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Beaufort Region Environmental Assessment and Monitoring Program

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Final Report for 1992/1993

Northern Affairs Program

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This report represents the collective efforts of all the study team members. We sincerely appreciate the contributions made by each of these individuals throughout the conduct of this study.

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Wayne Duval was responsible for overall project management and preparation of various report sections. Coordination of the project meetings, workshop and final report was the responsibility of Patricia Vonk. Ms. Vonk also prepared the Project Updates and sections of the report. Simon Skey acted as Contract Manager, and was responsible for all financial matters pertaining to the project. Dave Bernard acted as facilitator for the technical meetings of the Community-based Concerns Working Group and Catastrophic Oil Spill Working Group, and the project workshop. Dave Thomas and Jeff Green were also facilitators for subgroup discussions during the workshop, while Mike Lawrence, Patricia Vonk, Rolph Davis and John Richardson acted as rapporteurs for these discussions.

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EXECUTIVE SUMMARY

This report summarizes activities that occurred in the third year (1992/93) of the Beaufort Region Environmental Assessment and Monitoring Program (BREAM).

BREAM was initiated in 1990/1991 by the federal government as a planning program funded by the Northern Oil and Gas Action Program (NOGAP). The project is sponsored by Indian and Northern Affairs Canada (INAC), Environment Canada (EC) and the Department of Fisheries and Oceans (DFO). The overall purpose of BREAM is to identify environmental research and monitoring priorities related to future hydrocarbon development activities in the Beaufort Sea/Mackenzie Delta region and transportation of hydrocarbons to southern markets via a pipeline along the Mackenzie River Valley. Two earlier programs, the Beaufort Environmental Monitoring Project, (BEMP) 1983-1988 and the Mackenzie Environmental Monitoring Project, (MEMP) 1985-1988 had similar objectives but were more restricted in their scope of activities. The focus of both BEMP and MEMP was on routine activities associated with hydrocarbon exploration, production and transportation. The broader scope of BREAM, however, includes consideration of major oil spills, community-based concerns, contemporary issues such as global climate change and cumulative impacts of industrial development, and environmental assessment. BREAM also places far greater emphasis on use of traditional and local knowledge through involvement of northerners in project planning activities and workshops.

A variety of planning activities took place in the first year of BREAM (1990/1991) 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 1990/1991, Environmental Studies No. 67*, Indian and Northern Affairs Canada. In its second year (1991/1992), BREAM activities included the establishment of three Technical Working Groups to address: (1) Existing Impact Hypotheses, (2) Community-based Concerns and (3) Catastrophic Oil Spills. A summary of the activities of each of these groups is presented in *Environmental Studies No. 69*, Indian and Northern Affairs Canada.

This report discusses the activities that occurred during the third year (1992/93) of BREAM, which included meetings of two of the Technical Working Groups (Community-based Concerns and Catastrophic Oil Spills) and a three-day interdisciplinary workshop focussing on nine impact hypotheses and four oil spill scenarios.

Planning Meetings

Three planning meetings were held as part of the 1992/93 BREAM program. These included a Project Initiation Meeting and technical meetings of the Community-based Concerns and Catastrophic Oil Spill Working Groups. The Project Initiation Meeting was held on November 27, 1992 and was attended by representatives from the sponsoring agencies and the petroleum industry, and several members of the BREAM study team. The objectives of this meeting were to: (1) identify specific tasks to be completed by the Community-based Concerns and Catastrophic Oil Spill Working Groups; (2) discuss the contents and scope of material and documents to be prepared in advance of the three-day interdisciplinary

Catastrophic Oil Spill Workshop; (3) select impact hypotheses to be evaluated at the workshop; (4) discuss the composition of the two Working Groups, with respect to participants from government agencies, and northern communities and organizations; and (5) determine project milestones and schedules necessary to achieve the milestones.

Community-based Concerns

The second meeting of the Community-based Concerns Working Group was held on January 12, 1993 in Yellowknife, N.W.T. to continue the work initiated by this group during the 1991/1992 BREAM program. As in past years, this meeting was attended by representatives from federal and territorial government agencies, the pipeline industry, and northern communities and organizations. Members of the Working Group focussed their attention on: (1) identifying ecological concerns of northern residents specifically related to large oil spills and their cleanup; (2) exploring processes for identifying community-based ecological issues and concerns, and incorporating local and traditional knowledge into the BREAM program; (3) reviewing the list of issues and concerns that was produced during the previous meeting to determine whether or not each of these items has been adequately incorporated into the current set of BREAM impact hypotheses; and (4) identifying and refining any outstanding community-based ecological concerns or issues.

The single most important concern of participants at the meeting was that social and economic concerns related to northern oil and gas development are not currently being addressed by BREAM or any other program. Participants recommended that a process to address socio-economic concerns of northern residents be established and that this process be integrated with and compliment the BREAM process rather than exist as a separate parallel process.

The Working Group suggested some changes to the wording of the existing impact hypotheses and the four oil spill scenarios selected for use in the workshop, and recommended a number of deletions and additions to the list of Valued Ecosystem Components (VECs). General concerns expressed by several participants were that the selection of VECs appeared to exclude effects on important prey species and subsequent food chain effects for higher level predators and that several impact hypotheses explicitly excluded food chain effects. While it was noted that food chain effects are addressed in some hypotheses (e.g., effects on benthic invertebrates and subsequent effects on fish), it was felt similar linkages should be included in hypotheses dealing with birds, terrestrial and semi-aquatic mammals and marine mammals.

The Community-based Concerns Working Group also recommended that a review of recent land-use planning documents be undertaken to identify oil- and gas-related issues that have not been previously identified through the BREAM process.

Catastrophic Oil Spills

Major oil spills were the main focus of activities in BREAM this year, building on progress made in 1991/92 in terms of development of offshore and onshore oil spill scenarios and 18 impact hypotheses relating these scenarios to VEC species groups. A technical meeting of the Catastrophic Oil Spill Working Group was held on January 14, 1993 to: (1) review the ecological concerns related to oil spills and their cleanup that were identified in the Community-based Concerns technical meeting and modify the oil spill impact hypotheses as necessary; and (2) review each of the oil spill scenarios and impact hypotheses that were selected for the workshop. In addition, the group refined the list of VECs and Valued Social Components (VSCs) stated in the oil spill hypotheses, determined key individuals that should be involved in the workshop, defined information needs for the workshop including important literature sources and other documents, and discussed the procedure that would be used to assess the environmental significance of the impacts described in each hypothesis.

The interdisciplinary workshop was held on February 22-25 in Inuvik, N.W.T. It focussed on a number of complex issues specifically related to the effects of large oil spills and their cleanup on resources and resource use, and culminated in the identification of research and monitoring priorities related to spills in the Beaufort Sea and Mackenzie regions. Because it would not be possible to evaluate all 18 oil spill impact hypotheses in a three-day workshop, hypotheses considered most important, based on known community and scientific concerns related to large oil spills in this region, were selected for evaluation. These hypotheses considered the potential direct and indirect impacts of:

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

The following table identifies those impact hypotheses for which further research and monitoring was recommended by workshop participants.

Hyp #	Hypothesis Description	Recommended Future Research and Monitoring
C-1	Effects of an Offshore Oil Spill on Marine Mammals	(1) In event of spill, sample belugas to determine effect of oil on skin and internal organs. (2) In event of spill, monitor behaviour of beluga and bowhead whales to determine responses to oil and to well control and cleanup activities. (3) Review samples currently collected by DFO to determine whether they are adequate to serve as baseline data.
C-3	Effects of a Pipeline Spill of Crude Oil during Summer on Terrestrial Mammals	(1) Review existing information related to the chronic and acute effects of oil on terrestrial mammals (grizzly bear, moose, wolves and foxes). (2) If information gaps exist in database, opportunistic research should be conducted.
C-5	Effects of an Offshore Platform Blowout on Semi-Aquatic Mammals	(1) In the event of a spill, a monitoring program should be initiated to determine the extent of oil fouling of semi-aquatic mammals (mink, muskrat) populations.

C-6	Effects of a Pipeline Spill of Crude Oil during Summer on Semi-Aquatic Mammals	(1) Review existing information related to the chronic and acute effects of oil on semi-aquatic mammals (mink, muskrat and beaver). (2) If information gaps exist in database, opportunistic research should be conducted.
C-8	Effects of a Pipeline Rupture in Spring on Birds	(1) Gain a better understanding of oil fate under river ice, particularly as it relates to oil/particle interactions in the river. (2) Obtain more information regarding waterbird harvests in the Fort Norman area. (3) Obtain more information on the potential effects of oil on raptors, including aspects of oil uptake by birds. (4) Post-spill monitoring of birds should be initiated immediately following an oil spill, and should include observations of foraging behaviour.
C-9	Effects of a Diesel Spill from a Barge on the Mackenzie on Birds	(1) Determine the stopover and turnover patterns of Brant geese migrating along the Beaufort Sea coast in late summer. (2) Obtain better information about bird use of the East Channel to help in predicting impacts. (3) Obtain information on the aspects of oil uptake by birds. (4) Post-spill monitoring of birds should be initiated immediately following an oil spill, and should include observations of foraging behaviour.
C-11	Effects of an Offshore Platform Blowout on Birds	(1) Literature review on aspects of oil uptake by birds. (2) Conduct field tests of the effectiveness of selected bird scaring devices under Beaufort Sea conditions. (3) In the event of a spill, systematic surveys should be undertaken to determine changes in bird numbers, estimate number of birds affected, and determine short- and long-term effects of the oil. Effectiveness of bird scaring devices should be monitored, and the effects of the spill on hunting should be documented. (4) Determine the stopover and turnover patterns of Brant geese migrating along the Beaufort Sea coast and eider ducks migrating offshore. (5) Develop effective monitoring programs for some of the VEC bird species occurring in the Canadian Beaufort Sea. (6) Examine aerial- and boat-survey data on spatial and temporal patterns of the swimming migration of thick-billed murre.
C-17	Effects of an Island Platform Blowout on Fish	(1) Research the effects of oil on the homing abilities of Dolly Varden. The effects of oil on other aspects of fish behaviour for Dolly Varden and Arctic charr was also identified as a research need. (2) Monitor condition of livers of harvested fish species to provide adequate baseline information. (3) Continued archiving of tissue samples from harvested fish species. (4) Determine hydrocarbon depuration rates of more local fish species and develop a better understanding of the effects of suspended sediments on the acquisition of taint.
C-18	Effects of a Diesel Spill from a Barge on Fish	(1) Determine hydrocarbon depuration rates of more local fish species and develop a better understanding of the effects of suspended sediments on the acquisition of taint and on bioaccumulation aspects of taint. (2) Develop a better understanding of the role of suspended sediments on the fate of oil in the Mackenzie River.

Future Activities of BREAM

This report section discusses briefly the views of the BREAM project sponsors (Indian and Northern Affairs Canada, Environment Canada, and the Department of Fisheries and Oceans) in terms of the future directions of the program.

It is envisioned that BREAM will have three distinct objectives.

1. **SYNTHESIS** - One of the primary objectives of the last year of BREAM should be to provide a synthesis of the highlights and accomplishments of each year of BEMP, MEMP and BREAM over the period from 1983 to 1994.

2. **ASSESSMENT** - BREAM project sponsors should consider whether any further work should be carried out during the last year of BREAM regarding the development of an assessment methodology for future Beaufort Sea/Mackenzie Delta hydrocarbon projects. This should take into account the review of the Duval and Vonk procedure that was contracted by the Environmental Impact Review Board.

3. **COMMUNITY-BASED CONCERNS** - There are a number of outstanding issues that have been raised in the past two years by members of the Community-based Concerns Technical Working Group; BREAM should attempt to address as many of these as possible in its final year.

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Le présent rapport donne un aperçu des activités de la troisième année (1992-1993) de fonctionnement du Programme de surveillance et d'évaluation environnementales dans la région de Beaufort (PSEERB).

Le PSEERB a été lancé par le gouvernement fédéral en 1990-1991 comme programme de planification financé dans le cadre du Programme d'initiatives pétrolières et gazifères dans le Nord (PIPGN). Il est parrainé par les Affaires indiennes et du Nord Canada (AINC), Environnement Canada (EC) et le ministère des Pêches et des Océans (P&O). Ses objectifs généraux sont les suivants : établir les priorités en matière de recherche et de surveillance pour l'exploitation future des hydrocarbures dans la mer de Beaufort et le delta du Mackenzie et le transport de ces hydrocarbures vers les marchés du Sud au moyen d'un pipeline longeant la vallée du Mackenzie. Deux programmes antérieurs, le PSEMB (Programme de surveillance environnementale dans la mer de Beaufort, 1983-1988) et le PSEM (Programme de surveillance environnementale du Mackenzie, 1985-1988) visaient des objectifs similaires, mais leur portée était plus restreinte. Ils se limitaient essentiellement à l'exploration, à la production et au transport d'hydrocarbures, tandis que le PSEERB s'intéresse aux déversements importants de pétrole, aux préoccupations communautaires et aux questions contemporaines comme le changement climatique du globe et les répercussions cumulatives du développement industriel, ainsi qu'aux évaluations environnementales. De plus, le PSEERB insiste davantage sur la participation des résidants du Nord aux activités de planification des projets et aux ateliers.

Durant sa première année de fonctionnement (1990-1991), le PSEERB a donné lieu à diverses 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 Canada. Au cours de sa deuxième année de fonctionnement (1991-1992), le PSEERB a donné lieu à la création de trois groupes de travail technique chargés d'examiner 1) les cas éventuels, 2) les préoccupations communautaires et 3) les déversements désastreux de pétrole. Un sommaire des activités de chacun de ces groupes est présenté dans l'Étude environnementale n° 69, Affaires indiennes et du Nord Canada.

Le présent rapport aborde les activités qui ont eu lieu durant la troisième année de fonctionnement (1992-1993) du PSEERB, notamment les réunions de deux des groupes de travail technique (préoccupations communautaires et déversements désastreux de pétrole) et un atelier interdisciplinaire de trois jours qui a porté principalement sur neuf répercussions éventuelles et quatre scénarios de déversement désastreux.

Réunions de planification

Trois réunions de planification ont eu lieu dans le cadre du PSEERB en 1992-1993 : une réunion de lancement de projet et des réunions techniques des groupes de travail chargés des préoccupations communautaires et des déversements désastreux de pétrole. La première de ces réunions, à laquelle ont participé des représentants des organismes parrains et de l'industrie pétrolière et plusieurs membres de l'équipe d'étude du

PSEERB, s'est tenue le 27 novembre 1992. Elle visait à 1) préciser les tâches particulières des groupes de travail chargés des préoccupations communautaires et des déversements désastreux de pétrole, 2) examiner le contenu et la portée des documents à rédiger en prévision de l'atelier interdisciplinaire de trois jours sur les déversements désastreux de pétrole, 3) choisir les cas éventuels qui feraient l'objet d'une évaluation au cours de l'atelier, 4) examiner la représentation des organismes gouvernementaux ainsi que des collectivités et des organisations du Nord au sein des deux groupes de travail et 5) fixer les étapes des projets et les calendriers.

Préoccupations communautaires

La deuxième réunion du groupe de travail sur les préoccupations communautaires a eu lieu le 12 janvier 1993 à Yellowknife (T. N.-O.). Les participants y ont poursuivi le travail qu'ils avaient entrepris dans le cadre du PSEERB en 1991-1992. Comme par les années passées, les organismes fédéraux et territoriaux, l'industrie des pipelines ainsi que les collectivités et les organisations du Nord y étaient représentés. Les membres du groupe de travail ont surtout prêté attention aux points suivants : 1) la définition des préoccupations écologiques des résidants du Nord à l'égard, notamment, des déversements de pétrole importants et de leur nettoyage; 2) l'examen des moyens pour cerner les préoccupations et les questions écologiques des collectivités et l'utilisation des connaissances traditionnelles et de celles des populations locales dans le cadre du PSEERB; 3) l'examen de la liste de questions et de préoccupations dressée lors de la réunion précédente, afin de déterminer s'il a été dûment tenu compte de chacun de ces points dans la série de cas éventuels et 4) la définition et la description de toute question ou préoccupation écologique des collectivités.

Le principal sujet d'inquiétude des participants à cette réunion avait trait au fait qu'il n'était jamais question, dans le PSEERB ou dans tout autre programme, des préoccupations socio-économiques liées à l'exploitation du pétrole et du gaz dans le Nord. Les participants ont recommandé la mise en place d'un processus pour tenir compte de ces préoccupations qui seraient intégrées au PSEERB au lieu d'être un processus parallèle distinct.

Le groupe de travail a proposé quelques changements au libellé des cas éventuels et des quatre scénarios de déversement de pétrole retenus aux fins de l'atelier et a recommandé un certain nombre d'ajouts et de suppressions à la liste de composantes valorisées d'un écosystème (CVE). Plusieurs participants s'inquiétaient du fait que la sélection des CVE semblait ne pas tenir compte des répercussions sur les importantes espèces-proies et sur les autres prédateurs en remontant la chaîne alimentaire, et plusieurs hypothèses sur les répercussions excluaient explicitement les répercussions sur la chaîne alimentaire. On a fait remarquer que ces répercussions avaient été prises en considération dans certains cas éventuels (p. ex., les conséquences sur les invertébrés benthiques et ensuite sur les poissons), mais on pensait qu'il fallait établir de pareilles corrélations dans les cas impliquant des oiseaux, des mammifères terrestres et semi-aquatiques ainsi que des mammifères marins.

Le groupe de travail sur les préoccupations communautaires a également recommandé que l'on procède à un examen des documents récents sur l'aménagement du territoire afin de cerner les questions liées au pétrole et au gaz qui n'ont pas été définies dans le cadre du PSEERB.

Déversements désastreux de pétrole

Les activités de cette année, dans le cadre du PSEERB, ont porté principalement sur les déversements importants de pétrole après les progrès accomplis en 1991-1992 au regard des scénarios de déversement de pétrole sur les côtes et au large des côtes et des 18 cas éventuels de déversements et leurs répercussions sur les groupes d'espèces visés par les CVE. Le groupe de travail sur les déversements désastreux de pétrole a tenu une réunion technique le 14 janvier 1993 afin 1) d'examiner les préoccupations écologiques liées aux déversements de pétrole et à leur nettoyage qui avaient été cernées à la réunion technique sur les préoccupations communautaires et de modifier les hypothèses sur les répercussions de ces déversements en conséquence et 2) d'examiner chacun des scénarios et des cas éventuels qui ont été retenus aux fins de l'atelier. En outre, le groupe a amélioré la liste de CVE et de CSV (composantes sociales valorisées) énoncées dans les hypothèses, déterminé quelles étaient les personnes clefs qui devraient participer à l'atelier, défini les besoins en information pour l'atelier, y compris les sources documentaires importantes et autres documents, et examiné la méthode à utiliser pour évaluer l'incidence environnementale des répercussions décrites à l'égard de chaque hypothèse.

