*"

Fourthly, BREAM will deal with research and monitoring as well as environmental assessment in contrast to MEMP and BEMP which dealt only with research and monitoring. Broadening the focus of BREAM will enable research and monitoring information to be strongly linked to environmental assessment processes and information requirements. As a result, the quality and efficiency of environmental assessments should be improved.

BREAM can identify the information needed to enable northern residents, oil and gas companies, and public and aboriginal government agencies to make better decisions about hydrocarbon development.

5. FUTURE OIL AND GAS DEVELOPMENT SCENARIOS

Excerpts from the **1990/91 Beaufort Region Environmental Assessment and Monitoring Project** report describing future oil and gas exploration, production and transportation scenarios are attached for information purposes. Obviously, these scenarios can change but updates are part of the BREAM process.

COMMUNITY-BASED CONCERNS WORKING GROUP PARTICIPANTS

The following organizations have been invited to participate in the Community-Based Concerns Working Group Meeting in Yellowknife, February 19 and 20, (if required) at the Northern Frontier Visitors Centre Boardroom across from the Explorer Hotel.

-Gwich'in Tribal Council
-Joint Secretariat
-Inuvialuit Game Council
-Beaufort Mackenzie Delta DIZ Society
-Sahtu DIZ/Shihta Regional Council
-Deh Cho Regional Council
-GNWT Dept. of Renewable Resources
-GNWT Dept. of Energy, Mines & Petroleum Resources
-Oil and Gas Industry Representative
-Indian and Northern Affairs Canada
-Environment Canada
-Fisheries and Oceans Canada
-Axys Environmental Consultants
-ESSA Environmental & Social Systems Analysts
-North/South Consultants
-Lutra Associates

Meetings of the other technical working groups are scheduled as follows:

*Impact Hypothesis Working Group: January 28-30, 1992

*Catastrophic Oil Spill Working Group: January 30,1992

*Impact Hypothesis Interdisciplinary Workshop: February 26-28, 1992

ATTACHMENT B:

BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM (BREAM)

COMMUNITY-BASED CONCERNS WORKING GROUP: TERMS OF REFERENCE

What is BREAM?

BREAM is a process for identifying research that will broaden our understanding of the impacts of oil and gas developments on the northern environment. (See Overview paper on BREAM.)

What is the Community-Based Concerns Working Group?

The Community-Based Concerns Working Group is one of three (3) technical groups involved in the Beaufort Region Environmental Assessment and Monitoring (BREAM) program. The other two groups are: the Impact Hypothesis Working Group and the Catastrophic Oil Spill Working Group.

In February 1992, the Community-Based Concerns Working Group will meet for the first time. The Working Group will be made up of representatives from six regional organizations from the NWT-Alberta border to the Beaufort Sea. Representatives will be familiar with hydrocarbon development activities and their relationship to the ecology of their region. Federal Government, Government of the NWT, and oil and gas industry representatives with similar interests will also join the Working Group. The Community-Based Concerns Working Group will be supported by consultants from northern and southern Canada. In total, the size of the Working Group should not exceed 15 people to ensure that it operates efficiently.

[illegible] of each of the three technical working groups will have the same end result - **to broaden the understanding of the northern environment through the identification of research and monitoring programs to improve future environmental assessments of oil and gas activities in the western NWT.** Each of the three technical working groups will contribute to this goal in a different way. As its name suggests, the **Community-Based Concerns Working Group will identify ecological issues and concerns** that NWT community/regional people believe should be included in future environmental assessments of hydrocarbon activities. (Ecological should be understood as the relationship of living things/organisms to their natural environment and to each other.)

The Work of the Community-Based Concerns Working Group in 1991/92

The Community-Based Concerns Working Group will have an important role in both the immediate and longer term. In the longer term, the Working Group will contribute to the development of a comprehensive environmental information (data) base that will enable thorough environmental assessments of future hydrocarbon development activities in the NWT. This will be accomplished through research and monitoring projects, and the strengthening of processes for communicating and discussing research and monitoring results and activities.

The immediate tasks of the Community-Based Concerns Working Group will be completed before March 31, 1992. Over the next few weeks, the Working Group will:

- *1. develop a good understanding of the BREAM process and its role in environmental assessment(s) of future oil and gas developments,*
- *2. explore the types of and the extent of community-based ecological issues and concerns which should be considered in future environmental assessments of oil and gas developments in the region,*
- *3. identify work priorities for the Community-Based Concerns Working Group for 1992/93, and*
- *4. enable representatives of the Community-Based Concerns Working Group to participate in an Impact Hypothesis Interdisciplinary Workshop in Vancouver, February 26-28,1992.*

How the Work of the Community-Based Concerns Working Group Will Be Accomplished.

TASK 1: *Develop a good understanding of the BREAM process and its role in environmental assessment(s) of future oil and gas developments.*
TIMEFRAME: *Prior to February 19-20, 1992*

Regional/organizational representatives should familiarize themselves with BREAM prior to attending the first meeting of the Community-Based Concerns Working Group in Yellowknife on February 19-20,1992. An overview paper of the BREAM program is attached for this purpose. The paper provides a background to BREAM, identifies BREAM's players, describes the BREAM process, identifies how BREAM differs from its predecessors, BEMP and MEMP, and provides information on future oil and gas development scenarios. Matters arising from the overview paper requiring clarification and/or further discussion will be addressed at the February meeting. In the meantime, regional/organizational representatives can contact Lois Little at Lutra in Yellowknife (phone 873-8903: fax 873-8368) or Wayne Duval at Axys in Vancouver (phone 604-687-3385: fax 687-0171) to get further information or clarification.

TASK 2: *Explore the types of and the extent of community-based ecological issues and concerns which should be considered in future environmental assessments of oil and gas developments in the region.*
TIMEFRAME: *Ongoing*

Each member of the Community-Based Concerns Working Group should be prepared to discuss with some confidence, those ecological issues/concerns of importance to the people they represent. This discussion will take place at the Working Group's first meeting in February in Yellowknife and will continue at the Interdisciplinary Workshop in Vancouver. Community-based ecological issues/concerns related to future oil and gas developments could include:

- *changes to/loss of wildlife/fisheries habitat,*
- *disturbances to/displacement of wildlife/fisheries,*
- *changes in wildlife/fisheries harvesting, or*
- *loss of/changes to water quality.*

While many issues of this type have been the focus of previous environmental reviews, they remain a concern. These issues and the reasoning behind them will be discussed during the February workshop.

In addition to the issues identified above, community-based ecological concerns may relate to:

- *how traditional knowledge is recognized in ecological research and monitoring projects,*
- *how northern people are involved in research and monitoring projects, and in environmental assessments, or*
- *how ecological research and monitoring activities are communicated to and among northern people.*

Prior to attending the February meeting in Yellowknife, Working Group members should speak with knowledgeable people in their regions to identify ecological issues/concerns that should be considered as part of BREAM. <u>A one page, written summary</u> of these discussions should be available for distribution to other Working Group members.

This written summary should identify:

1. the agencies/individuals contacted in your region/organization,

2. the main ecological concerns/issues related to future hydrocarbon developments in the Beaufort and Mackenzie Delta/Valley, and

3. suggestions for improving future environmental research and monitoring activities.

TASK 3: *Identify work priorities for the Community-Based Concerns Working Group for 1992/93.*
TIMEFRAME: *at the Community-Based Working Group meeting, Yellowknife February 19-20,1992* (session will be extended to the 20th if required)

Emphasis this year (1991/92) in BREAM has been placed on careful planning of the focus of activities in subsequent years. The knowledge that representatives bring to the Community-Based Concerns Working Group meeting in Yellowknife is critical to determining work priorities for 1992/93. Future community based meetings and workshops will be necessary to ensure the success of BREAM.