L'atelier interdisciplinaire a eu lieu du 22 au 25 février à Inuvik (T. N.-O.). Il a porté essentiellement sur des questions complexes se rapportant particulièrement aux répercussions des grands déversements de pétrole et à leur nettoyage sur les ressources et leur utilisation et s'est terminé par la définition des priorités en matière de recherche et de surveillance dans les régions de la mer de Beaufort et du Mackenzie. Comme il serait impossible d'évaluer les 18 cas éventuels au cours d'un atelier de trois jours, on a décidé d'évaluer ceux qui étaient considérés les plus importants, selon les préoccupations scientifiques et communautaires connues par rapport aux déversements de pétrole importants dans la région. Les cas retenus sont les suivants :

- une éruption de pétrole brut durant l'été à partir d'une île artificielle et les répercussions directes et indirectes sur les mammifères marins, les oiseaux, les poissons et les mammifères semi-aquatiques ainsi que sur la récolte de ces ressources;
- un déversement de combustible pour moteur diesel à partir d'une barge fluviale près de Swimming Point durant l'été et les répercussions directes et indirectes sur les poissons et les oiseaux ainsi que sur leur récolte;
- une rupture de pipeline et un déversement de pétrole brut sous la glace de la rivière Great Bear au printemps et les répercussions directes et indirectes sur les oiseaux et leur récolte;
- une rupture de pipeline et un déversement de pétrole brut près de Fort Simpson durant l'été et les répercussions directes et indirectes sur les mammifères terrestres et semi-aquatiques ainsi que sur leur récolte.

Le tableau suivant indique les cas éventuels sur lesquels les participants à l'atelier ont recommandé d'autres travaux de recherche et de surveillance.

Cas n°	Description	Recherche et surveillance recommandées
C-1	Répercussions d'un déversement de pétrole en mer sur les mammifères marins	(1) En cas de déversement, déterminer les répercussions du pétrole sur la peau et les organes internes d'un échantillon de bélougas. (2) En cas de déversement, surveiller le comportement des bélougas et des baleines boréales afin de déterminer leurs réactions aux opérations destinées à circonscrire le pétrole renversé et à limiter l'importance du déversement et aux activités de nettoyage. (3) Examiner les échantillons que P&O prélève actuellement afin de déterminer s'ils peuvent effectivement servir de données de base.
C-3	Répercussions d'une rupture de pipeline et d'un déversement de pétrole brut durant l'été sur les mammifères terrestres	(1) Examiner les informations actuelles sur les effets chroniques et aigus du pétrole sur les mammifères terrestres (ours gris, orignal, loup et renard). (2) Si la base de données est incomplète, on devrait effectuer des recherches opportunistes.
C-5	Répercussions d'une éruption de pétrole à partir d'une plate-forme sur les mammifères semi-aquatiques	(1) En cas de déversement, on devrait entreprendre un programme de surveillance afin de déterminer l'importance de l'accumulation de pétrole sur les populations de mammifères semi-aquatiques (vison, rat musqué).
C-6	Répercussions d'une rupture de pipeline et d'un déversement de pétrole brut durant l'été sur les mammifères semi-aquatiques	(1) Examiner les informations actuelles sur les effets chroniques et aigus du pétrole sur les mammifères semi-aquatiques (vison, rat musqué et castor). (2) Si la base de données est incomplète, on devrait effectuer des recherches opportunistes.
C-8	Répercussions d'une rupture de pipeline au printemps sur les oiseaux	(1) Acquérir une meilleure compréhension de ce qui arrive au pétrole une fois qu'il est renversé sous la glace d'une rivière, notamment l'interaction entre le pétrole et les particules dans la rivière. (2) Obtenir plus d'information sur les récoltes d'oiseaux aquatiques dans la région de Fort Norman. (3) Obtenir plus d'information sur les effets éventuels du pétrole sur les rapaces, notamment sur l'absorption de pétrole par les oiseaux. (4) On devrait procéder immédiatement à la surveillance des oiseaux après un déversement, et notamment observer leur comportement lorsqu'ils cherchent de la nourriture.
C-9	Répercussions d'un déversement de combustible pour moteur diesel à partir d'une barge sur le Mackenzie sur les oiseaux	(1) Déterminer les tendances de la bernache cravant à s'arrêter à un seul ou à plusieurs endroits à la fin de l'été durant sa migration le long de la côte de la mer de Beaufort. (2) Obtenir de meilleures informations sur l'utilisation du chenal Est par les oiseaux afin de prédire les répercussions. (3) Obtenir des informations sur les divers aspects de l'absorption de pétrole par les oiseaux. (4) On devrait procéder immédiatement à la surveillance des oiseaux après un déversement, y compris l'observation de leur comportement lorsqu'ils cherchent de la nourriture.

C-11	Répercussions d'une éruption de pétrole à partir d'une plate-forme sur les oiseaux	(1) Examiner la documentation sur l'absorption du pétrole par les oiseaux. (2) Effectuer des essais de l'efficacité de certains dispositifs d'effarouchement des oiseaux dans la mer de Beaufort. (3) En cas de déversement, on devrait procéder à des études systématiques afin de déterminer s'il y a eu diminution du nombre d'oiseaux, d'estimer le nombre d'oiseaux affectés et de préciser les effets à court et à long terme du pétrole. On devrait contrôler l'efficacité des dispositifs d'effarouchement des oiseaux et rendre compte de l'incidence du déversement sur la chasse. (4) Déterminer les tendances de la bernache cravant à s'arrêter à un seul ou à plusieurs endroits durant sa migration le long de la côte de la mer de Beaufort et celles des eiders au cours de leur migration au large des côtes. (5) Élaborer des programmes de surveillance efficaces pour certaines espèces d'oiseaux visées par les CVE qui se retrouvent dans la mer de Beaufort au Canada. (6) Examiner les données des relevés effectués du haut des airs ou par bateau sur les tendances spatiales et temporelles de la migration à la nage de la marmette de Brunnich.
C-17	Répercussions d'une éruption de pétrole à partir d'une île de forage sur le poisson	(1) Effectuer des recherches sur les répercussions du pétrole sur les capacités de retour au nid du Dolly Varden ainsi que sur d'autres aspects du comportement du Dolly Varden et de l'omble chevalier. (2) Examiner le foie des espèces de poisson prises afin d'obtenir des informations de bases valables. (3) Continuer de conserver des échantillons de tissu provenant des espèces de poisson prises. (4) Déterminer les taux de dépuration des hydrocarbures d'un plus grand nombre d'espèces de poisson locales et acquérir une meilleure compréhension des effets des sédiments en suspension sur les odeurs parasites.
C-18	Répercussions d'un déversement de pétrole pour moteur diesel à partir d'une barge sur le poisson	(1) Déterminer les taux de dépuration d'un plus grand nombre d'espèces de poisson locales contaminées par les hydrocarbures et acquérir une meilleure compréhension des effets des sédiments en suspension sur les odeurs parasites et la bio-accumulation de celles-ci. (2) Acquérir une meilleure compréhension du rôle des sédiments en suspension sur la présence de pétrole dans le fleuve Mackenzie.

Prochaines activités du PSEERB

La présente section expose brièvement les vues des promoteurs du PSEERB (Affaires indiennes et du Nord Canada, Environnement Canada et le ministère des Pêches et des Océans) relatives à l'orientation future du programme.

On prévoit que le PSEERB aura trois objectifs distincts.

1. **SYNTHÈSE** - L'un des principaux objectifs du PSEERB dans sa dernière année de fonctionnement devrait être de fournir une synthèse des points saillants et des réalisations de chaque année de fonctionnement du PSEMB, du PSEM et du PSEERB pour la période allant de 1983 à 1994.

2. **ÉVALUATION** - Les promoteurs du PSEERB devraient déterminer s'il y a lieu d'effectuer d'autres travaux au cours de la dernière année de fonctionnement du Programme en ce qui touche élaboration de méthodes d'évaluation des futurs projets d'exploitation des hydrocarbures dans la mer de Beaufort et le delta du Mackenzie, compte tenu de l'examen de la méthode Duval et Vonk élaborée à la suite de l'octroi d'un marché par le Bureau d'examen des répercussions environnementales.

3. **PRÉOCCUPATIONS COMMUNAUTAIRES** - Il y a un certain nombre de questions non réglées que les membres du groupe de travail technique sur les préoccupations communautaires ont soulevées au cours des deux dernières années; les responsables du PSEERB devraient essayer de résoudre le plus grand nombre possible de ces questions au cours de la dernière année.

1. INTRODUCTION AND BACKGROUND

Prepared by
Wayne Duval
Axys Environmental Consulting Ltd.

The Beaufort Region Environmental Assessment and Monitoring (BREAM) project was initiated in 1990/1991 by the federal government as part of the Northern Oil and Gas Action Program (NOGAP). The project is sponsored by Indian and Northern Affairs Canada (INAC), Environment Canada (EC) and the Department of Fisheries and Oceans (DFO). The overall purpose of BREAM is to provide a mechanism for the recommendation and review of environmental research and monitoring programs (within the mandate of its sponsors) to accompany future hydrocarbon development activities in the Beaufort Sea/Mackenzie Delta region and transportation of hydrocarbons to southern markets via a pipeline along the Mackenzie River Valley. Two earlier programs, BEMP (Beaufort Environmental Monitoring Project, 1983-1988) and MEMP (Mackenzie Environmental Monitoring Project, 1985-1988) had similar objectives but were more restricted in their scope of activities. The focus of both BEMP and MEMP was on routine activities associated with hydrocarbon exploration, production and transportation, whereas the scope of BREAM was expanded to address major oil spills, community-based concerns, contemporary issues such as global climate change and cumulative impacts of industrial development, and environmental assessment. It also places far greater emphasis on use of traditional and local knowledge through involvement of northerners in project planning activities and workshops.

Environmental assessment, research and monitoring in the context of BREAM are defined below:

> **ENVIRONMENTAL ASSESSMENT** is a process whereby the risk (probability), nature, magnitude and duration of potential effects of a development or other activity are evaluated and decisions made regarding the possible significance of resultant changes in the biophysical and socioeconomic environments.

> **MONITORING** is the repetitive measurement of variables to detect changes directly or indirectly attributable to a specific development activity. Monitoring is the test of an impact hypothesis to: (1) measure environmental impacts; and (2) analyze cause-effect relationships.
>
> **RESEARCH** is the test of a system process hypothesis or baseline measurements necessary to adequately describe components of the environment and/or interpret the results of monitoring.

A variety of planning activities took place in the first year of BREAM (1990/1991) to help determine the direction of the program over the next few years. These included preparation of a hydrocarbon development scenario for the region based on views of representatives of the petroleum and pipeline industries at that time, review of research and monitoring initiated or completed since the last BEMP/MEMP workshops in 1986, and conduct of a Planning Meeting designed to determine the focus and priorities of the project relative to its predecessors. The results of the planning phase are presented in the BREAM Final Report for 1990/1991, Environmental Studies No. 67, Indian and Northern Affairs Canada.

In its second year (1991/1992), BREAM activities included the establishment of three Technical Working Groups to address: (1) Existing Impact Hypotheses, (2) Community-Based Concerns and (3) Catastrophic Oil Spills. Highlights of the activities of each of these Working Groups are presented below.

IMPACT HYPOTHESIS WORKING GROUP: The primary focus of BREAM in 1991/1992 was on existing and new impact hypotheses addressing the effects of routine aspects of hydrocarbon development and transportation. During a project planning meeting, 14 of 21 BEMP hypotheses and 22 of 25 MEMP hypotheses were concluded to remain valid for BREAM. Of these 36 hypotheses, many were altered in some way (e.g., structure or wording) to reflect new information or changes in the development scenario and the expanded scope of BREAM. Three new hypotheses were added to address concerns related to dredging in Husky Lakes, lake water drawdown and effects of offshore activities on the bowhead whale harvest. Several of these hypotheses were then examined in a 3-day interdisciplinary workshop held in Vancouver. During the workshop, participants were charged with the responsibilities of: (1) reviewing the hypotheses in terms of adequacy of existing information; (2) conducting a preliminary assessment of each hypothesis; and (3) identifying future research and monitoring requirements. Some level of further study was recommended for ten of the impact hypotheses.

COMMUNITY-BASED CONCERNS WORKING GROUP: This group met in Yellowknife for two days to introduce the BREAM process to representatives of northern communities, and to determine some of the environmental issues of importance to northerners. Food sources and the overall quality of the northern environment were identified as fundamental ecological concerns that need to be addressed by BREAM. Process-related concerns included the need to make more use of traditional knowledge and develop better communication pathways to northern communities. A preliminary model for accessing and incorporating traditional and local knowledge into decisions related to environmental research and monitoring was developed. Many of the concerns of northerners related to future oil and gas develop are socio-economic rather than ecological in nature and, therefore, are outside the scope of BREAM. It was recommended that a parallel process be initiated to address these other community concerns.

CATASTROPHIC OIL SPILL WORKING GROUP: This group focused on preparation of documents to be used in the 1992/1993 BREAM program, which would address major oil spills despite the low probability of these events. Activities included preparing a list of Valued Ecosystem Components (VECs) and Valued Social Components (VSCs), developing a series of oil spill scenarios for hypothetical offshore and onshore accidents, and formulating new impact hypotheses relating these VECs and spill scenarios.

The results of the second year of BREAM were presented in Indian and Northern Affairs Canada, Environmental Studies No. 69 (1992).

The present document summarizes the activities that occurred during the third year (1992/1993) of BREAM. These included a Project Initiation Meeting in Vancouver, meetings of the Catastrophic Oil Spill Technical and Community-Based Concerns Working Groups in Vancouver and Yellowknife, respectively, and a 3-day interdisciplinary workshop in Inuvik focusing on nine impact hypotheses and four oil spill scenarios. The remainder of this report discusses planning activities (Section 2), the results of a meeting of the Community-Based Concerns Working Group (Section 3), detailed descriptions of each of the nine oil spill impact hypotheses examined during the project workshop (Section 4), and the future activities of BREAM (Section 5). A variety of appendices identify the participants in each meeting, as well as Project Updates widely distributed by the program sponsors.

2. PLANNING ACTIVITIES

Prepared by
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2.1 Planning Activities in 1992/1993

Three planning meetings were held as part of the 1992/1993 BREAM program. These included a Project Initiation Meeting and technical meetings of the Community-based Concerns and Catastrophic Oil Spill Working Groups. The following sections briefly describe the objectives and summarize the conclusions of each planning session. More detail on the activities of the two Working Groups are provided in Sections 3 and 4 of this report.

2.1.1 Project Initiation Meeting

The 1992/1993 BREAM program was initiated with a one-day meeting involving representatives from the sponsoring agencies and the petroleum industry, and several members of the BREAM study team (Appendix A). The meeting was held on November 27, 1992 in Richmond, B.C. The objectives of this meeting were to: (1) identify specific tasks to be completed by the Community-based Concerns and Catastrophic Oil Spill Working Groups; (2) discuss the contents and scope of material and documents to be prepared in advance of the Catastrophic Oil Spill Workshop planned for this fiscal year; (3) select impact hypotheses to be evaluated at the workshop; (4) discuss the composition of the two Working Groups, particularly as it relates to participation from government agencies, and northern communities and organizations; and (5) determine project milestones and schedules necessary to achieve the milestones.

At the outset of the meeting, there was discussion of the need to maximize involvement of northern residents in BREAM if the workshop was to be held in Inuvik, and how best to ensure their participation. It was suggested that an open forum/presentation held at the

Family Hall in Inuvik would provide community members with an opportunity to voice their concerns and any questions they may have related to BREAM. Alternatively, it was suggested that the closing plenary of the workshop could be an open session. The results of the meeting could then be presented and any comments/concerns expressed by the public noted. To ensure public awareness of BREAM and the workshop in Inuvik, it was also recommended that CBC North be contacted to announce the upcoming workshop.

The following sections summarize the results of further discussions that occurred during the Project Initiation Meeting.

2.1.1.1 Community-based Concerns Working Group

- Although selection of community representatives for the Community-based Concerns Working Group would be made by the individual community organizations and councils, it was agreed that it would be desirable to involve many of the same representatives that participated in last year's program. One of the purposes of the technical meeting this year would be to further prepare community members for a workshop in the future dealing with community-based concerns and issues.

- It was noted that a measure of the success of the Community-based Concerns Working Group this year would in part be the acceptance of last year's work and recognition that concerns and issues identified during the 1992 meeting have been brought forward and incorporated into the BREAM process. Because the 1991/1992 Final BREAM report would not be available prior to this year's meeting, it was agreed that a brief, concise document should be prepared and distributed to the Working Group in advance of the meeting to show how and where some of the community concerns have been addressed by BREAM.

- In addition to this document, it was agreed that the following information would also be distributed to members of the Community-based Concerns Working Group: (1) the most recent BREAM Update; (2) an agenda for the technical meeting; (3) a participant list; (4) a table summarizing the impact hypotheses to be evaluated at this year's interdisciplinary workshop; and (5) a letter of invitation.

- A tentative list of participants for the technical meeting of the Community-based Concerns Working Group was prepared during the Project Initiation Meeting.

- It was agreed that the technical meeting of the Community-based Concerns Working Group would be held directly before the Catastrophic Oil Spill Group meeting to ensure that community issues and concerns related to oil spills were incorporated into the impact hypotheses to be evaluated at the interdisciplinary workshop. A brief summary of the results of this meeting would be prepared for distribution at the Catastrophic Oil Spill Group meeting and be included within the 1992/1993 BREAM Final Report.

2.1.1.2 Catastrophic Oil Spill Working Group

- It was suggested by one of the meeting participants that it may be more realistic to use small spill scenarios related to support/construction activities rather than a large offshore blowout scenario to evaluate impact hypotheses because oil and gas production from the Beaufort Sea region is unlikely to occur within the next 10 years. It was noted, however, that one of BREAM's mandates is to act on recommendations of the Beaufort Sea Steering Committee, specifically to address issues related to worst-case oil spill scenarios. Therefore, BREAM should deal with both realistic and worst-case spill scenarios.

- During the meeting, nine impact hypotheses were selected for review this year from a larger number formulated by the study team in 1991/92 (summarized in Table 4-1, Section 4.1). These hypotheses were expected to address those issues of greatest scientific and community concern in the event of an oil spill.

- The group identified a number of tasks to be completed by the Catastrophic Oil Spill Working Group prior to the workshop.

    - BREAM Hypotheses C-8, C-9 and C-11 should be combined to form one hypothesis that includes both the direct and indirect effects of an oil spill and cleanup activities on birds and their habitat.

    - Scenarios involving spills of refined fuel from barges and from trucks on winter roads should be developed in advance of the Community-based Concerns Working Group meeting. It was noted that the truck spill scenario would not represent a worst case because an effective cleanup response could be implemented. However, the barge spill scenario should be considered during the workshop to evaluate the effects of a river spill on fish resources because there have been a number of incidents in the Mackenzie River over the past year.

    - The list of VECs for each of the nine impact hypotheses would be finalized during the technical meeting of the Catastrophic Oil Spill Working Group.

- For each scenario, it will be necessary to determine the zone of influence of the spill in relation to the distribution of each VEC species and the amount of oil reaching the shoreline to evaluate impact significance. The Chairperson of the Working Group was charged with the responsibility of preparing maps for each of the scenarios to be considered during the workshop.

2.1.1.3 Catastrophic Oil Spill Workshop

- An agenda and tentative list of participants for the workshop was prepared during this meeting for finalization by members of the Catastrophic Oil Spill Working Group.
- It was agreed that the assessment procedure adapted from Duval and Vonk (1991) would be used during the workshop to determine impact significance.

2.1.2 Community-based Concerns Working Group

The second meeting of the Community-based Concerns Working Group was held on January 12, 1993 in Yellowknife, N.W.T. to continue the work initiated by this group during the 1991/1992 BREAM program. As in past years, this meeting was attended by representatives from federal and territorial government agencies, the pipeline industry, and northern communities and organizations (Appendix B). Specifically, the objectives of the meeting were to: (1) review the BREAM impact hypotheses related to catastrophic oil spills and routine aspects of hydrocarbon development to ensure that all community concerns are adequately addressed; (2) identify and discuss any outstanding community-based concerns and issues; and (3) continue exploring processes for identifying community-based ecological concerns and issues and incorporating local and traditional knowledge into the BREAM process. A summary of the results and conclusions of this meeting is presented in Section 3.

The single most important concern of participants at the meeting was that social and economic concerns related to northern oil and gas development are not currently being addressed by BREAM or any other program. Participants recommended that a process to address socio-economic concerns of northern residents be established and that this program be integrated with and compliment the BREAM process rather than exist as a separate parallel process.

The Community-based Concerns Working Group also identified a number of outstanding tasks that should be completed by the Group and/or the program sponsors. In addition to some minor changes to the existing impact hypotheses, the group recommended that a review of recent land-use planning documents be undertaken to identify oil and gas-related issues that have not been previously identified through the BREAM process.

2.1.3 Catastrophic Oil Spill Working Group Planning Meeting

2.1.3.1 Introduction

A technical meeting of the Catastrophic Oil Spill Working Group was held on January 14, 1993 in Richmond, B.C. and was attended by representatives of government agencies and industry, and members of the study team (Appendix C). The objective of this meeting was to prepare for an interdisciplinary workshop to be held from February 22-25 in Inuvik to focus on three different oil spill scenarios and nine impact hypotheses. The following tasks were completed during the meeting:

1. review of ecological concerns related to oil spills and their cleanup that were identified in the Community-based Concerns Technical Meeting held on January 12 in Yellowknife;

2. modification of any of the impact hypotheses related to catastrophic oil spills as appropriate given the results of this earlier meeting;

3. review of each of the three oil spill scenarios that will be the focus of the workshop;

4. review of the nine impact hypotheses that were recommended for detailed evaluation this year by participants in the Project Initiation Meeting to:

    (a) define the VECs/VSCs or refine those already stated in the hypotheses;

(b) review and revise, as necessary, the hypothesis statements and the organization of their linkages;

(c) determine key individuals that should be involved in the review of each hypothesis, and finalize the tentative list of workshop participants prepared at the Project Initiation Meeting; and

(d) define information needs for the workshop including important literature sources and other documents.

5. discussion of the procedure that will be used to assess, in a preliminary manner, the environmental significance of the impacts described in each hypothesis; and

6. finalization of any logistical arrangements for the February 22-25 workshop in Inuvik.

At the outset of the meeting, concerns were expressed over whether it is reasonable to use only three oil spill scenarios to evaluate the impact hypotheses and identify research needs. The potential impacts of any oil spill would be highly variable and depend in part on conditions surrounding the event. Hence, any research and monitoring needs identified during evaluation of a given hypothesis will reflect the time and space considerations implied by the scenario. In addition, there was concern that the dates specified within the scenarios may not coincide with critical times of all VEC species considered in each of the impact hypotheses. This concern was also expressed by participants in the Community-based Concerns Working Group meeting.

Due to time and financial limitations it was necessary to select only a worst-case scenario for each of the nine hypotheses that will be evaluated in the workshop. It was stressed that the scenarios are provided only as a tool to help evaluate the hypotheses, and there is the flexibility to modify the timing or location of the scenario to reflect a worst case for all VECs. It was agreed that this could be accomplished by either selecting an appropriate time window for the scenario or specific times that coincide with sensitive periods for each VEC considered in the hypothesis.

2.1.3.2 Review of the Community-based Concerns Working Group Meeting

An overview of the Community-based Concerns Working Group meeting held earlier in the week was presented during the morning session of the meeting. Comments and suggestions made by participants are presented below.

- It was suggested that members of the Community-based Concerns Working Group should prepare a table that identifies issues addressed by existing BREAM hypotheses and those community concerns that have been documented through several of the land-use planning processes to determine whether there are any outstanding ecological issues related to northern oil and gas development that still need to be addressed by BREAM. It was noted that the report on the Community Non-Renewable Resource Development Workshops (1989) is likely the most complete source of documented community-based concerns.

- A description of all 18 catastrophic oil spill hypotheses should be provided to workshop participants to indicate those issues that have been considered by BREAM but will not be addressed at this year's workshop.

- While an east-west pipeline route is not currently proposed in any development plan, it was noted by an industry representative that if such a pipeline was considered over the long term, it would be a gas line constructed in the offshore rather than onshore due primarily to economic considerations.

2.1.3.3 Review of the Oil Spill Scenarios

Overviews of the three oil spill scenarios selected for use in the February workshop were presented during the meeting. The following summarizes comments made by participants during this presentation.

Island Platform Scenario

- It was agreed that reference to August 1 in the timing of this scenario should be deleted and changed to July - early October to coincide with the presence of many of the VEC groups.

- There was discussion of the rationale for selection of an island platform scenario rather than a subsea blowout. It was noted that much of this scenario was based on the worst-case scenario developed by Task Group #1 of the Beaufort Sea Steering Committee, which involves a short-term, high-flow blowout. (A long-term high-volume scenario is not realistic for the Beaufort Sea because the sand would collapse and naturally cap the spill.) In the future, industry will likely be concentrating their efforts in shallower water where the risk of a sub-sea blowout is less.

- Selection of these three scenarios was considered important because it helps ensure involvement of representatives from the Inuvialuit, Sahtu, Deh Cho and Gwich'in regions.

- It was suggested that each workshop subgroup set aside adequate time to discuss relevant issues that are not addressed by each hypothesis that will be evaluated.

- Concern was expressed that it may not be reasonable for this scenario to involve stranding of oil onshore in the Delta because the Mackenzie River plume would likely prevent oil from reaching the shore in this area. It was eventually agreed, however, that this would probably represent a very worst case scenario. It was stressed that the scenarios are only intended as a framework for evaluating the hypotheses.

- It was suggested that rationale for development of this and the other two scenarios be prepared for presentation at the workshop and for inclusion in the final report. It will be important to make a clear distinction between this scenario and the scenario presented during the Gulf Kulluk EIRB review, which will be familiar to community representatives.

Fuel Barge Spill into the River in Summer

- This scenario was selected to represent a plausible spill involving a highly-toxic and dispersible refined product, which could have a significant effect on the survival of fish in the area. It was assumed that the spill could occur at any time during open water that coincides with sensitive periods in the life history of the species in the VEC group. However, it was noted that the sensitive life stages of fish (larvae) usually are dispersed along the coast by the time that barges begin travelling down the Mackenzie River after freshet.

- In response to concerns expressed during the Community-based Concerns Working Group Meeting, there was discussion regarding the selection of diesel oil rather than No. 4 heavy oil for this scenario. It was noted that while No. 4 oil is buoyant and would tend to remain on the water surface as a slick, No. 2 fuel is substantially more toxic. Selection of oil type for a worst-case scenario would, therefore, depend on the VEC group being considered in the impact hypotheses.

- It was agreed that justification for the timing, location and oil type should be provided in the overview of scenarios presented to workshop participants.

Oil Pipeline Break at a River Crossing in Summer

- It was noted that this scenario does not include any provision for oil being deposited along river bottom substrates through sedimentation. Although little is known about oil/particle interactions, it was suggested that assumptions can be made regarding the volume of oil and approximate locations along the river where oil would tend to settle following interactions with suspended sediments carried by the river.

- Concern was expressed that a pipeline spill during winter was not being evaluated in the workshop. The most critical time for birds would be at the start of break up when large concentrations of birds are present and oil trapped beneath an ice cover would begin to reach the surface through cracks in the ice. Considerable discussion was directed at the time of year when a pipeline break could result in the most extensive oiling of the shoreline and may have the most serious effects on birds and terrestrial and semi-aquatic mammals. It was noted that there is a greater capacity for wetlands to strip oil out onto the shore during the higher flows associated with spring freshet. However, if the spill occurred in winter, most of the oil would be encapsulated in ice and pool along the edge and under side of the ice. At break up, oil would tend to settle in low flow areas along the river banks.

- It was suggested that copies of all scenarios could be provided to workshop participants to allow the subgroups to work on alternate scenarios, if they wish to do so, after the primary scenarios have been addressed.

2.1.3.4 Review of the Nine Impact Hypotheses

Meeting participants were assigned to one of three subgroups (Marine Mammals and Fish; Terrestrial and Semi-Aquatic Mammals; Birds) to review the impact hypotheses that each group would be responsible for evaluating during the workshop. This review involved: (1) selection of the spill scenario that best addresses the issues that form the basis of the hypothesis; (2) selection of VECs and VSCs for each hypothesis; (3) refinement of the hypothesis structure and wording, including suggestions made by the Community-based

Concerns Working Group as appropriate; (4) finalization of the participant list for the subgroup; (5) identification of information needs for the workshop; and (6) highlighting of any outstanding issues that need to be resolved by the Working Group prior to adjournment of the meeting. The following summarizes the major conclusions of each subgroup. Recommended participant lists for each group are presented in Tables 2-1, 2-2, and 2-3.

Marine Mammals and Fish

BREAM HYPOTHESIS C-1:

- The timing of the island platform blowout scenario should be selected on the basis of the marine mammal VEC species being considered.
- No changes to the VECs or the hypothesis structure were considered necessary by the group. The VECs were to include:
  - Bowhead whale
  - Ringed seal
  - Polar bear
  - Beluga whale
  - Bearded seal
- As a result of suggestions made by the Community-based Concerns Working Group, Link 7 was reworded to include reference to consumption of oiled carrion. The present wording of the linkage is as follows; "Marine mammals (including polar bear and arctic fox) can ingest oil directly from the water or by eating oiled prey and carrion."
- It was emphasized that the most recent data on the abundance and distribution of each VEC species should be brought to the workshop by the discipline specialists.

BREAM HYPOTHESIS C-17:

- The group agreed with the selection of the island platform blowout scenario for evaluation of Hypothesis C-17. The timing of the spill should depend on the life history stage of the fish VEC species being considered.

- The group deleted lake trout, Arctic grayling and pike from the list of VECs. VECs for Hypothesis C-17 now include:

  - Broad whitefish
  - Inconnu
  - Arctic cisco
  - Arctic charr
  - Arctic cod
  - Pacific herring
  - Lake whitefish
  - Burbot

- The recommended changes to Hypothesis C-17 were as follows:

  (1) Hypothesis C-17 was revised to address community concerns related to tainting of bottom-feeding fish through ingestion of oiled benthic fauna and subsequent changes in species harvest. A number of linkages were added to the hypothesis to include this issue.

  (2) Link 6 now refers to estuarine and marine fish species rather than specifically to Arctic cod and Pacific herring. Similarly, Links 9 and 11 refer to freshwater and estuarine species rather than only Arctic cod, Pacific herring and Arctic cisco.

- The following list of information needs for the workshop was prepared.

  - Maps indicating oil spill fate and trajectory
  - Maps of sensitive areas for coastal fish
  - Beaufort Sea Oil Spill Atlas
  - NOGAP Fisheries Data Reports and other DFO Technical Reports
  - Beaufort Sea Steering Committee reports (particularly Task Group #2 reports)
  - Literature on effects of oil ingestion
  - Recent fish harvest data (available through the FJMC)

BREAM HYPOTHESIS C-18

- The scenario involving a diesel fuel spill from a river barge in summer was selected for evaluation of Hypothesis C-18. It was noted that a spill occurring during spring or under ice would have a greater potential to cause lethal effects on sensitive larval fish. However, because barges do not operate on the Mackenzie until after freshet when most of the larvae drift is dispersed along the coast, this scenario was not considered realistic. It was suggested, however, that the subgroup could evaluate a hypothesis involving a river spill under ice if there was sufficient time after evaluation of the primary hypotheses.

- The VECs for Hypothesis C-18 were to include:

  - Inconnu
  - Lake whitefish
  - Burbot
  - Least cisco
  - Broad whitefish
  - Arctic cisco

- A number of changes to the hypothesis were made to reflect concerns related to acute toxic effects, and tainting of fish from oil on the bottom and on the water surface.

  (1) Links were added to relate oil on the river bottom and on the water surface to tainting and subsequent changes in harvest.

  (2) The linkage leading to no effect was deleted.

  (3) Links were added to relate oil dissolved in water to lethal effects on fish, which then result in reduced populations of the VEC species and changes in harvest levels.

  (4) References to specific fish species in Links 15 and 17 were removed. The linkages now refer to all VEC species addressed by this hypothesis.

- The group identified the following documents as information that would be important to have available for reference at the workshop.

  - Community-based resource maps
  - Land use planning maps
  - Harvest data from various DFO Technical reports and FJMC reports

TABLE 2-1
RECOMMENDED MARINE MAMMAL AND FISH SUBGROUP

NAME	AFFILIATION
Dave Bernard Facilitator	ESSA Ltd.
Rolph Davis Rapporteur - Hypothesis C-1	LGL Limited
Michael Lawrence Rapporteur - Hypotheses C17 and C18	North/South Consultants Inc.
John Harper	Coastal and Ocean Resources Inc.
Martin Bergmann	Department of Fisheries and Oceans
Lois Harwood	Department of Fisheries and Oceans
Sue Cosens	Department of Fisheries and Oceans
Lyle Lockhart	Department of Fisheries and Oceans
Brian Fergusson	Department of Fisheries and Oceans
Jerry Payne	Department of Fisheries and Oceans
Unspecified Representative	Fisheries Joint Management Committee
Billy Archie	Inuvialuit Settlement Region
Evan Birchard	Esso Resources Canada Ltd.
Jim Swiss or Peter Devenis	Canadian Petroleum Association
Charlie Hoagak	Inuvialuit Settlement Region

Terrestrial and Semi-aquatic Mammals

BREAM HYPOTHESES C-3 AND C-6:

- It was agreed that the pipeline river spill scenario was the most appropriate scenario to use for evaluating Hypotheses C-3 and C-6 because it would potentially affect a larger geographic area than the barge spill, and is an issue of importance to residents of the Sahtu and Deh Cho Regions. This scenario would help to address concerns related to attraction of predators (i.e., grizzly and black bear, lynx, wolf, red fox, mink and wolverine) to oiled carrion, and contact of terrestrial and semi-aquatic mammals (i.e, bears, moose, muskrat, beaver, mink and wolf) with oil during swimming. It would be assumed that the spill occurs sometime during the open-water period to coincide with sensitive periods for each of the VEC species.

- The VECs to be considered in Hypothesis C-3 were as follows:

  - Black Bear
  - Wolf
  - Grizzly Bear
  - Wolverine
  - Fisher
  - Moose
  - Red Fox
  - Lynx
  - Marten

- The following revisions were made to Hypothesis C-3:

  (1) The wording of Links 14 and 15 was changed from "increased interactions between humans and bears, and between humans and foxes" to "increased interactions between humans and bears, foxes or wolves".

  (2) All references to restoration have been changed to habitat restoration.

  (3) A linkage was added to the hypothesis to address concerns related to the possible effects of tainting, or perceived tainting on the harvest of the VEC species.

- The VECs that would be considered in Hypothesis C-6 were:

  - Beaver
  - Muskrat
  - Mink

- The following revisions were made to Hypothesis C-6:

  (1) The wording of Link 5 was changed to include reference to ingestion of oil through fouling of food caches (muskrat, beaver), consumption of oiled prey (mink), and grooming of oiled fur.

  (2) A linkage was added to the hypothesis to address concerns related to the possible effects of tainting, or perceived tainting on the harvest of the VEC species.

- The group identified the following documents as information that would be useful at the workshop.

  - Beaufort Sea Oil Spill Atlas
  - GNWT Key Wildlife Maps
  - River charts
  - Oil effects literature

BREAM HYPOTHESIS C-5

- It was agreed that the scenario involving an open-water island platform blowout is the most appropriate scenario to address issues related to caribou and insect-relief habitat, muskrat and mink in the outer edges of the Delta, scavenging of oiled carrion by grizzly bear, wolf, red and arctic fox, wolverine and mink, and disturbance of VECs. These issues are of importance to residents in both the Gwich'in and Inuvialuit regions.

- The VECs selected for this hypothesis and their sensitive life history stages were as follows:

▸ Muskrat	Year round but particularly during spring when young are present
▸ Mink	Year round but particularly vulnerable during under-ice use
▸ Wolverine	Primarily during carrion feeding
▸ Wolf	During carrion feeding and swimming
▸ Caribou	During insect relief, and migration across Mackenzie tributaries
▸ Grizzly bear	During carrion feeding and swimming
▸ Arctic fox	During carrion feeding
▸ Red fox	During carrion feeding

- Several changes were made to the structure of the hypothesis and the wording of linkages.

  (1) Link 5 was reworded to include reference to ingestion of oil through fouling of food caches (muskrat and beaver), consumption of oiled prey (mink), and grooming of oil-contaminated fur.

  (2) All reference to cleanup and restoration have been changed to "containment, cleanup and habitat restoration".

  (3) A linkage was added to the hypothesis to address concerns related to the possible effects of tainting, or perceived tainting on the harvest of the VEC species.

- The group identified the following documents as information that would be useful at the workshop.