TASK 4: *Enable representatives of the Community-Based Concerns Working Group to participate in an Impact Hypothesis Interdisciplinary Workshop in Vancouver, February 26-28,1992.*
TIMEFRAME: *at the Impact Hypothesis Interdisciplinary Workshop, Vancouver, February 26-28, 1992*

A three-day Interdisciplinary Workshop this year will involve representatives from each of the three technical working groups - the Community-Based Concerns Working Group, the Impact Hypothesis Working Group, and the Catastrophic Oil Spill Working Group. The purpose of the Workshop will be to re-evaluate existing impact hypotheses and examine new hypotheses that have been developed by the Impact Hypothesis Working Group. This work will enable research and monitoring needs for the next few years to be identified.

Representatives from the Community-Based Concerns Working Group will actively participate in this workshop, bringing forth the ecological issues/ concerns, and research and monitoring priorities that the Group has identified. In preparation for the Interdisciplinary Workshop, Community-Based Concerns Working Group members will be asked to review a summary of existing and new impact hypotheses.

ATTACHMENT C:

COMMUNITY-BASED CONCERNS TECHNICAL WORKING GROUP
PLANNING MEETING

Yellowknife, N.W.T.
February 19-20,1992

Participants:

David Krutko,	Gwich'in Tribal Council
Bruce Hanbidge,	Joint Secretariat
Charlie Haogak,	Inuvialuit Game Council
Sheila Nasogaluak,	Beaufort Mackenzie DIZ Society
Frank Pope,	Sahtu DIZ/Shihta Regional Council
Steve Matthews,	Department of Renewable Resources, GNWT
Heather Myers,	Department of Renewable Resources, GNWT
Helena Laraque,	Department of Renewable Resources, GNWT
Lorne Matthews,	Energy Mines and Petroleum Resources, GNWT
Rick Hoos,	Polar Delta Project
Brian Herbert,	Indian and Northern Affairs
Wayne Duval,	Axys Environmental Consulting Ltd.
Dave Bernard,	ESSA Environmental and Social Systems Analysts Ltd.
Stuart Davies,	North/South Consultants Inc.
Lois Little,	Lutra Associates Ltd.
Bob Stephen,	Lutra Associates Ltd.

ATTACHMENT D:

PLANNING MEETING AGENDA

Community-Based Concerns
Technical Working Group
19-20 February 1992
Northern Frontier Visitor's Centre, Yellowknife, N.W.T.

WEDNESDAY, 19 FEBRUARY

09:00	Welcome and Introductions (Lois Little)
09:15	Overview of Background to BREAM (Wayne Duval)
09:45	Planning Meeting Objectives and Process (David Bernard)
10:00	Coffee Break
10:15	Process Discussions • Accessing and Incorporating Traditional Knowledge • Identifying and Registering Ecologically- or Natural Resource-Based Community Concerns
Noon	Lunch Break
13:00	Current Community-Based Concerns • Gwich'in Tribal Council • Joint Secretariat • Inuvialuit Game Council
15:00	Coffee Break
15:15	Current Community-Based Concerns (Continued) • Beaufort Mackenzie DIZ Society • Sahtu DIZ/Shihta Regional Council • Deh Cho Regional Council
17:00	Break for Day

THURSDAY, 20 FEBRUARY

09:00	BREAM Hypotheses - Current Status and Focus of Next Workshop
10:30	Coffee Break
10:45	Where We Go From Here
12:00	End of Technical Meeting

ATTACHMENT E:

COMMUNITY CONCERNS AND ISSUES (Tabled Summaries)

1. SHIHTA REGIONAL COUNCIL/SAHTU DEVELOPMENT IMPACT ZONE COMMITTEE presented by Frank Pope

Task #1:

All materials read and understood, however, it should be pointed out that when discussing Oil and Gas Development, the Environment, Ecology, etc., people in the communities have great difficulty leaving Socio-Economic out of such discussion, as far as most people are concerned they go hand in hand.

Task #2:

The number one concern at this time in our region, especially river communities is pollution from pulp mills. It seems that the concerns from the Norman Wells pipeline in the early 1980's are forgotten, due mainly to no incidents since construction and a stable environment on the route, eg. no Environmental damage, and game is plentiful on the right-of-way.

In Norman Wells there is still concern over what may be buried in the community from ongoing development from the last 70 years and some Canol Construction debris still lays around after 50 years. These issues are now being identified through an Inter-Agency Environmental Committee formed in the community. All the other communities still have concerns from the many hundreds of fuel drums left throughout the region. Our region in the 10-15 years have had a good working relationship with industry, with no major incidents.

Future Environment Assessments must be more of a home grown exercise and not job creation for Southern Environmentals and consultants. Most hearing are just a tool to get the local people's point of views and knowledge and non-local people compile the information for gain. Find a way to have local people do the work in co-ordination with other Northerners to write it up. Let's do future work in the North for the North by Northerners.

2. INUVIALUIT GAME COUNCIL presented by Charlie Haogak

<u>Community Based Concerns</u>

1. Catastrophic oil spill in the Beaufort.
-uncontrolled blow out

*Impact it would have on harvestable resources
-fish, marine mammals, polar bears and seabirds

-habitat

*Impact on harvesters

2. Socio-economic disruption as a result of a catastrophic oil spill

3. Pipelines: East/Wesy Route
-North Slope or adjacent to
-crossing Shallow Bay
-feeder lines -interfering with Beluga

4. Cumulative impact of increase in the number of people associated with the development of infrastructure eg. temporary or permanent roads, pipeline corridors which facilities access to the harvest areas.

5. Effect of increase in ambient noises and traffic (air & sea) on marine mammals.

3. JOINT SECRETARIAT presented by Bruce Hanbidge

<u>Concerns of the Joint Secretariat on the Objectives and Priorities of BREAM</u>

1. There is a need for an adequate and agreed upon baseline for harvestable resource populations, their harvest levels and habitat requirements.

n.b. if the BREAM process accomplishes this and nothing else it will be a major achievement.

2. Next there should be the establishment of relevant monitoring programs, which reliably assess the effects of any industrial activities.

3. Finally there should be direction on the development of adequate wildlife compensation agreements. Specifically one that has the ability to deal with the effects of a catastrophic oil spill.

SUMMARY OF ECOLOGICAL CONCERNS AND RESEARCH OPPORTUNITIES RELATED TO FUTURE HYDROCARBON DEVELOPMENT IN THE BEAUFORT SEA AND MACKENZIE DELTA/VALLEY

BY: NORTH/SOUTH CONSULTANTS INC.

1.0 Agencies and Individuals Contacted

The following individuals were contacted:

Dr. L. Lockhart	D.F.O.; Winnipeg
Mr. M. Lawrence	North/South Consultants Inc.; Hypothesis Working Group (Fish)

2.0 Ecological Concerns/Issues

- tainting of fish from hydrocarbons has been identified as a concern for some time but it was expected that tainting would be short-term and would be more a perceived than a real concern. Recent information indicates that fish with a high degree of fatty tissues, such as inconnu and whitefish, that have been exposed to hydrocarbons, have retained a taint for over 800 hours.

- reduced fish populations resulting from displacement of the species (i.e. avoidance of impacted areas) or from loss of recruitment. This is not considered as important a potential impact as tainting, based largely upon the high degree of uncertainty associated with the impact.

- potential need to temporarily relocate fish harvesting activities to access untainted fish.

- lack of information on location and timing of fish harvesting activities. The Beaufort Sea Steering Committee recommended that this be incorporated into the IGC harvest data study.

3.0 RESEARCH AND MONITORING OPPORTUNITIES

- if reductions in fish populations occur due to loss of recruitment it will not be detected in the harvest until the affected year class becomes susceptible to harvest gear. Comprehensive, long-term studies will be required to differentiate between project induced impacts and natural variation.

- if tainting of fish occurs, the harvesters will be given the opportunity (as per IFA) of relocating their harvesting to alternate sites. A need to identify and document these sites, and sites currently being harvested, is required. Computerized data management systems that have been developed to catalogue fish habitat information should be used as a basis for documenting, and routinely updating, both local knowledge and published information.