    - Beaufort Sea Oil Spill Atlas
    - GNWT Key Wildlife Maps
    - Map of the Mackenzie Delta
    - Oil effects literature

TABLE 2-2
RECOMMENDED TERRESTRIAL AND SEMI-AQUATIC MAMMALS SUBGROUP

NAME	AFFILIATION
Jeff Green (Facilitator)	Delta Group Ltd.
Patricia Vonk (Rapporteur)	Axys Group Ltd.
Brian Slough	Yukon Territorial Government
Paul Latour	Government of the Northwest Territories
John Hayes	Interprovincial Pipelines Ltd.
To be determined	Wildlife Health Specialist/Oil Spill Effects Specialist
Johnny Charlie/Steve Kotchea	Porcupine Caribou Management Board/Fort Liard
Charlie Hoagak/Joe Benoit	Inuvialuit Settlement Region/Gwich'in Region
Don Russell	Environment Canada (CWS)
John Nagy/Peter Clarkson	Government of the Northwest Territories

Birds

- The group merged Hypotheses C-8, C-9 and C-11 to form one complex hypothesis that deals with the effects of direct contact with oil, contaminated waterfowl habitat and waterfowl foods, and disturbances associated with spill response activities. Three spill scenarios were selected to evaluate the new hypothesis. These include: (1) a pipeline spill at a river crossing in late May (just before breakup); (2) an island platform blowout in summer; and (3) a diesel spill from a river barge in summer. The location for the pipeline spill was changed from Fort Simpson to Norman Wells to coincide with the presence of a large number of birds. It was assumed that most of the oil would be trapped in pools within the ice canopy until breakup, after which time both sides of the river would be sporadically oiled for a 10-km reach downstream.

- Ten (10) VECs were selected for this hypothesis. These include:

  - Snow geese
  - Loons
  - Common eider
  - Brant
  - Phalaropes
  - Ducks
  - Raptors
  - King eider
  - Black guillemot
  - Thick-billed murre

- The group identified the need to have maps for each of the three locations of the spills, as well as literature discussing the impacts of the *Exxon Valdez* spill to evaluate the three scenarios and hypothesis.

TABLE 2-3
RECOMMENDED BIRDS SUBGROUP

NAME	AFFILIATION
Dave Thomas (Facilitator)	Axys Group Ltd.
Steve Johnson (Rapporteur)	LGL Limited
Rolph Davis	LGL Limited
Ian Buist	SL Ross Environmental Research
Lynne Dickson	Environment Canada (CWS)
Bob Bromley	Government of the Northwest Territories
Jim Hynes/Jim Hawkings or Dave Mossop	Environment Canada (CWS) or Yukon Territorial Government
D. Brown	Bedford Institute of Oceanography
Community Rep (unspecified)	Sahtu Region
John Piatt	Alaska Fish and Wildlife Service

2.1.3.5 Assessment Component of the Hypothesis Evaluation

There was discussion of the use of the Duval and Vonk (1991) assessment procedure in determining impact significance to help establish priorities for research and monitoring. Concern was expressed by some participants over the use of the terms "significant" and "insignificant" (because of their legal connotation in the assessment framework followed in Canada) and how these would be used to assign priority. It was suggested that the terminology be changed, however, no conclusions were reached on alternative terminology. After the meeting, it was decided that the Duval and Vonk methodology would not be altered and that an attempt would be made to use the procedure in its existing form during the workshop.

2.1.3.6 Community Meeting and Participation in Workshop

During the meeting, considerable discussion occurred among some meeting participants regarding the format, objectives and logistics of the open community session, which was originally planned for the evening of Monday, February 22. However, due to time and financial constraints it was eventually concluded that members of the community would be invited to the opening and closing plenary sessions as a means of providing a vehicle for public input and understanding of the BREAM process. To help meet this goal, INAC prepared a brief description of the history of BREAM for distribution from government offices in Inuvik. A Special Service Announcement was also prepared by INAC and broadcast by CBC North for a week in advance of the workshop, as well as during the period of the meetings.

3. COMMUNITY-BASED CONCERNS

Prepared by
Dave Bernard
ESSA Environmental and Social Systems Analysts Ltd.

3.1 Introduction

This chapter summarizes discussions that occurred during the second meeting of the Community-based Concerns Technical Working Group, held in Yellowknife, N.W.T. on 12 January 1993.

The main role of the Community-based Concerns Technical 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 BREAM in 1991/92, activities of this Working Group focused on introducing the BREAM process to northern communities and on identifying some of the environmental issues of concern 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 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.

3.1.1 Meeting Preparation

Following the Project Initiation Meeting in November 1992, regional organizations in the Mackenzie Valley and Beaufort Sea regions were invited to attend the second meeting of the Community-based Concerns Working Group. These organizations were asked to select a representative familiar with BREAM and with the relationship of hydrocarbon developments to the region's ecology. From the outset it has been emphasized to the Working Group members that BREAM focuses on ecological concerns, and that social and economic issues associated with hydrocarbon development are outside the scope of the program.

In preparation for the technical meeting, a package of materials was distributed to each participant. This package contained:

1. List of participants invited to the technical meeting
2. An agenda for the technical meeting
3. BREAM Overview
4. BREAM Update No. 3
5. The current hydrocarbon development scenario for the Beaufort Sea/Mackenzie Delta region
6. Nine impact hypotheses
7. The proposed method for determining environmental significance
8. Three oil spill scenarios
9. The Community-based Concerns section from the 1990/1991 BREAM report

3.1.2 Technical Working Group Members

The Community-based Concerns Working Group this year consisted of representatives from the federal and territorial governments, the oil and gas industry and northern communities. These northern communities and organizations were represented at the meeting:

- Joint Secretariat, Inuvialuit Settlement Region;
- Gwich'in Tribal Council, Gwich'in Settlement Region;
- Shihta Regional Council/Development Impact Zone Committee, Sahtu Region;
- Deh Cho Regional Council, Deh Cho Region; and
- Fort Liard Band.

Unfortunately, representatives of the Porcupine Caribou Management Board and the Inuvialuit Game Council were unable to attend. A list of participants is provided in Appendix B.

3.1.3 Meeting Objectives

At this year's meeting, members of the Technical Working Group focused their attention on these objectives:

1. Identification of ecological concerns of northern residents specifically related to large oil spills and their cleanup. This was accomplished by reviewing the new impact hypotheses formulated for the catastrophic oil spill component of BREAM to ensure that community environmental concerns are adequately addressed;

2. Continued exploration of processes for identifying community-based ecological issues and concerns, and incorporating local and traditional knowledge into the BREAM program. This involved examination and refinement of the conceptual model developed last year for accessing and incorporating traditional and local knowledge into decisions related to environmental research and monitoring;

3. Review of the list of issues and concerns that was produced during the previous meeting to determine whether or not each of these items has been adequately incorporated into the current set of BREAM impact hypotheses; and

4. Identification and refinement of any outstanding community-based ecological concerns or issues.

Finally, the meeting also provided Working Group members with another opportunity to develop an understanding of the BREAM Program. This helped prepare them for the BREAM technical workshop, held in Inuvik during March.

3.2 Community Concerns

At last year's Working Group meeting, participants identified these 13 issues and areas of concern:

1. baseline data collection and monitoring,
2. fish quality,
3. solid waste disposal sites and associated contaminants,
4. catastrophic oil spills,
5. refined oil spills,
6. east-west pipeline route,
7. effects of increased ambient noise and traffic,
8. cumulative effects of industrial developments,
9. process-related issues and concerns,
10. accessing and incorporating traditional knowledge into BREAM,
11. Northern community participation,
12. existing sources of community-based ecological concerns, and
13. social and economic concerns.

To date, BREAM has addressed all items except numbers 3, 6, and 13. Because Indian and Northern Affairs Canada (INAC) has initiated, under the Arctic Environmental Strategy, activities to clean up abandoned solid waste disposal sites, participants in this year's meeting indicated that item 3 is no longer a significant issue.

Regarding item 2, it was agreed that Hypothesis R-26 adequately addresses the issue of fish quality. However, concerns were expressed that adequate research is still not being directed at this subject.

With respect to item 12, participants noted that several recent land-use planning processes have included extensive community consultation, which has led to documentation of concerns and issues related to northern oil and gas development. Copies of some references were provided during the meeting:

- Wildlife Management Advisory Council (North Slope). 1992. Yukon North Slope: Wildlife Conservation and Management Plan, Volume 2. 53 pp.
- Wildlife Management Advisory Council (North Slope). 1992. Yukon North Slope: Wildlife Conservation and Management Plan, Volume 2. Summary. 15 pp.
- Community Non-Renewable Resource Development Workshops: Holman, Aklavik, Inuvik, Paulatuk, Sachs Harbor, Tuktoyaktuk, Fort McPherson, and Arctic Red River.
- Robinson, M.P. 1989. Non-renewable resources in the Mackenzie Delta Beaufort Sea Land Use Planning Region. Workshop Proceedings.
- Livingston, D. 1989. Non-renewable resources development. Options Paper.

It was suggested that these documents be reviewed as part of BREAM to produce a synthesized list of issues related to oil and gas development and help identify those issues that have not been previously recognized by the project.

3.2.1 Current and Emerging Issues and Concerns

The single most important outstanding issue that workshop participants expressed was that social and economic concerns related to northern oil and gas development (issue 13 on above list) are currently not being examined by BREAM or any other program. Participants strongly recommended that a program to investigate social and economic concerns should be integrated with and be complimentary to BREAM, rather than a separate, parallel process as suggested in earlier BREAM reports. Others argue, however, that social and economic issues are quite distinct from the largely scientific questions addressed by BREAM and that integration of the former topics within the BREAM framework is not only inappropriate but could fail to adequately address social and economic concerns of northerners [because the tools employed by BREAM may be ineffective for evaluation of non-ecological questions]. This subject is discussed in some detail in Section 3.4, below.

Participants also reiterated the importance of baseline data collection and monitoring. Some members of the group stated that there does not appear to be any scenario or hypothesis that directly addresses northern concerns related to spills of refined oil products. It is assumed that this is due to a misunderstanding by some participants as to what constitutes a refined oil product because the one of three scenarios proposed involved a diesel (No. 2) fuel spill from a river barge. The issue of an east-west pipeline route was not raised this year.

3.2.2 Incorporating Traditional Knowledge

Again this year, a considerable amount of time was spent discussing not only the value of accessing and incorporating traditional knowledge into BREAM, but also the mechanics of doing so. After reviewing the model developed last year, participants suggested revisions that appear in Figure 3-1. They also suggested that personnel involved in BREAM contact John Newton of the Arctic Institute (Calgary) to investigate methods used by his group in accessing and using traditional knowledge as part of his ongoing snow studies.

3.3 Catastrophic Oil Spill Hypotheses

3.3.1 Scenarios

Three oil spill scenarios were originally developed for consideration during the Catastrophic Oil Spill workshop scheduled for late February 1993 in Inuvik, N.W.T [later increased to four scenarios]. These were:

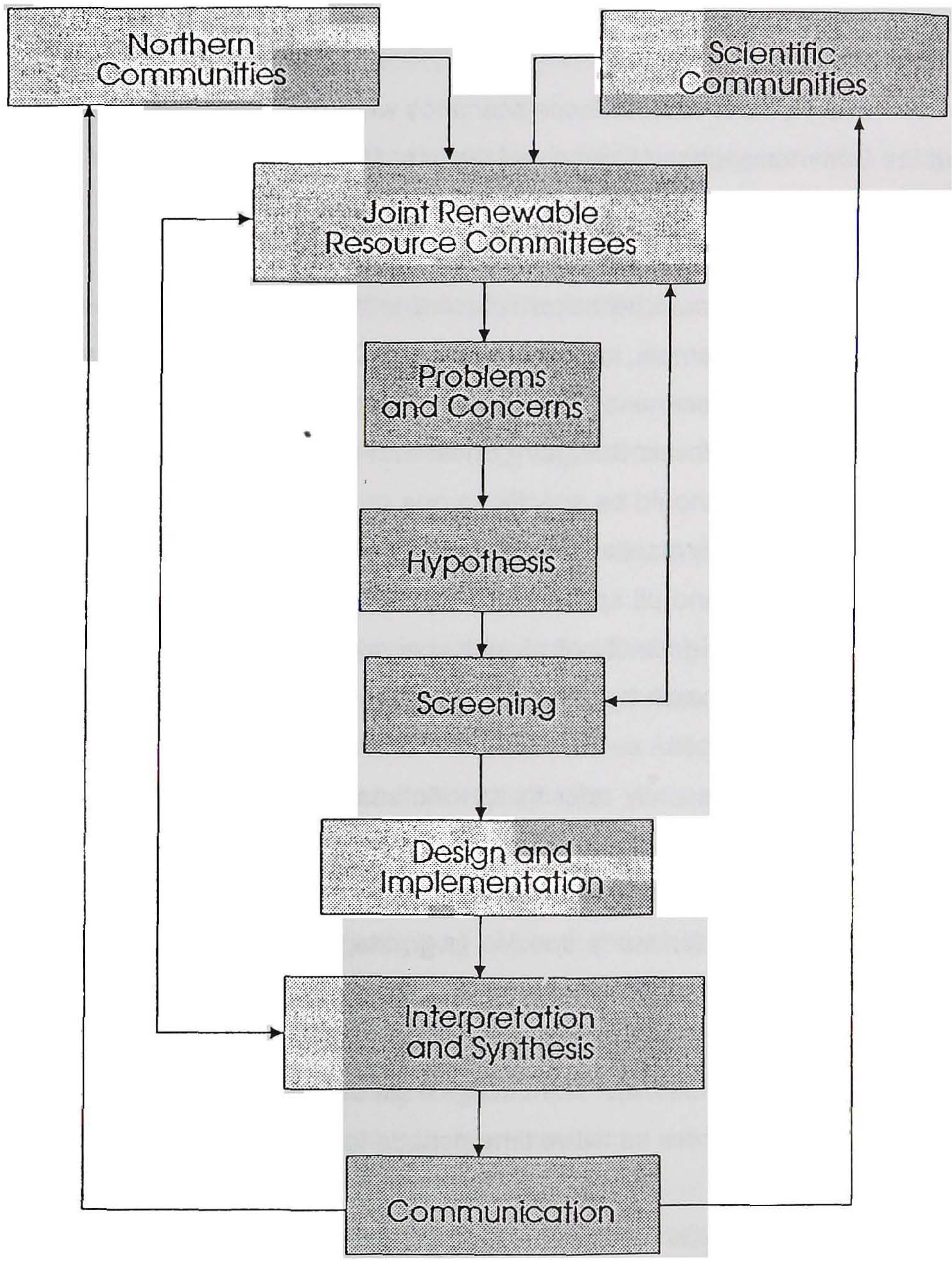

Figure 3-1: Model for Incorporating Community-based Concerns and Traditional Knowledge into the BREAM Process

1. Fuel barge spill into the river in summer,
2. Oil pipeline break at a river crossing in summer, and
3. Island platform blowout scenario.

Overviews of each of these scenarios were presented during the early afternoon session of the Community-based Concerns Meeting. Major comments on the scenarios by the community representatives were as follows:

- Scenarios should be better reflected in the impact hypotheses for catastrophic spills. For example, Impact Hypotheses C-8, C-9 and C-11 are not specific to any of the three scenarios. It was suggested that for the February workshop, the Impact Hypothesis Summary Sheet and the detailed descriptions of the impact hypotheses should be specific to one or more of the three spill scenarios. This comment likely resulted from misunderstanding of the different purposes of impact hypotheses and oil spill scenarios in BREAM - an impact hypothesis should be applicable to a variety of oil spill scenarios, which are only a tool to aid in the evaluation of each hypothesis.

- Scenarios presently refer to specific seasons or dates (i.e., fuel barge spill in summer, pipeline break in summer, blowout on 1 August). Participants expressed concern that these dates may not reflect worst case scenarios because sensitive time periods for many species (e.g., staging of waterbirds, calving) would be temporally separated from the timing of the hypothetical spills. Substantial discussion occurred on important life history periods for individual VECs or groups of VECs (see below). The timing of the scenarios should be modified to reflect as many of these sensitive time periods for VECs as possible.

  The following life history phases for the major groups of VECs were identified by participants:

- Birds: spring and fall staging, moulting, nesting and brood rearing.
- Terrestrial Mammals: migrations (caribou), insect relief (caribou), calving (moose on river islands) and carrion feeding.
- Semi-Aquatic Mammals: spring breakup and open water (muskrat and beaver).
- Marine Mammals: breakup, birth, feeding (bowheads in the Beaufort Sea during summer).
- Fish: spawning, overwintering, migration.
- Epontic (under ice) flora and fauna: early spring prior to breakup.
- Landscape Quality: during the spring freshet for all river scenarios; during open water storm surges for the blowout on an oil platform in the Beaufort Sea. It was noted that the Beaufort Sea Atlas could serve as a database for coastal zone landform categories.

- It was suggested that a scenario be developed to address the effects of a spill of diesel oil resulting from the tipping of a tanker truck on an ice bridge onto the river ice surface and subsequent rupture of the diesel tank. It was noted by the facilitators that a number of possible spill scenarios had been considered for the Oil Spill Workshop, including a tanker truck spill on an ice bridge. However, due to time and financial constraints, a maximum of nine hypotheses could be considered during the workshop. The hypotheses selected were expected to address the most important issues related to major oil spills in the region. Furthermore, project staff rejected the tanker truck scenario as it would not constitute a "catastrophic" event in comparison with the other scenarios for the project.

- It was also recommended that the Fuel Barge Scenario be changed from a spill of diesel oil to No. 4 Heavy Oil, as (1) large volumes of this oil are shipped along the Mackenzie River annually, and (2) effects of a heavy oil spill on the environment would be more severe than a diesel oil spill. However, available oil effects literature does not substantiate the second point for most resource categories and, therefore, this recommendation was not accepted by BREAM management staff.

3.3.2 Selection of Valued Ecosystem Components (VECs)

The list of potential VECs for consideration during the Catastrophic Oil Spill workshop was presented to the meeting participants (Table 3-1). A number of additions and deletions to this list were suggested. It should be noted that many of these suggestions do not meet the three VEC criteria used to date in BREAM (and its predecessor programs BEMP and MEMP) to establish VECs. *VECs are activites, 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.* Further consideration of these suggestions will be necessary before they can be established as VECs within BREAM.

- Tundra Swans should be included as a bird VEC as they are becoming increasingly abundant in the Deh Cho region and are more commonly harvested by residents than in previous years.

- Black Brant should also be included as a bird VEC.

- Marine ducks, especially the Old Squaw, should be included as a VEC (although they were already on the list - Table 3-1).

TABLE 3-1

LIST OF VALUED ECOSYSTEM COMPONENTS (VECs) FOR CATASTROPHIC OIL SPILLS AND ASSOCIATED COUNTERMEASURES

(VECs proposed by Community-based Concerns [CBC] Working Group are indicated in italics)

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 (*CBC Group recommended removal)*
   - ▸Wolverine
   - ▸*Mink*
   - ▸*Black bear*
   - ▸*Lynx*

   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
   - ▸Raptors
   - ▸Loons
   - ▸Common eider
   - ▸King eider
   - ▸Thick-billed murre
   - ▸Black guillemot
   - ▸Phalaropes
   - ▸*Tundra swans*
   - ▸*Black brant*
   - ▸*Ravens*

   e. Epontic organisms

- Ravens would be likely to attempt to scavenge oil-contaminated carcasses and should be included as a bird VEC.

- Marten are not an appropriate mammal VEC as they would not be highly susceptible to contact with oil on the river or along the Beaufort Sea coastline.

- Mink should be included as a mammal VEC because there is a high risk that they would be fouled by oil in the Mackenzie River, or by transport of oil from an offshore blowout into wetlands on the Mackenzie Delta during storm surges. Effects of oil on the mink population would be of concern to the Gwich'in.

- Black bear should be considered a VEC, especially in the Sahtu and the Deh Cho regions.

- Lynx should be included as a mammal VEC as they may be a good indicator of food chain effects resulting from a spill (e.g., consumption of oiled vegetation or oil by snowshoe hares and predation of snowshoe hares by lynx).

- As recently reported from the Shetland Island oil spill, fumes can have a direct effect on air quality, humans (e.g., odours) and wildlife. While air quality is already a VEC with respect to particulate emissions resulting from burning of oil in a cleanup response, it was suggested that effects of hydrocarbon vapours be addressed in any hypothesis dealing with air quality issues.

The facilitators noted that while all of the VECs in the list (Table 3-1) were selected in part because of their importance to native communities, scientists and/or regulators may also elect to evaluate some species that may provide evidence of potential effects of oil spills on other populations or habitats (i.e., the concept of key or indicator species). Suggestions by the community participants for modifications to the list of VECs were discussed with the species specialists at the Catastrophic Spill Working Group Technical Meeting in January. Some of the recommendations of the Community-based Concerns Working Group were adopted, while others were not on scientific grounds (e.g., ravens should not be a VEC just because they may scavenge on oil-contaminated carcasses).

A general concern of several community participants was that the selection of VECs appeared to exclude effects on important prey species and subsequent food chain effects for higher level predators. In addition, as discussed below, several impact hypotheses explicitly excluded food chain effects. Such effects are important to the communities, since tainting and contaminant effects may occur as a result of biomagnification and bioaccumulation of hydrocarbons. The facilitators noted that food chain effects are addressed in some hypotheses (e.g., effects on benthic invertebrates and subsequent effects on fish). Similar linkages should be included in hypotheses dealing with birds, terrestrial and semi-aquatic mammals, and marine mammals.

3.3.3 Review of Selected Impact Hypotheses for the Catastrophic Oil Spill Workshop

A total of eighteen (18) impact hypotheses were developed by members of the 1991-92 BREAM study team to describe the major effects of catastrophic oil spills on air quality, water quality, coastlines, landscape quality, populations and harvest of wildlife (i.e., marine and marine-associated mammals, terrestrial and semi-aquatic mammals, fish, and birds), and epontic communities. Due to time constraints implicit in a 3-day workshop, the BREAM Project Manager proposed nine (9) hypotheses for detailed review and assessment. These nine hypotheses were reviewed by the meeting participants and the specific comments on each are provided below.

3.3.3.1 C-1: Offshore Blowout of Crude Oil vs. Marine Mammals

- Link 7 should include consumption of oiled carrion by polar bears and Arctic foxes.

- The scenario should occur in early July when polar bears and whales are still present in the Beaufort Sea region, instead of 1 August as proposed in the existing scenario.

3.3.3.2 C-3: Pipeline River Spill of Crude Oil vs. Terrestrial Mammals

- Some community participants wanted to see similar hypotheses for waterfowl and fish. Because communities such as Fort Simpson draw their drinking water directly from the Mackenzie River, effects on water quality should also be considered. It was noted by the facilitators that effects on waterfowl and fish are considered in other hypotheses, whereas water quality is included in hypotheses for fish (although effects on human water supplies are not directly addressed).

- The impact hypothesis should address mammal species other than grizzly bear and Arctic fox. In particular, black bear and moose should be assessed.

- Food chain effects (i.e., consumption of contaminated vegetation or prey) are not considered in this impact hypothesis. If they are not addressed in another hypothesis, they should be included here.

3.3.3.3 C-5: Offshore Well Blowout of Crude Oil vs. Semi-Aquatic Mammals

- Mink should also be included in the hypothesis.

- In Link 2, oil cleanup activities should be added to the list of important activities.

- Participants suggested that the hypothesis should address the long-term time frame required for habitat restoration (e.g., mitigation of habitat losses is difficult and will require decades). It was also suggested that cleanup activities could cause more damage, particularly if permafrost will be affected, than leaving the oil *in-situ* and allowing natural processes to break down the oil. These and other concerns will be evaluated by the subgroup established to consider the impact hypothesis at the interdisciplinary workshop.

3.3.3.4 C-6: Pipeline River Spill of Crude Oil vs. Semi-Aquatic Mammals

- The introduction for the hypothesis should include a description of the timing of the spill in relation to the spring freshet on the Mackenzie River, and the potential for oil to be carried high onto the shore and floodplain during peak flood levels.

- The statement in the introductory paragraph that "muskrat and beaver could be affected" should be changed to "will be affected". Similar changes should be incorporated into all hypotheses.

- Mink should be included as a VEC for this hypothesis.

- Participants questioned why the term "individuals" was included in Link 7 and 8. The facilitators noted that fouling and ingestion are effects that involve individual animals, whereas other effects involve populations and/or their habitat. It was suggested that the statement could be clarified by the use of the term "individual animals" rather than "individuals". It was also noted by one participant that muskrat and beaver normally occur in family groups, and that a spill would likely result in fouling of all or most of a family unit comprised of several animals of different age groups, rather than just an individual animal. Mutual grooming within a family group could also result in ingestion of oil by fouled and unfouled animals.

- Linkages reflecting food chain effects should also be included in this hypothesis. These should include food chain effects for semi-aquatic mammals, as well as food chain effects on predators of these species.

3.3.3.5 C-8 through C-9: Oil/Condensate Spill, Leak or Blowout vs. Birds

- These three hypotheses address specific effects on birds that may result from one or more spill sources, whereas all other hypotheses address the effects of one spill source on a specific VEC or group of VECs. Participants preferred the latter format and recommended that the bird hypotheses be modified prior to the workshop.

- Point of discussion was whether a "worst case" scenario for birds would involve an offshore blowout or a river spill. It was recommended that a worst case scenario be selected by the bird specialists at the January meeting of the Catastrophic Oil Spill Technical Working Group.

- It was suggested that the hypothesis also consider the implications of delayed stranding of oil on shorelines or on the river floodplain over the winter, and the subsequent release of this stranded oil during storm surges and spring freshet, respectively, during the following open water period.

3.3.3.6 C-17: Offshore Island Platform Blowout vs. Fish

- The introductory paragraph should identify Arctic Cod and Pacific Herring as VECs.

- Link 5 should be reworded to read " Oil dissolved in water *immediately adjacent* to the blowout site" to differentiate between lethal effects in Link 5 and sub-lethal effects in Link 7.

3.3.3.7 C-18: Diesel Oil Spill from a River Barge in Spring vs. Fish

- Participants noted that the scenario description is for the summer period, whereas this hypothesis focuses on a spill during spring. As barges are not generally used on the Mackenzie River during periods when ice floes are present, it was suggested that Link 1 be modified to reflect summer (open water) conditions.

- If specific fish species are to be considered in this hypothesis, Arctic Char should be included in the list of species assessed. However, as effects on all species of fish, including species of low domestic importance (e.g., suckers), are important, participants suggested that this hypothesis be modified to refer to fish in general, and that effects on all fish or major fish groups be addressed.

3.3.4 General Concerns Regarding the Impact Hypotheses

At the conclusion of the afternoon session, community representatives discussed their general concerns regarding the impact hypotheses and the assessment process. Important points included:

- Each of the communities has a variety of information on the abundance and distribution of various natural resources. Some of this information is in written and map form. Lists of available information from each community should be compiled. Traditional information should be included in the baseline data for the BREAM program, and also used in the assessment of impact hypotheses.

- Cumulative effects of oil and gas development, as well as secondary development (associated with oil and gas activity) should be addressed. It was not readily apparent to the community representatives how cumulative effects would be addressed. For example, it was noted that natural resources in the BREAM study area are presently in a relatively undisturbed state, but that the status of these

VECs will change as development proceeds. Participants wanted to know how effects on "already disturbed" wildlife and other VECs as development and production continues will be addressed by BREAM.

- It was noted that some species of mammals and birds are characterized by cycles in abundance, and that effects on these species during low population periods could be much more serious to a population than effects during high population periods. Participants questioned how cyclic changes might be addressed by BREAM.

3.4 Social Issues

Reflecting back as far as the Berger Commission, it seems clear that whenever arctic hydrocarbon developments are being evaluated, social and economic concerns of northern residents are inevitably amplified. During BEMP, MEMP, and the first two phases of BREAM, attempts were always made to ensure that the environmental monitoring and assessment process generated results that were directly relevant for evaluating social and economic consequences of the scenarios being examined. However, the process always stopped short of directly addressing social and economic issues.

An illustration of the BEMP, MEMP, and BREAM process is provided in Figure 3-2. This figure shows that the overall strategy of each of these three programs has been through time to narrow the number of impact hypotheses to a core group for which there were substantial real concerns or significant scientific unknowns. Even with widening the mandate further in BREAM to include accidental oil spills and assessment issues, little has been done to reduce the uneasiness or uncertainty in northern communities over social and economic implications of oil and gas development.

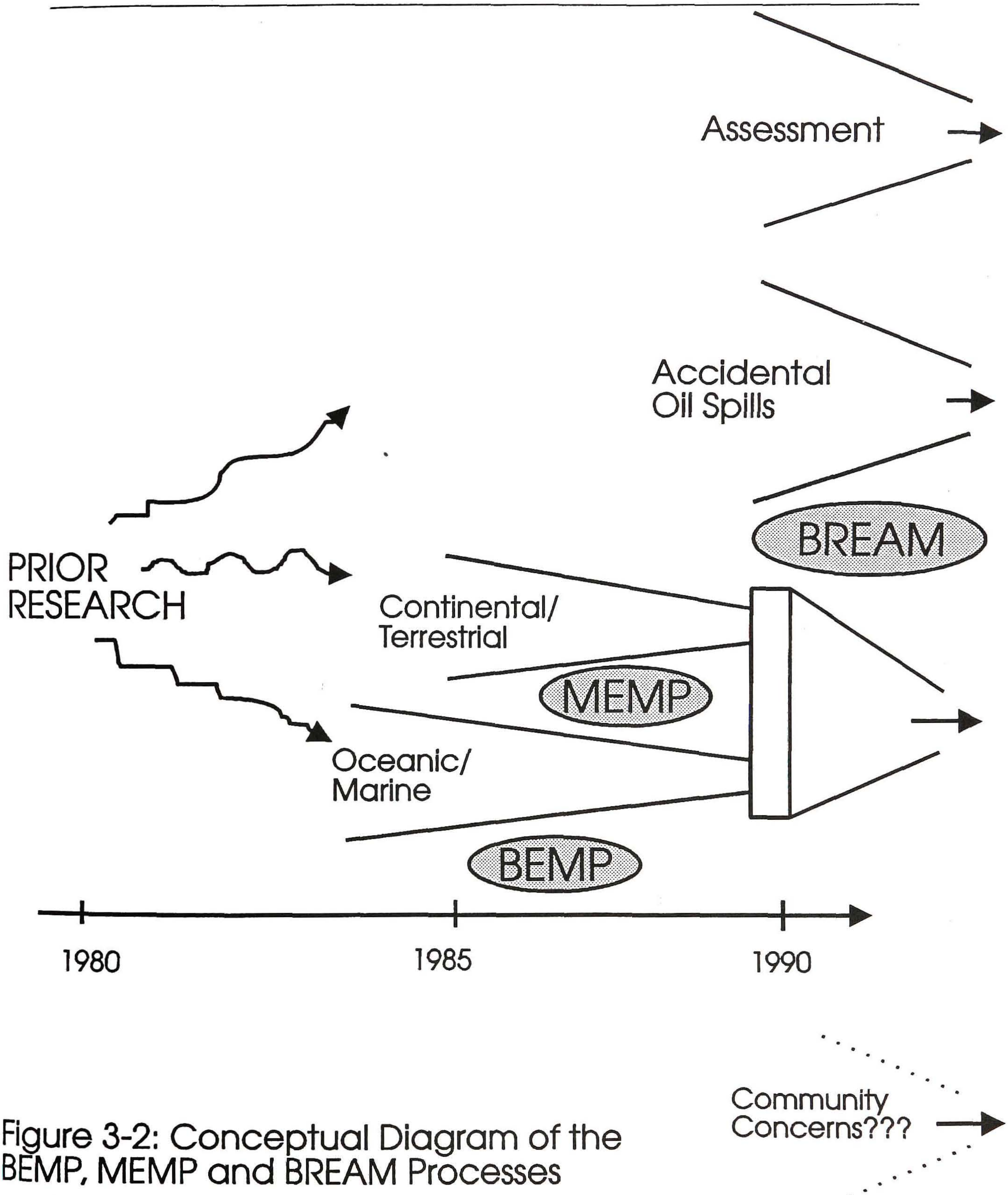

Figure 3-2: Conceptual Diagram of the BEMP, MEMP and BREAM Processes

To date, the ecological and environmental considerations have far outweighed the social and economic investigations . To provide balance, we may now need a new initiative that will address these aspects of northern oil and gas initiatives.

3.5 Summary and Conclusions

There were four areas of necessary action that followed from the Community-based Concerns Technical Working Group meeting:

- Alter the wording of some of the catastrophic oil spill scenarios,
- Change the structure, wording, or VECs addressed in some oil-spill hypotheses,
- Search through references from the recent land-use planning exercises to identify oil and gas related issues that have not been previously identified; and
- Vigorously pursue the identification of an appropriate agency to begin assessment of the social and economic issues identified by the northern communities related to northern oil and gas development.

4. CATASTROPHIC OIL SPILLS

4.1 Introduction

Prepared by
Wayne Duval
Axys Environmental Consulting Ltd.

Major oil spills were the main focus of activities in BREAM this year, building on progress made in 1991/1992 in terms of development of offshore and onshore oil spill scenarios and impact hypotheses relating these scenarios to VEC species groups. Table 4-1 identifies each of the 18 impact hypotheses developed for BREAM. Because it would not be possible to evaluate all of these hypotheses in a 3-day workshop, the Project Manager selected the nine hypotheses considered most important to examine in 1992/1993 based on known community and scientific concerns related to large oil spills in this region. These hypotheses are in shaded boxes in Table 4-1. It should be emphasized, however, that the remaining nine hypotheses still reflect areas of concern and scientific uncertainty; these hypotheses should therefore be evaluated further when there is an opportunity to do so.

The nine impact hypotheses selected for review involve the following four hypothetical oil spill scenarios:

- Diesel fuel spill from a river barge during summer
- Well blowout from a nearshore drilling platform
- Crude oil leak from a pipeline into ice-covered river water
- Oil pipeline break at a river crossing during summer

TABLE 4-1
CATASTROPHIC OIL SPILL IMPACT HYPOTHESES

Hypothesis #	Hypothesis	Description of Hypothesis and Associated Linkages
C-1	Offshore Blowout of Crude Oil in Summer - Marine Mammals	Direct effects of oil (surface contact and ingestion) on polar bear, arctic fox, seals and whales Indirect effects of noise and disturbance from well control and clean-up activities on marine mammals Indirect effect of clean-up activities (human interaction) on polar bear populations
C-2	Offshore Blowout of Crude Oil - Terrestrial Mammals	Direct effects of stranded oil (fouling and ingestion) on populations and harvest of terrestrial mammals Direct effects of stranded oil on habitat Indirect effects of pipeline repair, clean-up, restoration and monitoring operations (noise, disturbance, human interaction) on populations and harvest of terrestrial mammals
C-3	Pipeline River Spill of Crude Oil in Summer - Terrestrial Mammals	Direct effects of oil (ingestion and fouling) on populations and harvest of terrestrial mammals Indirect effects of repair, clean-up, restoration and monitoring operations (noise, disturbance) on populations and harvest of terrestrial mammals Indirect effects of repair, clean-up, restoration and monitoring operations (human interaction) on bear and fox populations and the harvest of same
C-4	Pipeline River Spill of Condensate - Terrestrial Mammals	Direct effects of condensate (fouling and ingestion) on populations and harvest of terrestrial mammals Indirect effects of repair, clean-up, restoration and monitoring operations (noise and disturbance, human interaction) on populations and harvest of terrestrial mammals Indirect effects of repair, clean-up, restoration and monitoring operations (human interaction) on populations and ultimately the harvest of bears and foxes
C-5	Offshore Well Blowout of Crude Oil - Semi-Aquatic Mammals	Direct effects of stranded oil in Delta wetlands (fouling, ingestion, chronic irritation of mucous membranes) on populations and harvest of semi-aquatic mammals (primarily muskrat) Indirect effects of clean-up, restoration and monitoring activities on wetland habitat and semi-aquatic mammals (noise and disturbance) Direct effects of stranded oil on wetland habitat
C-6	Pipeline River Spill of Crude Oil in Summer - Semi-Aquatic Mammals	Direct effects of oil (ingestion, fouling, chronic irritation of mucous membranes) on populations and harvest of semi-aquatic mammals (muskrat and beaver) Indirect effects of pipeline repair, oil clean-up, restoration and monitoring activities (noise and disturbance) on semi-aquatic mammals and ultimately their harvest Indirect effects of pipeline repair, oil clean-up, restoration and monitoring activities on habitat of semi-aquatic mammals
C-7	Pipeline River Spill of Condensate - Semi-Aquatic Mammals	Direct effects of condensate (ingestion, fouling, chronic irritation of mucous membranes) on semi-aquatic mammals and the harvest of same Indirect effects of pipeline repair, clean-up activities and site restoration on habitat of semi-aquatic mammals Indirect effects of pipeline repair, clean-up activities and site restoration (noise and disturbance) on semi-aquatic mammals and the harvest of same
C-8	Pipeline River Spill of Crude Oil under Ice - Birds	Effects of oil spill response (cleanup) activities on bird habitat, bird populations and the harvest of same Effects of oil on bird habitat and bird foods Effects of oiling of birds on their physiology and reproduction and thereby bird populations and their harvest