APPENDIX D

TABLED SUMMARIES OF COMMUNITY CONCERNS AND ISSUES

COMMUNITY CONCERNS AND ISSUES (Tabled Summaries)

1. SHIHTA REGIONAL COUNCIL/SAHTU DEVELOPMENT IMPACT ZONE COMMITTEE presented by Frank Pope

Task #1:

All materials were read and understood; however, it should be pointed out that when discussing oil and gas development, the environment, ecology, etc., people in the communities have great difficulty leaving socio-economic factors out of such discussions. As far as most people are concerned, they go hand in hand.

Task #2:

The most important concern in our region at this time, especially for river communities, is pollution from pulp mills. It seems that the concerns from the Norman Wells pipeline in the early 1980s are forgotten, due mainly to the lack of incidents since construction and a stable environment on the route (e.g., no environmental damage, and an abundance of game on the right-of-way).

In Norman Wells there is still concern over what may be buried in the community from ongoing development from the last 70 years and some Canol Construction debris still lies around after 50 years. These issues are now being identified through an Inter-Agency Environmental Committee formed in the community. All the other communities still have concerns from the many hundreds of fuel drums left throughout the region. Our region in the 10-15 years has had a good working relationship with industry, with no major incidents.

Future environmental assessments must be more of a home-grown exercise and not one of job creation for Southern environmentalists and consultants. Most hearings are just a tool to get the local peoples' point of views and knowledge, and non-local people compile the information for gain. Find a way to have local people do the work in co-ordination with other Northerners to write it up. Let's do future work in the North for the North by Northerners.

2. INUVIALUIT GAME COUNCIL presented by Charlie Haogak

Community Based Concerns

1. Catastrophic oil spill in the Beaufort.
   - uncontrolled blow out

   *Impact it would have on harvestable resources
   - fish, marine mammals, polar bears and seabirds
   - habitat

   *Impact on harvesters

2. Socio-economic disruption as a result of a catastrophic oil spill

3. Pipelines: East/West Route
   - North Slope or adjacent to
   - crossing Shallow Bay
   - feeder lines - interfering with Beluga

4. Cumulative impact of increase in the number of people associated with the development of infrastructure (e.g., temporary or permanent roads, pipeline corridors which facilities access to the harvest areas).

5. Effect of increase in ambient noises and traffic (air and sea) on marine mammals.

3. JOINT SECRETARIAT presented by Bruce Hanbridge

Concerns of the Joint Secretariat on the Objectives and Priorities of BREAM

1. There is a need for an adequate and agreed-upon baseline for harvestable resource populations, their harvest levels and habitat requirements.

   n.b. if the BREAM process accomplishes this and nothing else, it will be a major achievement.

2. Next, there should be the establishment of relevant monitoring programs, which reliably assess the effects of any industrial activities.

3. Finally, there should be direction on the development of adequate wildlife compensation agreements. Specifically, one that has the ability to deal with the effects of a catastrophic oil spill.

APPENDIX E

A CATALOG OF CRUDE OIL AND OIL PRODUCT PROPERTIES

A CATALOGUE OF CRUDE OIL AND OIL PRODUCT PROPERTIES
(1990 version)

by:

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Environment Canada
Environmental Protection Directorate
River Road Environmental Technology Centre
Ottawa K1A 0H3

EE-125 September, 1990

ADGO CRUDE OIL

1.0 TYPE: Adgo Crude Oil

2.0 API GRAVITY (15/15°C): 16.8 (EETD 84)

3.0 DENSITY (g/mL):

TEMP			WEATHERING		
(°C)	0	2.6(vol%)	4(%)	5.4(vol%)	12(%)
0	0.9590 (EETD 84)	0.9620 (EETD 84)		0.9672 (EETD 85)	
15	0.9530 (EETD 84)	0.9600 (EETD 84)		0.9572 (EETD 85)	
20	0.9520 (ESSO 83)		0.9526 (ESSO 83)		0.9546 (ESSO 83)

4.0 VISCOSITY:

4.1 DYNAMIC VISCOSITY (mPa.s or cP):

TEMP			WEATHERING (VOL %)
(°C)	0	2.6	
0	165.0 (EETD 84)	220.0 (EETD 85)	
15	61.6 (EETD 84)	73.0 (EETD 85)	

ADGO CRUDE OIL

4.2 KINEMATIC VISCOSITY (mm^2 / sec or cSt):

TEMP (°C)	0	2.6(vol%)	WEATHERING 4(%)	12(%)
-10	661.3 (ESSO 83)	724.5 (ESSO 83)	1302.0 (ESSO 83)	
0	172.1 (ESSO 83)	228.7 (EETD 85)	263.6 (ESSO 83)	413.8 (ESSO 83)
15	64.6 (ESSO 83)	76.0 (EETD 85)	79.08 (ESSO 83)	103.8 (ESSO 83)
25	39.83 (ESSO 83)		42.74 (ESSO 83)	53.58 (ESSO 83)

5.0 INTERFACIAL TENSIONS:

5.1 AIR-OIL (mN/m or dynes/cm):

TEMP (°C)	0	2.6	WEATHERING (VOL%)
0	33.3 (EETD 84)	31.5 (EETD 84)	
15	32.0 (EETD 84)	30.6 (EETD 84)	

5.2 OIL-SEAWATER (mN/m or dynes/cm):

TEMP (°C)	0	2.6	WEATHERING (VOL%)
0	16.8 (EETD 85)	16.8 (EETD 85)	
15	6.9 (EETD 84)	21.5 (EETD 85)	

5.3 OIL-WATER (mN/m or dynes/cm):

TEMP (°C)	WEATHERING (VOL%) 0	2.6
0	25.9 (EETD 85)	22.6 (EETD 85)
15	24.9 (EETD 84)	22.2 (EETD 85)

6.0 POUR POINT (°C):

WEATHERING (%)	POUR POINT (°C)
0	-26 (ESSO 83)
4	-26 (ESSO 83)
12	-26 (ESSO 83)

7.0 FLASH POINT (°C):

WEATHERING (%)	FLASH POINT (°C)
0	95 (ESSO 83)
4	94 (ESSO 83)
12	126 (ESSO 83)

8.0 VAPOUR PRESSURE (kPa): N/M (EETD 84)

9.0 DISTILLATION DATA (°C):

VOLUME PERCENT	WEATHERING(%) 0	4	12
INITIAL BP	159(ESSO 83)	170(ESSO 83)	205(ESSO 83)
50	329 (ESSO 83)	326(ESSO 83)	348(ESSO 83)
FINAL BP	535(ESSO 83)	542(ESSO 83)	538(ESSO 83)
FINAL VOL.	93%(ESSO 83)	96%(ESSO 83)	87%(ESSO 83)

10.0 EMULSION FORMATION TENDENCY AND STABILITY:

10.1 EMULSION FORMATION TENDENCY:

TEMP (°C)	0	WEATHERING (VOL %) 2.6	5.4
0	0.61(EETD 84)	0.72(EETD 84)	
15	0(EETD 85)	0(EETD 85)	0(EETD 85)

10.2 EMULSION STABILITY:

TEMP (°C)	0	WEATHERING (VOL %) 2.6	5.4
0	0.95(EETD 84)	0.96(EETD 84)	
15	0(EETD 85)	1.00(EETD 85)	0.79(EETD 85)

10.3 WATER CONTENT OF STABLE EMULSION (VOLUME %):

TEMP (^oC)	WEATHERING (VOL %) 0	2.6	5.4
0	71.5(EETD 84)	73.8(EETD 84)	
15	N/M(EETD 85)	77.1(EETD 85)	78.2(EETD 85)