TABLE 4-1 (continued)
CATASTROPHIC OIL SPILL IMPACT HYPOTHESES

Hypothesis #	Hypothesis	Description of Hypothesis and Associated Linkages
C-9	River Barge Spill of Diesel Fuel in Summer - Birds	Effects of oilspill response (cleanup) activities on bird habitat, bird populations and the harvest of same Effects of oil on bird habitat and bird foods Effects of oiling of birds on their physiology and reproduction and thereby bird populations and their harvest
C-10	Oil/Condensate Spill, Leak or Blowout - Scavenging Birds	Effects of consumption of oiled birds by scavengers
C-11	Island Platform Blowout in Summer - Birds	Effects of oil spill response (cleanup) activities on bird habitat, bird populations and the harvest of same Effects of oil on bird habitat and bird foods Effects of oiling of birds on their physiology and reproduction and thereby bird populations and their harvest
C-12	Condensate Pipeline River Spill under Ice - Fish	Effects of dissolved oil-in-water on spawning and migration behaviour of Arctic grayling and northern pike Sublethal and toxic effects of dissolved oil-in-water on newly emerging fry of fall-spawning species Effects of dissolved oil-in-water on quality of fish and harvest levels
C-13	Condensate Pipeline River Spill in Summer - Fish	Sublethal and toxic effects of oil dissolved in water on fish Effects of dissolved oil-in-water on quality of fish and harvest levels Effects of surface oil on surface-feeding fish and their prey
C-14	Oil Pipeline River Spill in Summer - Fish	Behavioural and sublethal effects of oil dissolved in water on fish Effects of dissolved oil-in-water on quality of fish and harvest levels Effects of surface oil on surface-feeding fish and their prey Effects of oil on nearshore bottom on prey of bottom feeders
C-15	Oil Pipeline River Spill in Spring - Fish	Effects of oil dissolved in water on behaviour and migration of Arctic grayling and northern pike Sublethal effects of oil dissolved in water on fish Effects of dissolved oil-in-water on quality of fish and harvest levels Effects of oil on the bottom on benthic invertebrates and bottom-feeding fish
C-16	Offshore Sub-sea Blowout in Fall - Fish	Lethal, sublethal and food-chain effects of oil dissolved in water on fish Effects of dissolved oil-in-water on quality of broad whitefish and the harvest of broad whitefish Effects of oil/water emulsion and solid residues from countermeasures burning on benthic invertebrates and bottom-feeding fish
C-17	Offshore Island Platform Blowout - Fish	Lethal, sublethal and food-chain effects of oil dissolved in water on fish Effects of dissolved oil-in-water on quality of broad whitefish and the harvest of broad whitefish Effects of oil/water emulsion and solid residues from countermeasures burning on benthic invertebrates and bottom-feeding fish
C-18	River Barge Spill of Diesel Fuel in Summer - Fish	Effects of oil on prey of bottom feeders and subsequent effects on growth, population size and harvest of these fish Effects of tainting on fish harvest Effects of oil on spawning/migration behaviour of fish Sublethal effects of oil on growth and reproduction and thereby population size

VECs or VEC groups included in the selected impact hypotheses were marine and marine-associated mammals, anadromous fish species, terrestrial and semi-aquatic mammals, and various species of birds. Depending on the hypothesis, the evaluation focused on the populations, habitats and harvest of each VEC group. To help address cumulative impacts of major oil spills, actions included within the scope of the review included both the impacts of oil in the environment and the cleanup response and related oilspill countermeasures.

4.2 Oil Spill Scenarios

Prepared by
Ian Buist
S.L. Ross Environmental Research Ltd.

4.2.1 Scenario A: Fuel Barge Spill into the River in Summer

Incident Description

A 1000 tonne barge loaded with diesel fuel breaks away from its train near Lower Island, just upriver from Swimming Point, and is holed by an unknown submerged object. Three tanks are breached releasing a total of 300 tonnes (362.76 m^3 = 2300 bbls) of diesel fuel into the river.

Environmental Conditions

The wind speed averages 7 m/s and is blowing along the river. The air temperature is 15°C, and the water temperature is 10°C. The river depth averages 3 m downriver from the spill site; the current is 0.5 m/s.

Spill Behaviour

On release, the diesel spreads out to cover an area of 0.16 km^2 (equivalent to a circle some 450 m in diameter). About 90% of the oiled area is covered with a sheen 1 micron (1×10^{-6} m) thick; 10% of the oiled area is covered with thick oil lenses. These thick areas contain 90% of the volume of oil spilled.

Figure 4-1 shows the predicted spreading of the slick (both in area and equivalent diameter of a circular slick) as it drifts downriver. At its maximum size, the slick covers 1.2 km^2 of water of which 0.14 km^2 is thicker portions. Figure 4-2 illustrates the thinning of the thick slick as it moves downriver. Initially, the thick slick is several mm thick, but this declines rapidly as the slick spreads. After 24 hours (43 km), the thickness has declined to about 1 mm; after 2 days (87 km) it has further declined to 0.35 mm. The thick slick is completely dissipated about 105 km downstream from the spill site.

Figures 4-3 and 4-4 show the predicted fate of the slick as it moves downriver. After 59 hours (105 km), 60% of the slick naturally disperses and 40% evaporates. Peak, initially dispersed oil concentrations beneath the slick (evenly mixed over the entire slick area and to a depth of 3 m) remain relatively constant, declining from 5 ppm early on to 1 ppm near the end of the spill. Average oil concentrations in the cloud trailing behind the slick are indicated on Figure 4-4; they decline from 5 ppm at the spill site to 0.2 ppm by the time the surface slick dissipates. Any fixed point in the river is initially subjected to a higher dispersed oil concentration (the peak); the oil concentration then declines as the cloud moves past. The exposure time [in seconds] for any point may be calculated by the result of the cloud length, in metres (= 0.035 x 7 x 3600 x [hours]) divided by the current speed (0.5 m/s).

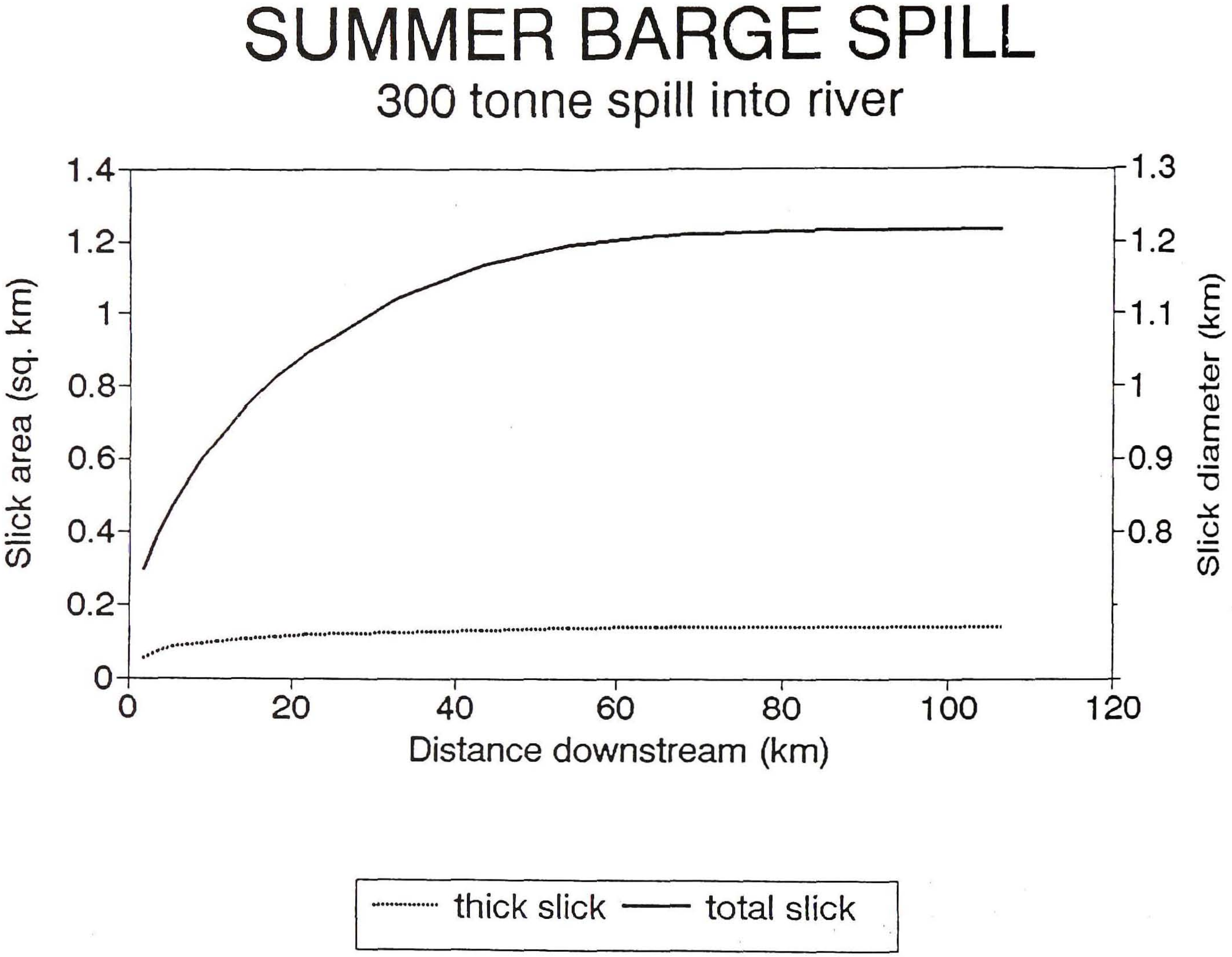

Figure 4-1: Predicted Spreading of the Slick - Fuel Barge Spill

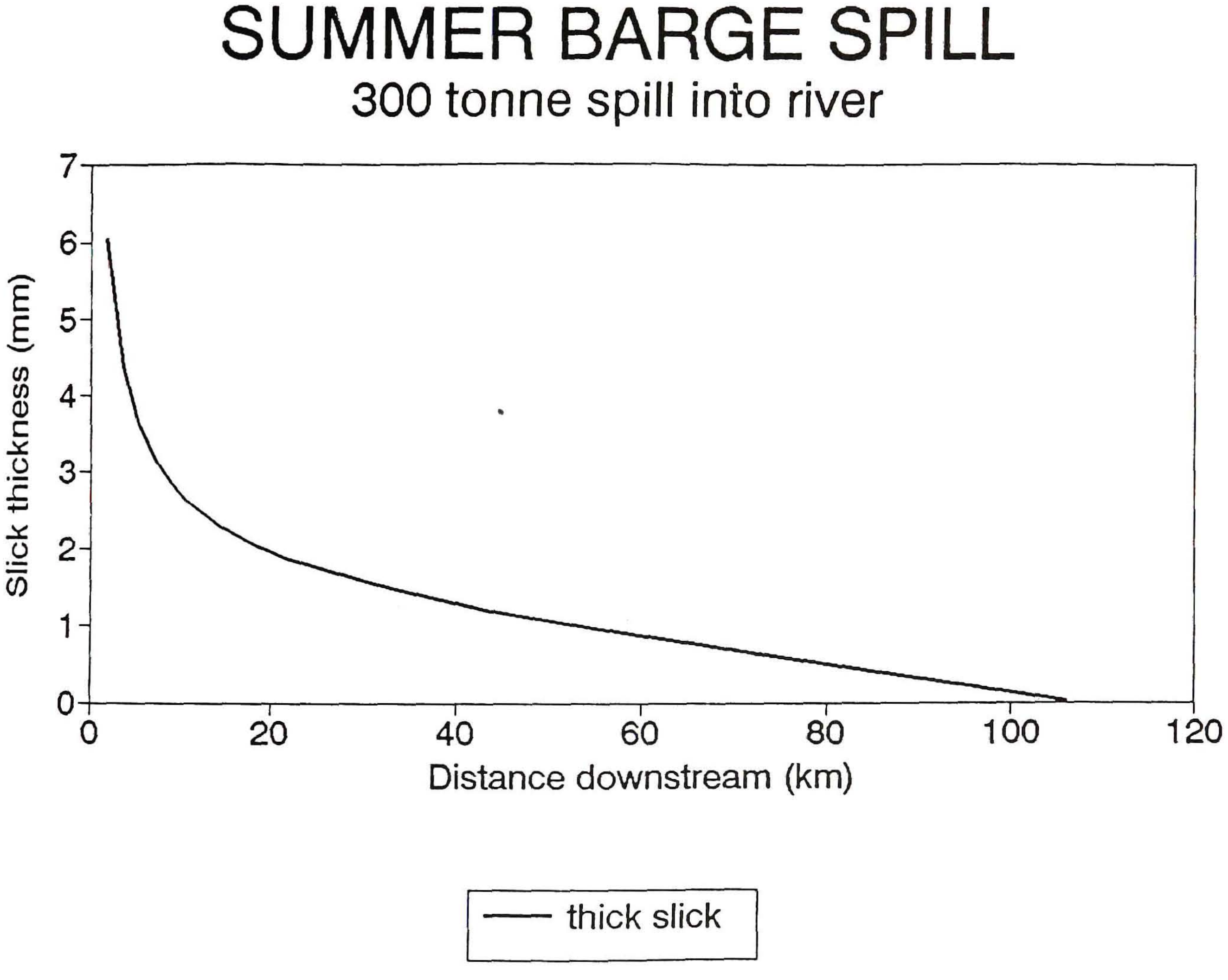

Figure 4-2: Predicted Thinning of the Slick - Fuel Barge Spill

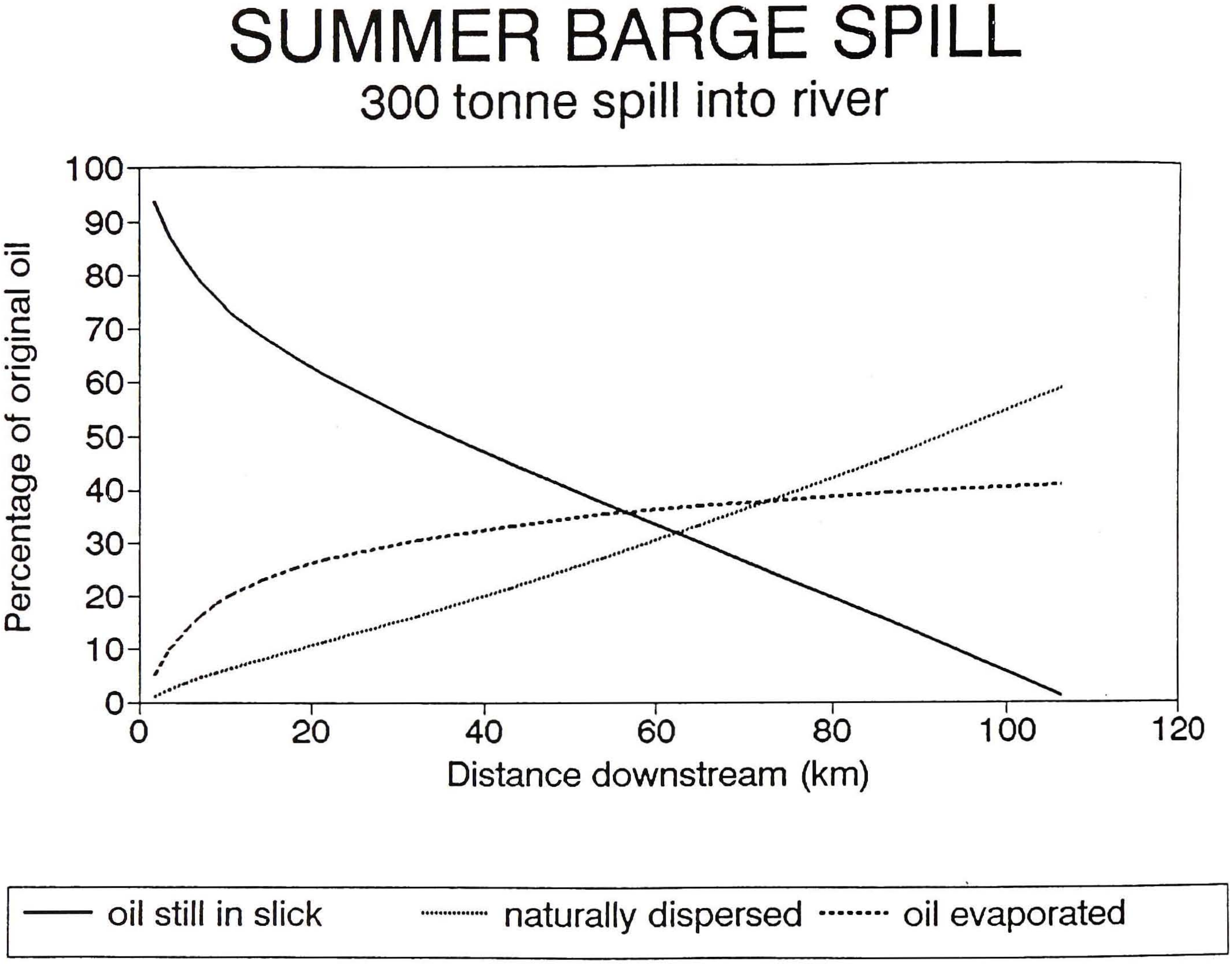

Figure 4-3: Predicted Fate of the Slick - Fuel Barge Spill

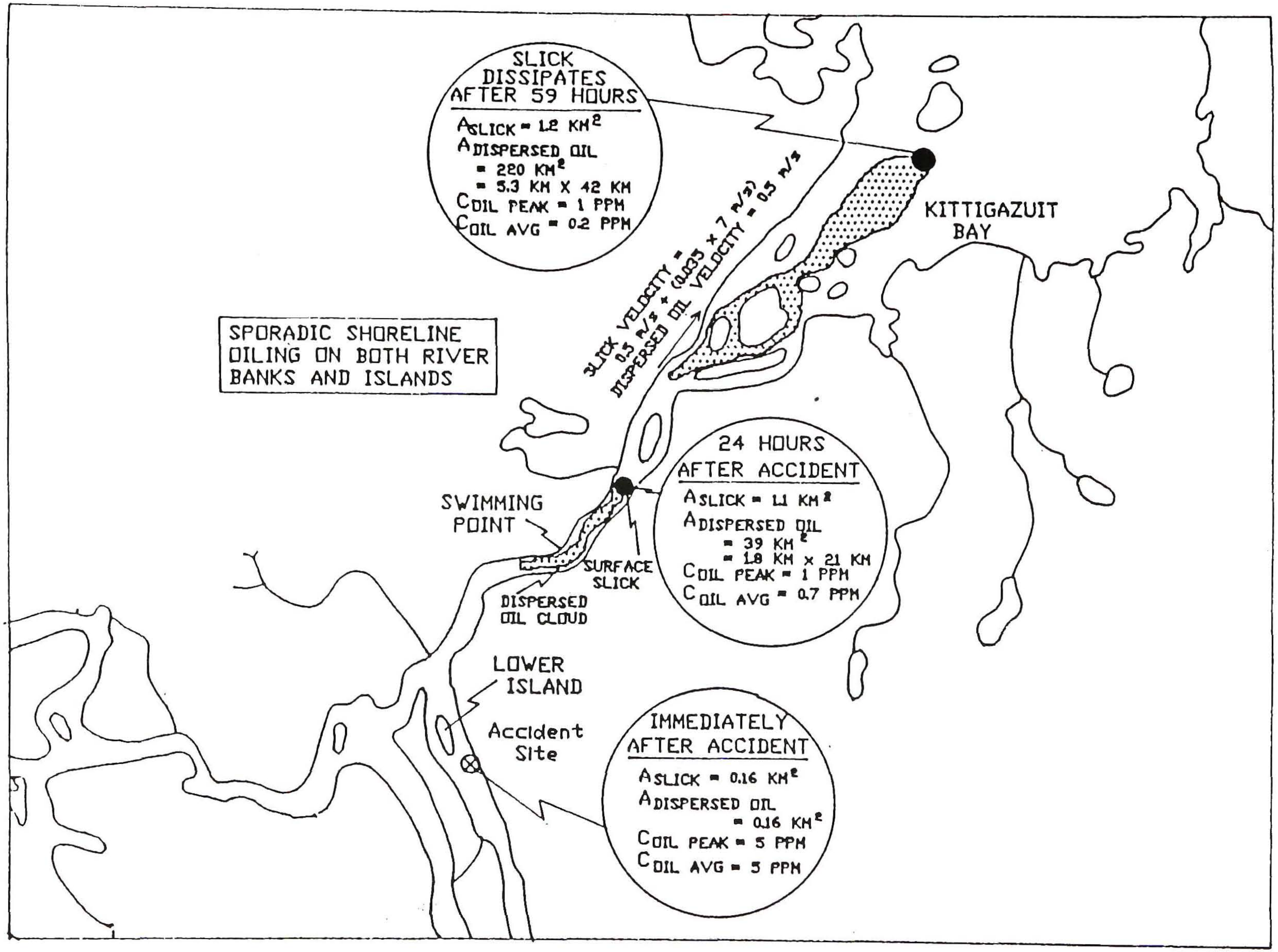

Figure 4-4: Predicted Movement of the Slick - Fuel Barge Spill

Countermeasures

For the purpose of this scenario, it is assumed that 500 m of containment boom and one 150 bbl/hr skimmer are deployed one day after the spill for on-water recovery operations. Assuming a 50% effectiveness, this effort results in the removal of about 500 bbls (22%) of the oil released.