11.0 WEATHERING:

$$Fv = \frac{\ln(1 + 2012.6\ \theta \exp(6.3 - 5675.3/T_k)/T_k)}{(2012.6/T_k)}$$

Where: Fv is fraction of oil weathered by volume
ln is natural log
θ is evaporation exposure
exp is exponential base e
T_k is environmental temperature (Kelvin, K = ^oC + 273)
(EETD 84)

12.0 DISPERSIBILITY:

12.1 CHEMICAL DISPERSIBILITY (% DISPERSED):

DISPERSANT	% EFFECTIVENESS
C9527	61
CRX-8	39
ENER 700	59
DASIC	8(FINGAS 90)

12.2 NATURAL DISPERSIBILITY @15^oC (% DISPERSED): 10(FINGAS 90a)

ADGO CRUDE OIL

13.0 HYDROCARBON GROUP ANALYSIS (WT %):

		WEATHERING (VOLUME %)
	0	2.6
SATURATES	79.8	
AROMATICS	18.8	
POLARS	0.9	
ASPHALTENES	0.5(EETD 85) 0.59(EETD 89)	0.83(EETD 89)

14.0 WAX CONTENT (WT %):

WEATHERING (VOLUME %)	WAX (WT %)
0	0.88(EETD 89)
2.6	1.42(EETD 89)

15.0 AQUEOUS SOLUBILITY:

16.0 TOXICITY:

17.0 SULPHUR (WT %):

WEATHERING (VOLUME %)	SULPHUR (WT %)
0	0.19(EETD 86)
5.4	0.21(EETD 86)

18.0 OTHERS:

18.1 FIRE POINT (°C):

WEATHERING (%)	FIRE POINT (°C)
0	116(ESSO 83)
4	123(ESSO 83)
12	129(ESSO 83)

AMAULIGAK CRUDE OIL

1.0 TYPE: Amauligak Crude Oil.

2.0 API GRAVITY: 27.4(15/15°C)(EETD 85)

3.0 DENSITY (g/mL): For Fv < 19.4 % & T between 0 and 15 °C:
DEN = 0.900496 + 0.000717 Fv - 0.000698 T
where: DEN is density of oil at T and Fv (g/mL)
Fv is volume percent of oil weathered
T is oil temperature (°C)

TEMP (°C)	WEATHERING (VOL %) 0	13.4	19.4
0	0.9014(EETD 85)	0.9090(EETD 85)	0.9146(EETD 85)
15	0.8896(EETD 85)	0.8992(EETD 85)	0.9048(EETD 85)

4.0 VISCOSITY:

4.1 DYNAMIC VISCOSITY (mPa.s or cP):

TEMP (°C)	WEATHERING (VOL %) 0	13.4	19.4
0	25.0(EETD 85)	41.9(EETD 85)	67.5(EETD 85)
15	14.0(EETD 85)	21.0(EETD 85)	32.2(EETD 85)

4.2 KINEMATIC VISCOSITY (mm^2/sec or cSt):

TEMP (°C)	WEATHERING (VOL %) 0	13.4	19.4
0	27.7(EETD 85)	46.1(EETD 85)	73.8(EETD 85)
15	15.7(EETD 85)	23.4(EETD 85)	35.6(EETD 85)

AMAULIGAK CRUDE OIL

5.0 INTERFACIAL TENSIONS:

5.1 AIR-OIL (mN/m or dynes/cm):

TEMP (°C)	0	WEATHERING (VOL %) 13.4	19.4
0	30.0(EETD 85)	31.1(EETD 85)	31.3(EETD 85)
15	29.2(EETD 85)	29.0(EETD 85)	28.5(EETD 85)

5.2 OIL-SEAWATER (mN/m or dynes/cm):

TEMP (°C)	0	WEATHERING (VOL %) 13.4	19.4
0	21.1(EETD 85)	19.7(EETD 85)	17.8(EETD 85)
15	20.9(EETD 85)	15.0(EETD 85)	15.1(EETD 85)

5.3 OIL-WATER (mN/m or dynes/cm):

TEMP (°C)	0	WEATHERING (VOL %) 13.4	19.4
0	27.5(EETD 85)	21.6(EETD 85)	20.8(EETD 85)
15	21.5(EETD 85)	20.4(EETD 85)	19.6(EETD 85)

6.0 POUR POINT (°C):

WEATHERING (WT %)	POUR POINT (°C)
0	<-25(EETD 85) -66(EETD 86)
13.4	-48(EETD 86)

7.0 FLASH POINT (°C): 0 (C.C.)(EETD 85)

8.0 VAPOUR PRESSURE:

9.0 DISTILLATION DATA (°C):

VOLUME PERCENT	LIQUID TEMPERATURE	VAPOUR TEMPERATURE
IBP	198	66
5	216	134
10	238	156
15	259	172
20	275	187
25	289	194
29	301	246
	(EETD 85)	(EETD 85)

10.0 EMULSION FORMATION TENDENCY & STABILITY:

10.1 EMULSION FORMATION TENDENCY:

		WEATHERING (VOL %)	
TEMP (°C)	0	13.4	19.4
0	0(EETD 85)	0(EETD 85)	1.0(EETD 85)
15	0(EETD 85)	0(EETD 85)	0(EETD 85)

10.2 EMULSION STABILITY:

		WEATHERING (VOL %)	
TEMP (°C)	0	13.4	19.4
0	0.29(EETD 85)	0.13(EETD 85)	0.78(EETD 85)
15	0(EETD 85)	0(EETD 85)	0(EETD 85)

AMAULIGAK CRUDE OIL

10.3 WATER CONTENT OF STABLE EMULSION (VOLUME %):

TEMP (°C)	WEATHERING (VOL %) 0	13.4	19.4
0	91.3(EETD 85)	92.0(EETD 85)	78.8(EETD 85)
15	N/M(EETD 85)	N/M(EETD 85)	N/M(EETD 85)

11.0 WEATHERING:

$$Fv = \frac{\ln(1 + 3811\,\Theta\,\exp(6.3 - 4851/T_k)/T_k)}{(3811/T_k)}$$

where: Fv is fraction of oil weathered by volume
ln is natural log
Θ is evaporation exposure
exp is exponential base e
T_k is environmental temperature
(Kelvin, K = °C + 273)
(EETD 85)

12.0 DISPERSIBILITY:

12.1 CHEMICAL DISPERSIBILITY (% DISPERSED):

DISPERSANT	%EFFECTIVENESS
C9527	45
CRX-8	50
ENER 700	62
DASIC	28 (FINGAS 90)

12.2 NATURAL DISPERSIBILITY @15°C (% DISPERSED): 8(FINGAS 90a)

13.0 HYDROCARBON GROUP ANALYSIS (WT %):

SATURATES	89.5
AROMATICS	9.3
POLARS	0.4
ASPHALTENES	0.8(EETD 86)
	0.3(EETD 89)

14.0 WAX CONTENT (WT %): 0.9(EETD 89)

AMAULIGAK CRUDE OIL

15.0 AQUEOUS SOLUBILITY (mg/L):

in fresh water @ 22°C:	9.6(SUNTIO 86)
in fresh water:	9.1(MACLEAN 88)
in seawater:	6.54(MACLEAN 88)

16.0 TOXICITY (mg/L):

ACUTE TOXICITY OF WATER SOLUBLE FRACTION TO DAPHNIA MAGNA:

48 hour EC_{50}:	1.66(MACLEAN 88)
	1.8(BOBRA 88)
48 hour LC_{50}:	6.73(MACLEAN 88)
	7.2(BOBRA 88)

ACUTE TOXICITY OF WATER SOLUBLE FRACTION TO ARTEMIA SPP.:

24 hour EC_{50}:	6.40(MACLEAN 88)
	7.54(BOBRA 88)
24 hour LC_{50}:	>6.54(MACLEAN 88)
	>7.7(BOBRA 88)

NOTE: RESULTS FROM (MACLEAN 88) OBTAINED BY FLUORESCENCE SPECTROSCOPY. RESULTS FROM (BOBRA 88) OBTAINED BY PURGE-AND-TRAP GC ANALYSIS.

17.0 SULPHUR (WT %): 0.15(EETD 86)

18.0 OTHERS:

COHASSET CRUDE OIL

1.0 TYPE: Cohasset A-52 Crude Oil, Offshore Nova Scotia.
Data for equilibrium liquid of separator flash test.

2.0 API GRAVITY (15.5/15.5°C): 50.1(PETRO-CAN 87)

3.0 DENSITY (g/mL):

TEMP (°C)	WEATHERING (VOLUME %) 0	11.2	25.6
1	0.8002(EETD 89)	0.8149(EETD 89)	0.8469(EETD 89)
15	0.7900(EETD 89) 0.7789(PETRO-CAN 87)	0.8046(EETD 89)	0.8367(EETD 89)

4.0 VISCOSITY:

4.2 KINEMATIC VISCOSITY (mm^2/sec or cSt):

TEMP (°C)	WEATHERING (VOLUME %) 0	11.2	25.6
1	2.79(EETD 89)	4.05(EETD 89)	7.23(EETD 89)
15	2.06(EETD 89) 0.7789(PETRO-CAN 87)	2.70(EETD 89)	4.83(EETD 89)

5.0 INTERFACIAL TENSIONS:

5.1 AIR-OIL (mN/m or dynes/cm):

TEMP (°C)	WEATHERING (VOLUME %) 0	11.2	25.6
0	25.7(EETD 89)	25.4(EETD 89)	27.4(EETD 89)
15	25.6(EETD 89)	25.2(EETD 89)	26.8(EETD 89)

COHASSET CRUDE OIL

5.2 OIL-SEAWATER (mN/m or dynes/cm):

TEMP (°C)	WEATHERING (VOLUME %) 0	11.2	25.6
0	15.3(EETD 89)	13.1(EETD 89)	12.1(EETD 89)
15	16.5(EETD 89)	12.5(EETD 89)	13.0(EETD 89)

6.0 POUR POINT (°C):

WEATHERING (VOLUME %)	POUR POINT (°C)
0	-30
11.2	-18
25.6	-12

7.0 FLASH POINT (°C):

WEATHERING (VOLUME %)	POUR POINT (°C)
0	32
11.2	40
25.6	82

8.0 VAPOUR PRESSURE:

9.0 DISTILLATION DATA:

COHASSET CRUDE OIL

10.0 EMULSION FORMATION TENDENCY & STABILITY:

10.1 EMULSION FORMATION TENDENCY:

TEMP (°C)	WEATHERING (VOLUME %) 0	11.2	25.6
0	0(EETD 89)	0(EETD 89)	0(EETD 89)
15	0(EETD 89)	0(EETD 89)	0(EETD 89)

10.2 EMULSION STABILITY:

TEMP (°C)	WEATHERING (VOLUME %) 0	11.2	25.6
0	0(EETD 89)	0(EETD 89)	0(EETD 89)
15	0(EETD 89)	0(EETD 89)	0(EETD 89)

10.3 WATER CONTENT OF STABLE EMULSION (VOLUME %):

TEMP (°C)	WEATHERING (VOLUME %) 0	11.2	25.6
0	N/M(EETD 89)	N/M(EETD 89)	N/M(EETD 89)
15	N/M(EETD 89)	N/M(EETD 89)	N/M(EETD 89)

11.0 WEATHERING:

12.0 DISPERSIBILITY:

12.1 CHEMICAL DISPERSIBILITY (% DISPERSED):

DISPERSANT	WEATHERING (VOLUME %)	% EFFECTIVENESS
C9527	0	95
	11.2	96
	25.6	88
	28.1	90(FINGAS 90)

COHASSET CRUDE OIL

12.2 NATURAL DISPERSIBILITY @15°C (% DISPERSED):

WEATHERING (VOLUME %)	% DISPERSED
0	6
11.2	6
25.6	5
28.1	4(FINGAS 90a)

13.0 HYDROCARBON GROUP ANALYSIS (WT %):

WEATHERING (VOLUME %)	ASPHALTENES (WEIGHT %)
0	0.35
11.2	0.24
25.6	0.46
28.1	0.32(EETD 89)

14.0 WAX CONTENT (WT %):

WEATHERING (VOLUME %)	WAX (WT %)
0	0.90
11.2	1.31
25.6	1.20
28.1	1.48(EETD 89)

15.0 AQUEOUS SOLUBILITY:

16.0 TOXICITY:

17.0 SULPHUR:

COHASSET CRUDE OIL

18.0 OTHERS:

18.1 RELATIVE MOLECULAR MASS: 148.2(PETRO-CAN 87)

18.2 COMPOSITIONAL ANALYSIS:

COMPONENT	MOLE FRACTION	MASS FRACTION	VOLUME FRACTION
N_2	0.0000	0.0000	0.0000
CO_2	0.0000	0.0000	0.0000
H_2S	0.0000	0.0000	0.0000
C_1	0.0032	0.0003	0.0009
C_2	0.0007	0.0001	0.0003
C_3	0.0020	0.0006	0.0009
iC_4	0.0023	0.0009	0.0012
C_4	0.0032	0.0013	0.0017
iC_5	0.0090	0.0044	0.0055
C_5	0.0108	0.0053	0.0065
C_6	0.0589	0.0337	
C_7	0.0969	0.0646	
C_8	0.1288	0.0979	
C_9	0.0819	0.0699	
C_{10}	0.0894	0.0846	
C_{11}	0.0722	0.0750	
C_{12}	0.0583	0.0661	
C_{13}	0.0529	0.0649	
C_{14}	0.0451	0.0595	
C_{15}	0.0400	0.0565	
C_{16}	0.0285	0.0430	
C_{17}	0.0241	0.0385	
C_{18}	0.0167	0.0282	
C_{19}	0.0132	0.0235	
C_{20}	0.0102	0.0191	
C_{21}	0.0086	0.0170	
C_{22}	0.0070	0.0144	
C_{23}	0.0049	0.0106	
C_{24}	0.0040	0.0091	
C_{25}	0.0032	0.0076	
C_{26}	0.0024	0.0059	
C_{27}	0.0022	0.0056	
C_{28}	0.0014	0.0037	
C_{29}	0.0010	0.0028	
C_{30+}	0.0031	0.0102	

COHASSET CRUDE OIL

18.2 COMPOSITIONAL ANALYSIS continued:

AROMATICS:

COMPONENT	MOLE FRACTION	MASS FRACTION	VOLUME FRACTION
C_6H_6	0.0014	0.0007	
C_7H_8	0.0071	0.0044	
C_8H_{10}	0.0234	0.0166	
C_8H_{10}	0.0102	0.0072	
C_9H_{12}	0.0090	0.0072	
NAPHTHENES:			
C_5H_{10}	0.0037	0.0017	
C_6H_{12}	0.0073	0.0041	
C_6H_{12}	0.0054	0.0030	
C_7H_{14}	0.0464	0.0303 (PETRO-CAN 87)	

APPENDIX F

RISK, BEHAVIOUR AND EFFECTS OF OIL SPILLS (excerpt)

COHASSET/PANUKE FIELD DEVELOPMENT PROJECT: RISK, BEHAVIOUR AND EFFECTS OF OIL SPILLS

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APRIL 1989

5. IMPACT ASSESSMENT FOR FINFISH AND SHELLFISH AND THEIR FISHERIES

The potential environmental impact of spills at the Panuke and Cohasset sites are considered in this section. In this treatment we have considered the risks posed by the above hypothetical spills, to the larvae and adults of finfish and shellfish stocks and to the fisheries of the Sable Island Bank. Oil fate information generated above has been used in conjunction with resource sensitivity and vulnerability data, in order to estimate the proportions of each target group that might be threatened in each spill scenario. Impact has been expressed as major, moderate, minor or negligible as previously defined in Mobil Oil Canada (1983).