Shoreline Oiling

It is assumed that both shores of the river are sporadically oiled along the 105 km stretch of the river affected. It is estimated that 500 bbls of diesel are stranded in widely-scattered areas in the affected zone.

Summary

The following summarizes the predicted fate of the oil released from this hypothetical spill:

OIL SPILLED: 300 tonnes = 2300 bbls
OIL EVAPORATED: 500 bbls
OIL NATURALLY DISPERSED: 800 bbls
OIL ON SHORELINES: 500 bbls
OIL RECOVERED FROM WATER: 500 bbls

4.2.2 Scenario B: Island Platform Blowout

Incident Description

During the open-water season 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.

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 wind direction varies from N to NE over the 6 days. 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.

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, in a generally southerly direction at 0.25 m/s.

Oil Fate Predictions

As the continuous slick drifts slowly away from the spill site, it spreads, thins, evaporates, emulsifies and naturally disperses. Figure 4-5 shows the predicted width of the continuous slick as a function of distance from the spill site; Figure 4-6 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.

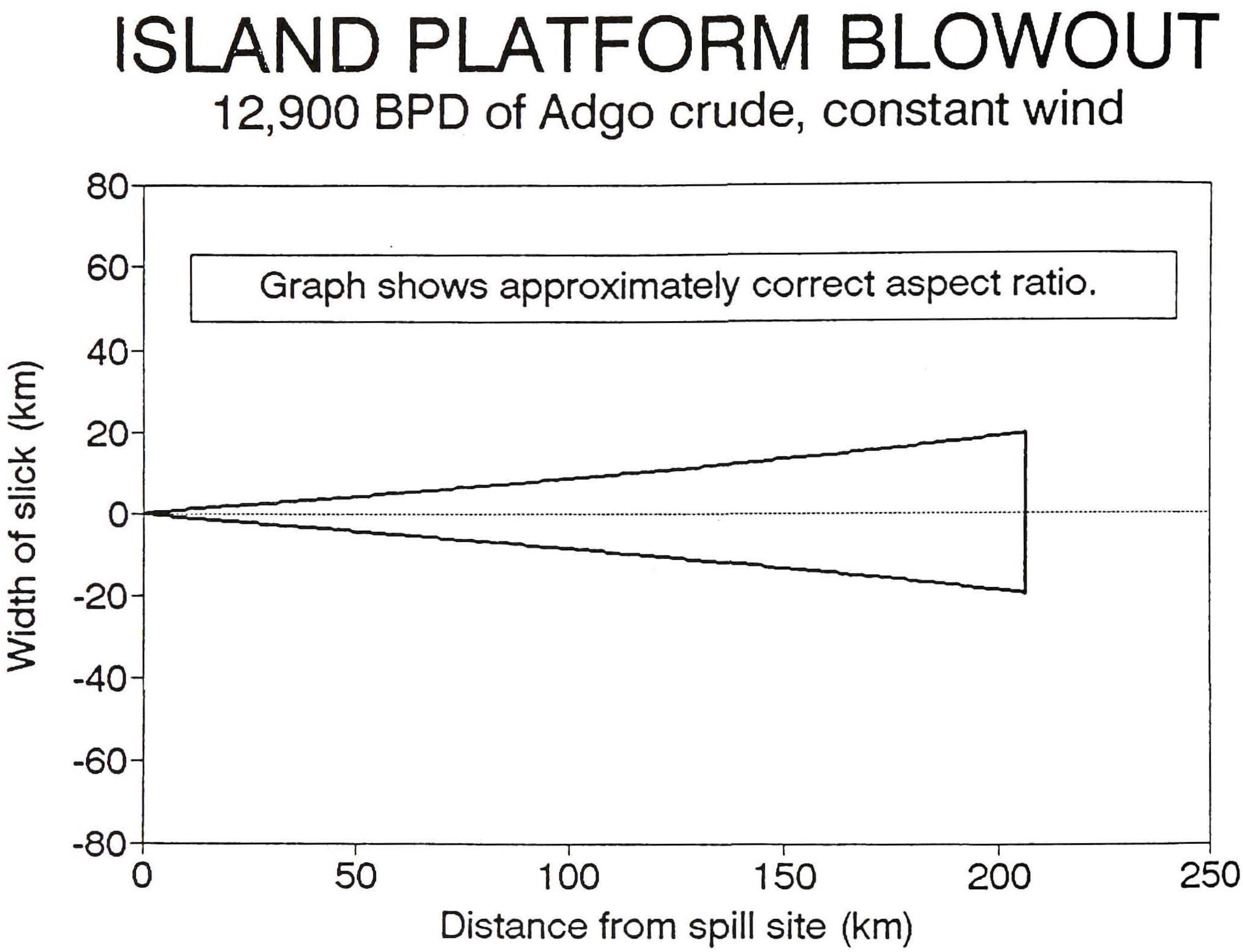

Figure 4-5: Predicted Spreading of the Slick - Island Platform Blowout

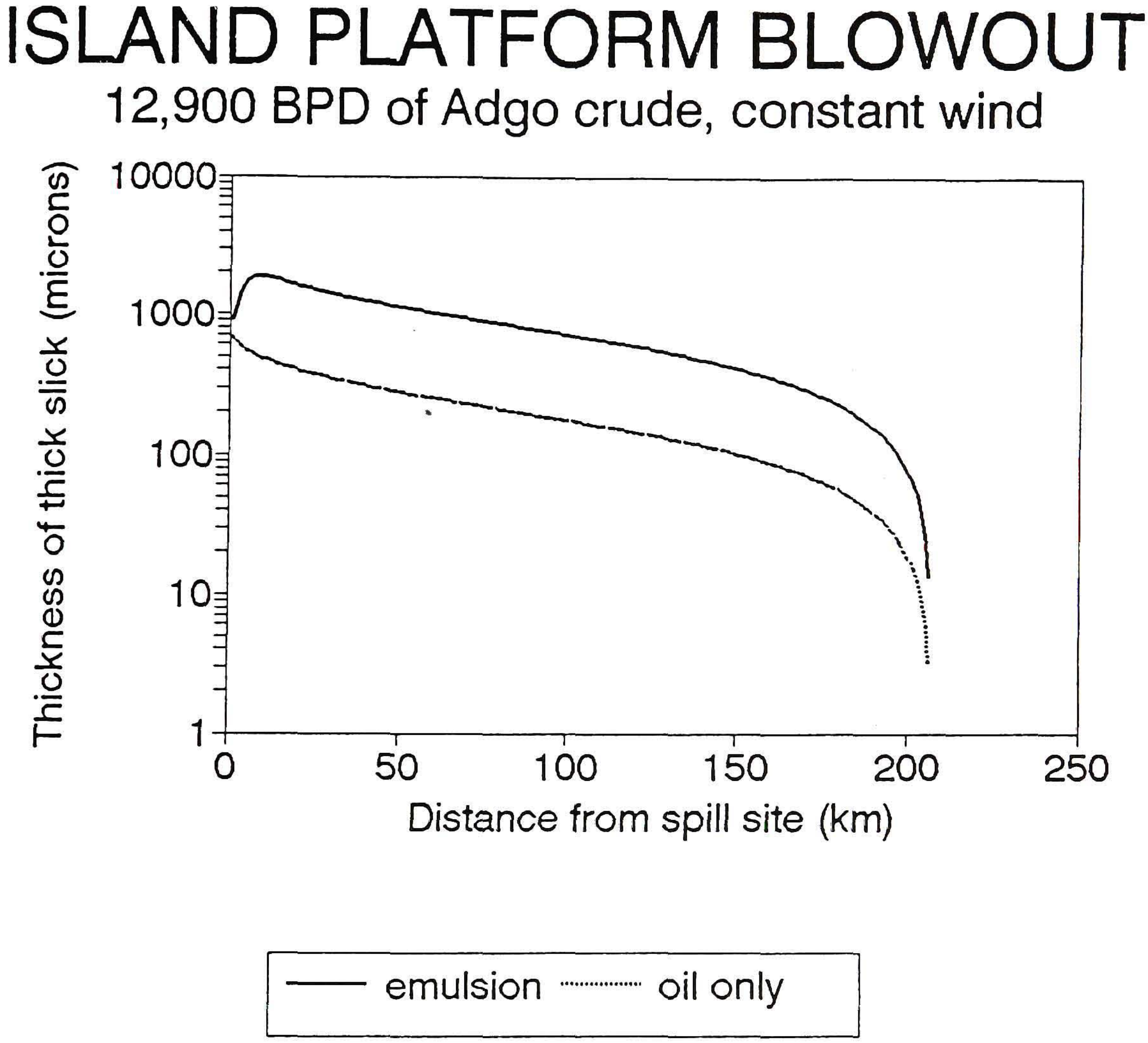

Figure 4-6: Predicted Thinning of the Slick - Island Platform Blowout

Figure 4-7 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.

Near-Source Countermeasures

The Beaufort Sea Co-op's Response Barge (Figure 4-8) 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.

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.

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 (see also Figure 4-9):