Detailed and comprehensive assessments of the risk of tainting have been made for fisheries, but assessments of hazards to adults and larval life stages were less complete due to the limited data available concerning the distributions of stocks. For adult fish, tentative assessments have been made for several species (cod, herring, and winter flounder), based on limited distributional data available in Mobil Oil Canada (1983). Estimates of the sizes and locations of areas–of–effect have been reported, in detail, in the form of illustrations and tables, so that more comprehensive assessments can be made quickly when the appropriate spatial data for fish stocks becomes available. Risk estimates for the 0+ age classes of stocks (as planktonic larvae) are at best preliminary, since they are based on very crude assumptions concerning the spatial distributions of larvae. As with adults, detailed information concerning the sizes of areas–of–effect for larvae have been reported, so that better founded risk assessments can be made if larval distribution data becomes available.

In this treatment we have considered only the risks to water column organisms and fisheries because it was originally believed that the condensates produced at these sites would be very highly volatile and non–persistent and hence pose little hazard to seabirds. However, subsequent analysis of the condensates suggest that they would be slightly more persistent than originally believed and results of the oil fate modelling suggest that certain of the larger "worst–case" spills might produce slicks covering several tens of square kilometres. Hence it would be prudent to consider the potential hazard posed by these larger spills to local seabird populations.

Impact assessments for typical spills at the Panuke and Cohasset sites ranged in severity from negligible to moderate for the 0+ age class, from negligible to minor for subadults and adults, and from negligible to minor for fisheries.

5.1 METHODS

The level of risk posed by spills to fish populations or their fisheries has been assessed by estimating: i) the proportion of each fish stock that might be damaged by a given spill; and ii) the proportional reduction in annual yield to a fishery that might result if part of a stock were to become tainted. In all cases, spill impact is estimated using i) model-generated information concerning the fate and movement of oil; ii) data concerning the hydrocarbon concentrations required to cause mortality or tainting; and iii) information concerning the spatial and temporal distributions of resources and fishing activity. Specific methods and assumptions used in estimating impact on larvae, adults, and fisheries are outlined below.

5.1.1 Larvae

Larval life stages of fin- and shellfish are highly sensitive to hydrocarbons (HCs). In addition, larvae of most species are pelagic and may be confined to limited spatial areas by effects of a gyre in the Emerald-Western-Sable Island Bank area, making them vulnerable to the effects of spills in this area. The risks posed by spills to the young-of-the-year age class of fin- and shellfish populations can be assessed by estimating the proportion of the year class that may come into contact with the cloud of dissolved/dispersed oil, while HC concentrations in the cloud are toxic (see Table 21). The level of risk to stocks of larvae depend on i) the size of clouds or plumes of HCs; ii) location of the clouds or plumes in relation to locations of higher larval concentrations; iii) vertical distribution of larvae in the water column; iv) timing of the spill relative to the time of occurrence of larvae in the water column; and v) degree of synchrony of spawning and development of young-of-the-year through the planktonic life stage(s).

TABLE 21

REASONABLE VALUES FOR HYDROCARBON CONCENTRATIONS REQUIRED TO CAUSE EFFECTS IN FISH AND SHELLFISH

Effect	Reasonable Threshold HC Concentrations	Reference
Tainting of fish and shellfish	1 ppm	Ernst et al. 1987, Carter and Ernst 1989
Lethality in larval fish	1ppm	Tilseth et al. 1984, Carls 1987
Lethality in adults (based on rainbow trout assay)	Cohasset 24HLC50 = 3.3 ppm Panuke 24HLC50 = 3.3 ppm	Harris, unpublished

To estimate the risk of spills to young-of-the-year as larvae, oil fate models have been used in conjunction with HC toxicity data to estimate the size and locations of toxic clouds of hydrocarbons generated by batch spills and the width of toxic plumes of hydrocarbons resulting from blowouts. For batch spills, the damage to the young-of-the-year age class can be estimated based on the proportion of the standing stock of larvae that may lie within the toxic cloud. For blowouts damage is estimated based on the proportion of the age class that is entrained into the discharge plume over the duration of the blowout. Since larvae of different species differ in their vertical distribution in the water column, impact estimates have been made based on i) assumed distribution in the upper 10 m of the water column; and ii) assumed uniform distribution throughout the water column.

5.1.2 Sub-Adults and Adults

Risks posed by spills to the sub-adult and adult segments of populations are assessed by estimating the proportions of defined target stocks or populations that might encounter lethal concentrations of hydrocarbons as a result of a spill. For all species it has been assumed that the cloud of dissolved/dispersed hydrocarbons will move and spread from the spill site engulfing all individuals in its path. Individuals are judged to be affected if they come into contact with the cloud while HC concentrations exceed the toxic threshold for adults (See Table 21). For pelagic species, it has been assumed that hydrocarbons are restricted to the upper 10 m of the water column. For demersal species, it has been assumed that hydrocarbons disperse uniformly throughout the water column, surface to bottom (down to 30 m). The areas-of-effect estimated in this way are compared to the spatial distributions of target fish stocks to estimate the proportion of each stock that might lie within the affected area.

Toxicity thresholds for adult fish were estimated based on toxicity tests conducted using rainbow trout exposed to the water-soluble fraction (WSF) of Cohasset and Panuke oils. Test methods and results are described in detail elsewhere. Hydrocarbon concentrations in the exposure medium were estimated using gas chromatographic analysis for water soluble aromatics (benzene, toluene, xylenes, and ethyl benzene (BTEX)).

The results of these tests suggest that LC50 values for the aromatic components of these oils are >0.1 ppm. 0.1 ppm, and 0.9 ppm for Panuke, Cohasset and a standard reference oil Alberta Sweet Mixed Blend, respectively. These values are considerably lower than the LC50 values for any of these toxicants alone (these values lie in the 10–100 ppm range), suggesting that components of the WSF other than BTEX are contributing significantly to the toxicity of the exposure medium.

In the absence of more suitable data, we have assumed a toxic threshold value of 0.1 ppm for the BTEX component of the WSF and have assumed that since BTEX make up roughly 3% (by weight) of fresh Cohasset and Panuke oils, the toxic threshold for these oils, based on the total HC content of the water column (concentrations as output by the oil fate models), would be roughly 3 ppm.

The methods used for estimating the size of the affected area during batch spills is illustrated in Figure 34. As illustrated, the cloud of dissolved/dispersed oil moves, following a zig–zag path, under the influence of tidal and residual currents, while the size of the cloud increases by diffusion. The labelled circles indicate the end–points at which HC concentrations fall below the toxic threshold level. Using this type of model, the estimated size of the affected area is strongly determined by the initial size of the cloud, the initial concentration of hydrocarbon, and the speed of the tidal and residual currents. Since current speeds have been held constant in this application, the size of the areas–of–effect have been influenced largely by the factors that determine initial concentrations of HCs in the clouds including spill size, oil properties, and environmental conditions.

The method used for estimating the size of areas–of–effect during blowouts is illustrated in Figure 35. Although the oil fate model conceptualizes oil fate as a continuous plume, the trajectory model conceptualizes discharges as a series of discrete plumelets or cloudlets, with each successive cloudlet being discharged at a different point in the tidal cycle. The path of a cloudlet discharged on a rising tide is roughly the mirror image of that cloudlet discharged on a falling tide and hence the size of the area affected by a continuous spill is much larger than that of an individual cloudlet. The present model does not allow for shifts in the direction of the prevailing residual current and hence assumes that each successive day's discharge will follow the same path as the previous day's discharge. Thus the estimate of impact on adults and fisheries is independent of blowout duration.

5.1.3 Tainting

The impact of spills on fisheries through tainting is assessed by estimating the proportional reduction in annual yield to a fishery that might result from a spill. The methods used in estimating the risks of tainting are similar to those used in estimating the damage to adults and sub-adults with exception of the following:

i) the exposure threshold for tainting is 1 ppm;

ii) unlike mortality, tainting is a transitory phenomenon and is quickly reversed once the source of contamination is removed. Hence tainting only disrupts fisheries for a month or so following a spill so that damage is proportional to the level of fishing activity at the time of the spill as well as to the annual yield taken in the vicinity of the spill.

For purposes of the present work, the target fisheries have been taken to be the fisheries of NAFO Statistical Zone 4W, that is, the reductions in annual yield to the fisheries are expressed as proportions of the catch taken in 4W.

It is important to recognize that estimates of risk for larvae, adults, and fisheries are overestimated for the following reasons:

i) the oil fate model does not allow for evaporation of HCs from the water column and hence the model overestimates both the HC concentration in the water column and the size of the affected areas;

ii) in all likelihood HCs would not penetrate into the deeper strata of the water column in high concentrations and hence the risks to benthic and demersal species are probably overestimated.

APPENDIX G

LIST OF PARTICIPANTS
PROJECT INITIATION MEETING

November 25, 1991

LIST OF PARTICIPANTS

Martin Bergman	Fisheries and Oceans Canada
Dave Bernard	ESSA Environmental and Social Systems Analysts Ltd.
Evan Birchard	Esso Resources Canada
Rolph Davis	LGL Limited
Rick Hurst	Indian and Northern Affairs Canada
Gordon Kerr	Environment Canada
Lois Little	Lutra Associates Ltd.
Steve Potter	S.L. Ross Environmental Research Limited
Anne Snider	Indian and Northern Affairs Canada
David Thomas	Axys Environmental Consulting Ltd.
Patricia Vonk	Axys Environmental Consulting Ltd.

APPENDIX H

LIST OF PARTICIPANTS
IMPACT HYPOTHESIS AND OIL SPILL PLANNING MEETING

January 28-30, 1992

LIST OF PARTICIPANTS

John Babaluk	Fisheries and Oceans Canada
John Bailey	Inuvialuit Game Council
Martin Bergman	Fisheries and Oceans Canada
Dave Bernard	ESSA Environmental and Social Systems Analysts Ltd.
Ian Buist	S.L. Ross Environmental Research Limited
Rolph Davis	LGL Limited
Wayne Duval	Axys Environmental Consulting Ltd.
David Fissel	Arctic Sciences Ltd.
Jeff Green	The Delta Environmental Management Group Ltd.
John Harper	Coastal and Ocean Resources Inc.
Rick Hurst	Indian and Northern Affairs Canada
Steve Johnson	LGL Limited
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Harvey Martens	Hardy BBT Ltd.
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David Thomas	Axys Environmental Consulting Ltd.
Patricia Vonk	Axys Environmental Consulting Ltd.

APPENDIX I

LIST OF PARTICIPANTS
COMMUNITY-BASED CONCERNS PLANNING MEETING

February 19-20, 1992

LIST OF PARTICIPANTS

Dave Bernard	ESSA Environmental and Social Systems Analysts Ltd.
Stuart Davies	North/South Consultants Inc.
Wayne Duval	Axys Environmental Consulting Ltd.
Bruce Hanbidge	Joint Secretariat
Charlie Haogak	Inuvialuit Game Council
Brian Herbert	Indian and Northern Affairs Canada
Rick Hoos	Polar Delta Project
David Krutko	Gwich'in Tribal Council
Helena Laraque	Department of Renewable Resources, GNWT
Lois Little	Lutra Associates Ltd.
Lorne Matthews	Energy Mines and Petroleum Resources, GNWT
Steve Matthews	Department of Renewable Resources, GNWT
Heather Myers	Department of Renewable Resources, GNWT
Sheila Nasogaluak	Beaufort Mackenzie DIZ Society
Frank Pope	Sahtu DIZ/Shihta Regional Council
Bob Stephen	Lutra Associates Ltd.

APPENDIX J

LIST OF PARTICIPANTS
PROJECT WORKSHOP ON EXISTING AND NEW IMPACT HYPOTHESES

May 5-7, 1992

LIST OF PARTICIPANTS

Dan Andre	Gwich'in Tribal Council
Alex Aviguana	Inuvialuit Settlement Region
John Bailey	Wildlife Advisory Board
Gary Beckstead	HBT Agra Limited
Martin Bergman	Fisheries and Oceans Canada
Evan Birchard	Esso Resources Canada
Ken Chang-Kue	Fisheries and Oceans Canada
Johnny Charlie	Porcupine Caribou Management Board
Susan Cosens	Fisheries and Oceans Canada
Rolph Davis	LGL Limited
Larry de March	Fisheries and Oceans Canada
Lynn Dickson	Environment Canada, Canadian Wildlife Service
Wayne Duval	Axys Environmental Consulting Ltd.
Brian Fergusson	Fisheries and Oceans Canada
David Fissel	Arctic Sciences Ltd.
Jeff Green	The Delta Environmental Management Group Ltd.
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Rick Hurst	Indian and Northern Affairs Canada
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Don Meisner	ESSA Environmental and Social Systems Analysts Ltd.
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Rob Owens	Foothills Pipeline Ltd.
Frank Pope	Shihta Regional Council, Sahtu DIZ
Don Robinson	ESSA Environmental and Social Systems Analysts Ltd.
Mike Rose	ESSA Environmental and Social Systems Analysts Ltd.
Don Russel	Environment Canada, Canadian Wildlife Service
Don Schell	University of Alaska, Water Research Centre
Brian Smiley	Fisheries and Oceans Canada
David Thomas	Axys Environmental Consulting Ltd.
Patricia Vonk	Axys Environmental Consulting Ltd.
Gary Wagner	Environmental Impact Review Board

APPENDIX K

PROJECT UPDATES

BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

The purpose of this paper is to introduce you to the Beaufort Region Environmental Assessment and Monitoring Program (referred to as BREAM). BREAM was initiated in 1991 by Indian and Northern Affairs Canada, Environment Canada and Fisheries and Oceans Canada as a planning component of the Northern Oil and Gas Action Program. Its objective is to establish research and monitoring priorities related to future oil and gas development and transportation systems in the Beaufort Sea, Mackenzie Delta and Mackenzie Valley. This program combines and builds on the efforts of earlier projects of this type - the Beaufort Environmental Monitoring Project (BEMP), and the Mackenzie Environmental Monitoring Project (MEMP). These programs were started in the mid 1980s because of concern about the environmental impacts of such development in the region and uncertainties with environmental impact assessment.

Like BEMP and MEMP, BREAM is a process that ensures that environmental research and monitoring programs are integrated with exploration and development plans. Through the use of impact hypotheses, the potential environmental effects of various activities associated with oil and gas development and transportation are examined. This process helps to identify areas where further information gained through research and monitoring is needed. It identifies studies needed to fill data gaps and allows subsequent assessments to be more practical and successful.

While BREAM is seen as a continuation of these earlier programs, its objectives are broader. In addition to addressing the potential environmental impacts that may be associated with routine aspects of oil and gas development, BREAM will consider the issue of catastrophic oil spills. This has dominated discussions in recent public reviews of hydrocarbon exploration proposals in the region and has been the subject of much work undertaken by the Beaufort Sea Steering Committee. BREAM will also consider environmental concerns of the Inuvialuit and other northern residents related to oil and gas development to a greater extent than has been the case in the past, and will make better use of traditional knowledge through stronger involvement of northerners. Several contemporary issues such as global climate change and cumulative impacts will also be examined as part of BREAM.

Rather than focussing solely on defining research and monitoring needs, BREAM will also provide a mechanism for assessing the possible significance of environmental impacts associated with offshore and onshore development in the region. An assessment procedure will be selected for future use by participants in BREAM workshops.

The first year of BREAM was the planning phase, which involved a range of activities to help decide the direction of the project over the next few years. A planning meeting, involving government and industry representatives as well as several consultants, was held to determine the focus and priorities of BREAM relative to BEMP and MEMP and to the more recent work of the Beaufort Sea Steering Committee. In addition, a number of research and monitoring programs completed in the Beaufort Sea since the last BEMP workshop in 1986 were reviewed. The results of these studies as well as conclusions and recommendations of the planning meeting are presented in the 1990/1991 BREAM Final Report (INAC and Environment Canada 1991).

Between December 1991 and March 1992, a number of activities will take place. New to this process will be three technical working groups. One group will review existing (BEMP/MEMP) and new impact hypotheses developed to examine possible environmental effects of development and transportation activities, while the others will deal with issues related to catastrophic oil spills and community-based concerns. Each of these groups will be responsible for determining specific issues that should be dealt with in future workshops and preparing background documents in support of these workshops. Some members of the Beaufort Sea Steering Committee, and representatives of northern communities and the Government of the Northwest Territories will be invited to participate in the working group meetings.

In late February, 1992, a 3-day workshop will be held to review those impact hypotheses developed during BEMP and MEMP that will be re-evaluated as part of BREAM, as well as new ones developed by the Impact Hypothesis Technical Working Group. As in the past with BEMP and MEMP, a number of individuals from government, industry and northern communities will be invited to participate in this workshop. While the focus of the workshop will be on routine aspects of development, impact hypotheses dealing with catastrophic oil spills and community-based concerns will be developed by the respective working groups during the technical meetings for evaluation in future BREAM workshops. The results of this year's workshop will play an important role in determining the focus of the 1992/1993 BREAM program.

A final report for this year's BREAM program will be prepared by late March, 1992. This will include the results of each of the technical meetings and background material prepared by the Working Groups, as well as the results of the workshop with recommendations for future work. A second project update will be issued in March to summarize the highlights of the 1991/1992 BREAM program.

If you have any comments or questions regarding BREAM, the following individuals can be contacted.

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BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

The second year (1991/92) of the BREAM Program is now near completion. Since Update #1 was issued in December, 1991, many activities have taken place. The purpose of this paper is to highlight the many accomplishments made this year. As mentioned in the first update, three new technical working groups were established to deal with the broadened scope of the project. These are the Impact Hypothesis Technical Working Group, the Catastrophic Oil Spill Working Group, and the Community-based Concerns Working Group. A number of planning and technical meetings of these groups were held earlier this year, and were followed by a 3-day workshop to identify research and monitoring needs associated with future hydrocarbon development in the Beaufort Sea, Mackenzie Delta and Mackenzie Valley.

The Impact Hypothesis Working Group was charged with the responsibility of reviewing existing BEMP and MEMP impact hypotheses related to routine aspects of hydrocarbon development and transportation systems to determine research and monitoring priorities for BREAM and NOGAP over the next two years. On January 28-29, 1992, there was a meeting of this group to review each of the hypotheses and develop new ones for consideration at a workshop. Of the existing hypotheses, many were restructured, reworded, combined or eliminated to reflect new information, changes in the scope of the project, or changes in the development scenario. An additional three impact hypotheses were developed to deal with the effects of lake water drawdown on Arctic cisco and broad whitefish, offshore activities on the bowhead whale harvest and dredging in Husky Lakes on the lake trout population. The result of this review was 32 BREAM hypotheses, some of which were identified for a detailed evaluation, while others were considered valid but not necessary to evaluate at this time.

A planning meeting of both the Catastrophic Oil Spill and Impact Hypothesis Working groups was held in Vancouver, B.C. on January 30, 1992. A tentative list of Valued Ecosystem Components (VECs) was developed, which included all of those originally used in BEMP and MEMP as well as a number of new ones such as coastlines, non-harvested bird and fish populations, and air and groundwater quality. Six spill scenarios have been developed by the Oil Spill Working Group, which describe environmental conditions, spill behaviour, countermeasures, and the extent of shoreline oiling. The scenarios include:

- Condensate pipeline leak under ice at a river crossing at a rate of 10 barrels/day from February 15 to April 15
- Condensate pipeline leak at a river crossing in summer involving a release of 1,000 barrels over a 2-hour period
- Oil pipeline leak at a river crossing in spring involving a release of 10,000 barrels over a 2-week period (80 litres/minute)

- Oil pipeline (weld) failure in summer in a section of pipeline buried beneath the Mackenzie River involving a release of 5,000 barrels over a 2-week period

- Artificial island platform offshore blowout (August 1) involving a release of a total of 77,400 barrels oil over 6 days

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

New impact hypotheses related to these six scenarios will be developed by the Working Group for future evaluation.

The main role of the Community-based Concerns Working Group was to identify ecological issues and concerns that northern communities believe should be included in environmental assessments of future hydrocarbon activities in the Beaufort Sea/Mackenzie Valley region. This year's work focused on introducing the BREAM process to northern communities, identifying some of the environmental issues of importance to northerners, and determining priorities of the Working Group for 1992/93. This was accomplished during a planning meeting, which was held in Yellowknife, N.W.T. on February 19-20, 1992. This meeting was attended by a number of representatives from regional organizations in the Beaufort Sea and Mackenzie Valley regions. Central to all of the issues and concerns identified by the representatives was harvestable food resources and the overall quality of the northern environment. In particular, these concerns related to: (1) baseline data collection and monitoring; (2) fish quality (tainting and texture of whitefish and appearance of burbot livers); (3) solid waste disposal sites and associated contaminants; (4) catastrophic oil spills; (5) refined oil spills resulting from increased winter road travel; (6) an east-west pipeline route and its effect on estuarine beluga calving areas; (7) increased ambient noise and traffic; and (8) cumulative effects of atmospheric deposition and other contaminant inputs on northern ecosystems. A number of process-related issues were also raised during the meeting. These included the need to: (1) access and incorporate traditional knowledge into BREAM; (2) involve northern participation in all stages of research, monitoring and assessment, and improve information exchange and feedback with the communities; and (3) access existing information (e.g., land use plans and issues documents) that identifies community-based concerns in each region, and archive this information at a central location at the N.W.T. Because BREAM focuses only on environmental concerns associated with hydrocarbon development, the group also identified the need for a parallel process that addresses socio-cultural and economic issues.

Work this year culminated with a 3-day Interdisciplinary Workship to review those impact hypotheses that are to be re-evaluated as part of BREAM. The workshop, attended by 40 representatives of government, industry, and northern communities, was held in Richmond, B.C. on May 5-7, 1992. The primary objectives were to review the hypotheses in terms of the adequacy of existing information, conduct a preliminary assessment of each of the 32 hypotheses , and identify future research and monitoring requirements. Some of the research and monitoring priorities identified by the four workshop subgroups were as follows: (1) examination of surface flow across shorebird nesting habitat and research on the distribution of nesting habitat on the Delta to help assess the effects of any changes in drainage resulting from land subsidence along a pipeline or the creation of drainage barriers (frost bulbs, access roads); (2) assessment of the effects of hunting pressure on the response of caribou to roads; (3) systematic aerial surveys of bowhead whales within the Mackenzie River estuary and in offshore regions of the Beaufort Sea to determine their distribution in the absence of industry activity (i.e. a control year) and in relation to the position of the Mackenzie plume; and (4) analysis of the relative contribution of contaminant inputs to the Mackenzie River resulting from long-range atmospheric transport and inputs from upstream industrial and agricultural sources compared to natural inputs from within the regions such as hydrocarbon seeps.

The Final 1991/92 BREAM report is currently being prepared and will be available for distribution by early to mid July, 1992. This report will include the results of each of the Technical Working Group meetings and the Interdisciplinary Workshop, background documents prepared by each of the groups, and recommendations for future activities of BREAM.

If you have any comments regarding BREAM or wish to receive a copy of the final report, please contact Anne Snider, NOGAP Coordinator, Indian and Northern Affairs Canada, Hull, Quebec at (819) 997-0046.