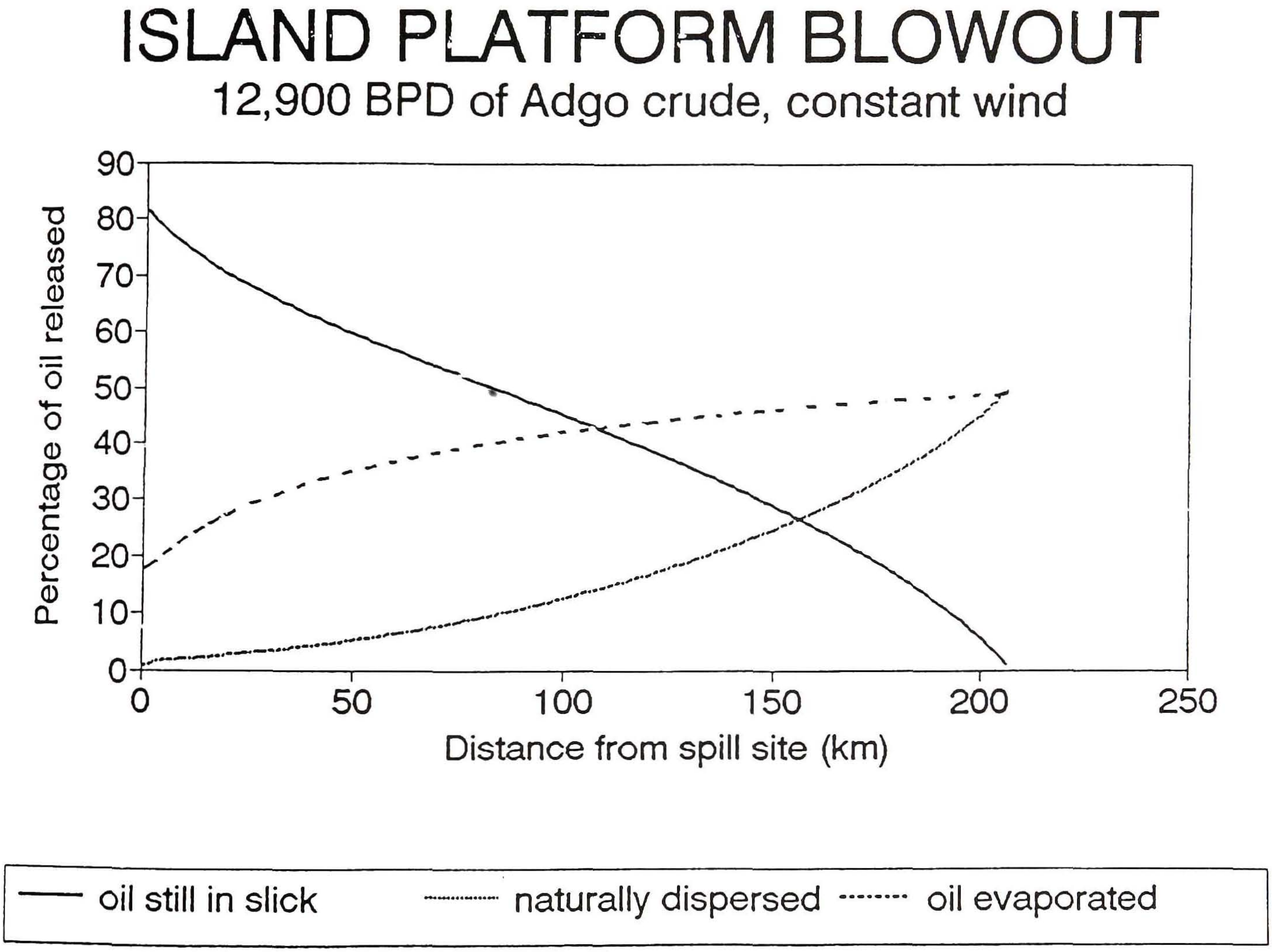

Figure 4-7: Predicted Fate of the Slick - Island Platform Blowout

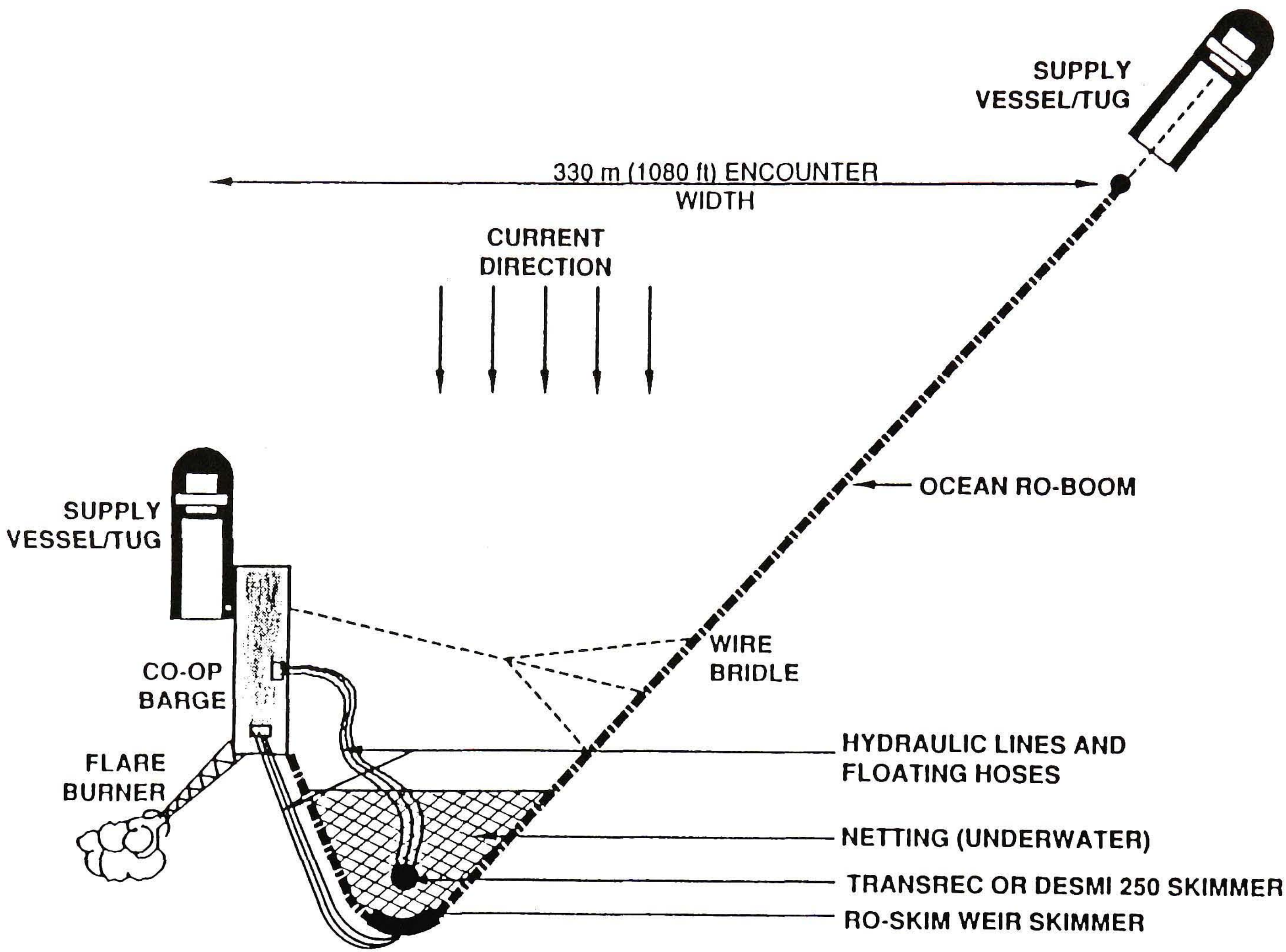

Figure 4-8: Schematic of Redesigned Response Barge Deployment

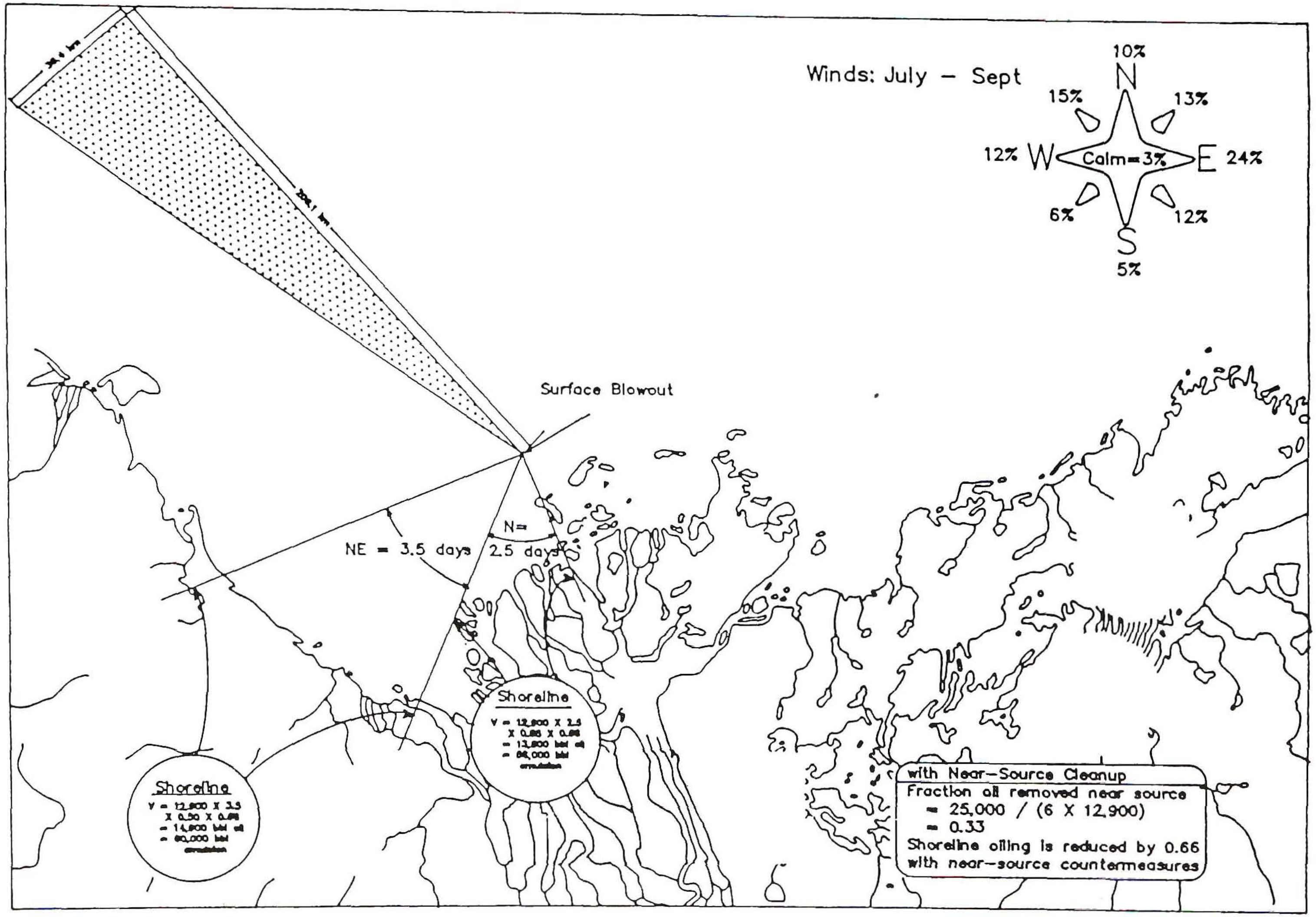

Figure 4-9: Predicted Shoreline Oiling - Island Platform Blowout

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.

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

4.2.3 Scenario C: Oil Pipeline Spill under Ice Cover

Incident Description

A pinhole leak develops in an oil pipeline buried beneath a tributary (the Great Bear River), 1/2 km upstream of where it empties into the Mackenzie River. Oil leaks from the submerged pipeline at a rate of 1000 barrels/day from February 15 to April 15, when breakup occurs and the leak is discovered.

Environmental Conditions

The water temperature is 0°C, and the water current is 0.5 m/s. During breakup, the air temperature is 15°C and the wind speed is 5.5 m/s.

Spill Behaviour

The oil from the leak, flowing at about 10 L/min, rises up to collect on the underside of the ice. It is 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 is continuing to grow downwards and encapsulates the pooled oil 48 to 72 hours after its release. As such, with an average under-ice coverage of 1 cm, the 10,000 bbls spill covers an area of 160,000 m^2 or a swath of 20 m wide and 8 km long extending down-river from the spill. This oiled area extends from the spill site to the Mackenzie River and then 7.5 km down-river along the eastern bank of the Mackenzie River.

Once the melt arrives and the ice begins to rot, the oil migrates to the surface of the ice, collects in melt pools on the river surface and evaporates slowly. Any oil remaining in the ice at breakup will be released slowly from the rotting ice and rapidly evaporates.

Countermeasures

No countermeasure operations are mounted in response to this spill (leak discovery does not occur until after breakup).

Shoreline Oiling

No shoreline oiling is assumed to occur as a result of the spill.

Summary

The following is a summary of the predicted fate of the oil released from this hypothetical spill.

OIL RELEASED: 10,000 bbls
OIL INITIALLY DISSOLVED: 100 bbls
OIL ENCAPSULATED IN ICE: 9,900 bbls
OIL EVAPORATED FROM ICE SURFACE DURING MELT: 3,000 bbls
WEATHERED OIL RELEASED ONTO WATER AT BREAKUP: 6,900 bbls

4.2.4 Scenario D: Oil Pipeline Break at a River Crossing in Summer

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, 13 km upriver of Fort Simpson. 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.

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 averages 1 m/s.

Spill Behaviour

While the oil is still leaking out, it forms a narrow slick 3.6 km long and 100 m wide. The majority of the surface area of this slick is in the form of a sheen (85% = 0.3 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 4-10 shows the predicted spreading of the slick (both in area and equivalent diameter of a circular slick) as it drifts downriver. At its maximum size, the slick covers an area of 3.4 km^2 of water, of which 0.25 km^2 contains thicker portions. Figure 4-11 illustrates the thinning of the thick slick as it moves downriver. Initially the oil is not emulsified, but after 23 h of exposure (82 km downriver), it has weathered enough to begin forming an emulsion.

Figures 4-12 and 4-13 show the predicted fate and movement of the slick as it moves downriver. 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 early on to 0.7 ppm near the end of the spill. Average oil concentrations in the dispersed oil cloud are 1 ppm early on, declining to 0.6 ppm by the end of the spill. Two hours after the spill, the diameter of the dispersed oil cloud equals the width of the river; after 57 hours, the dispersed oil cloud is 66 km long.

Countermeasures

For the purposes of this scenario, it is assumed that no countermeasures are implemented prior to dissipation of the oil.

Shoreline Oiling

It is assumed that both shores of the river are sporadically oiled along the 200 km stretch affected by the spill. It is estimated that 1000 bbls of oil are stranded in widely-scattered areas within this affected zone.

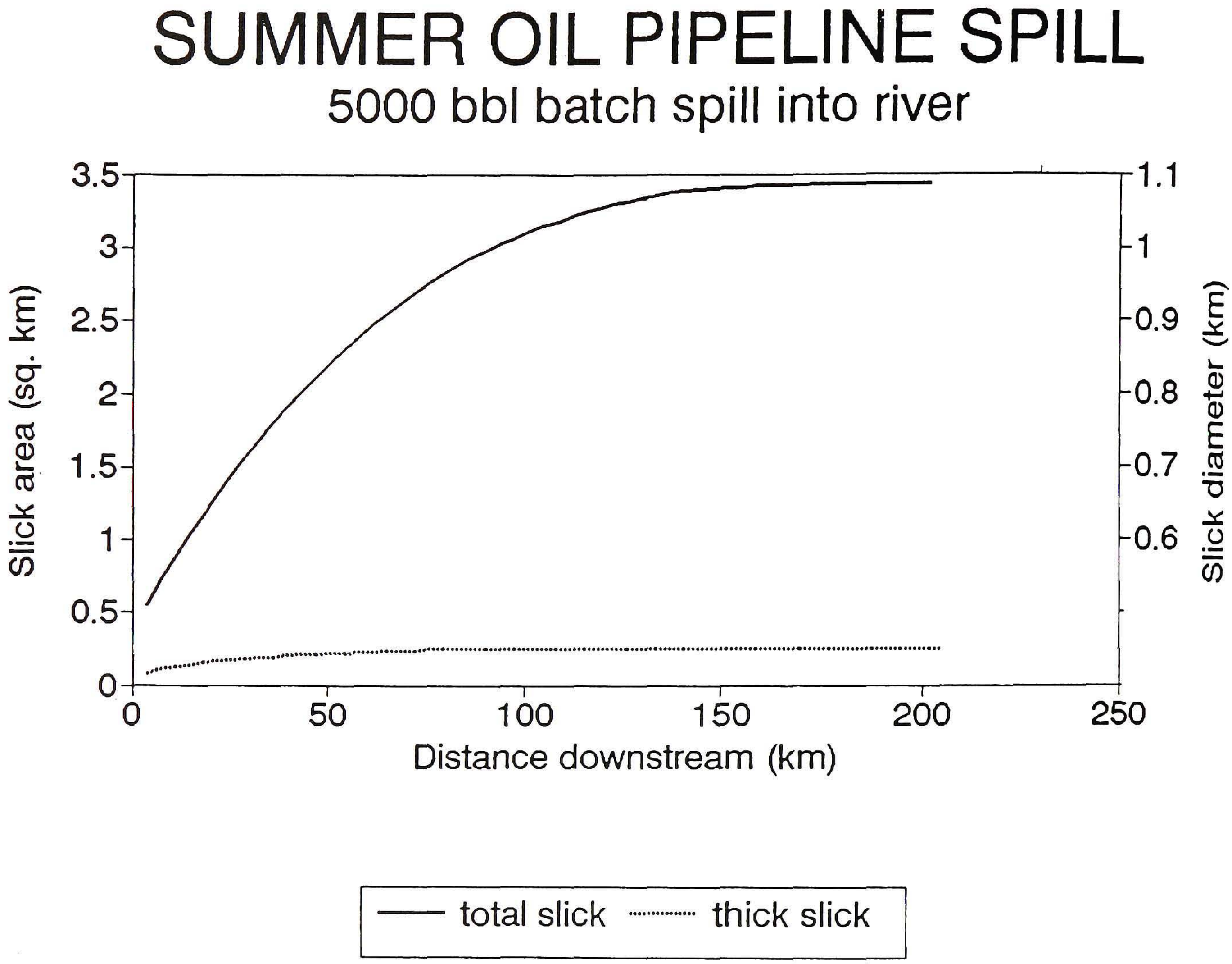

Figure 4-10: Predicted Spreading of the Slick - River Pipeline Break

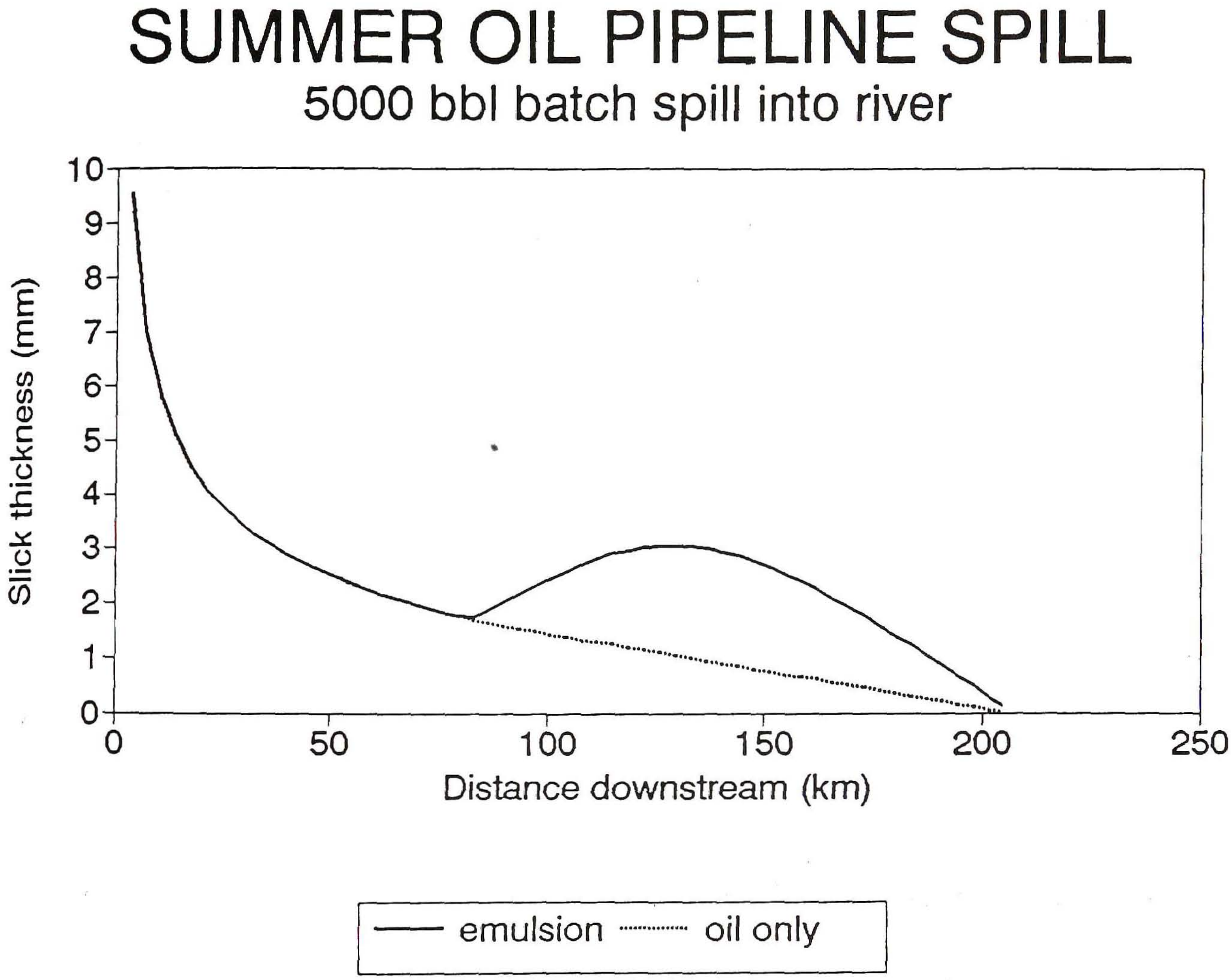

Figure 4-11: Predicted Thinning of the Slick - River Pipeline Break

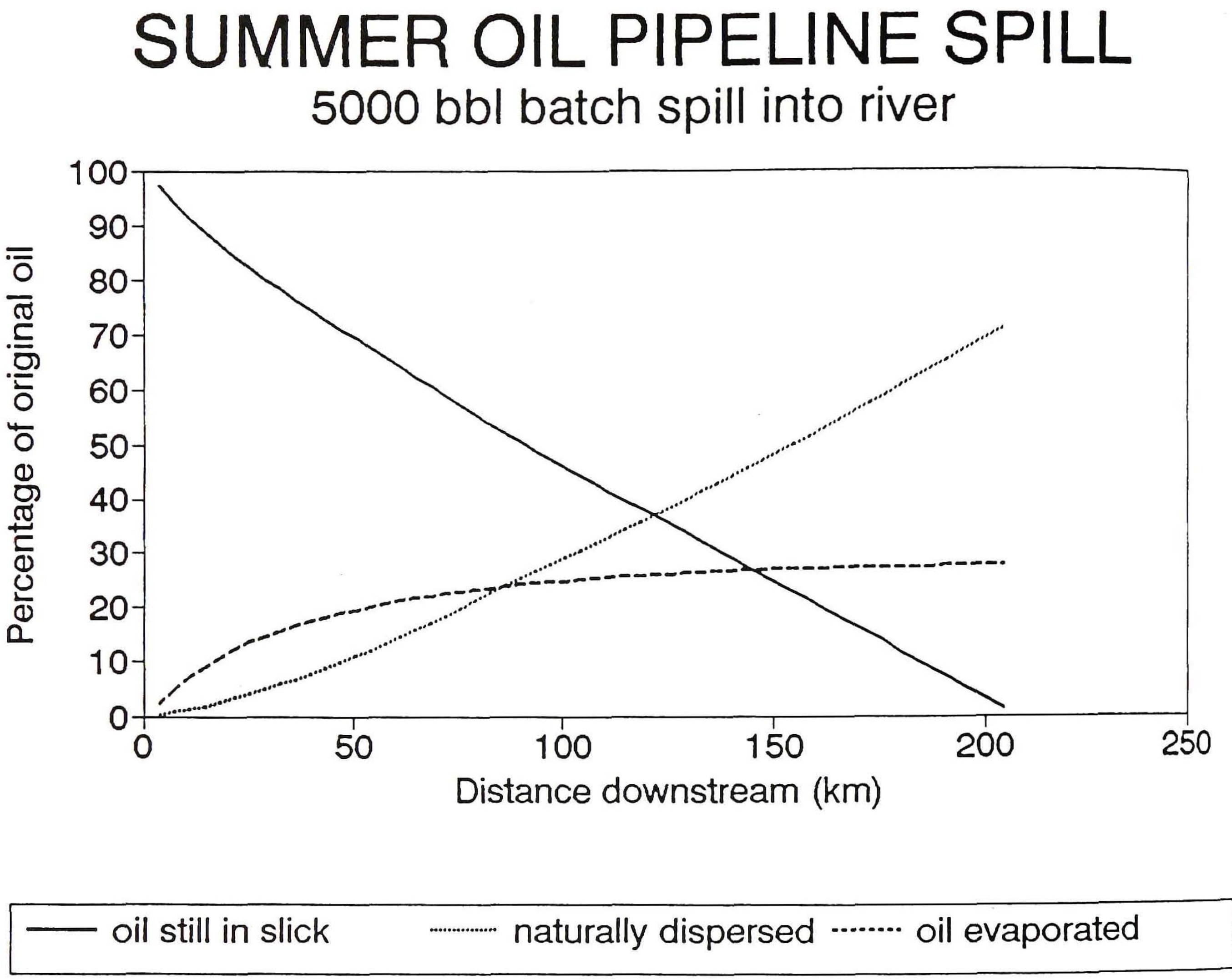

Figure 4-12: Predicted Fate of the Slick - River Pipeline Break

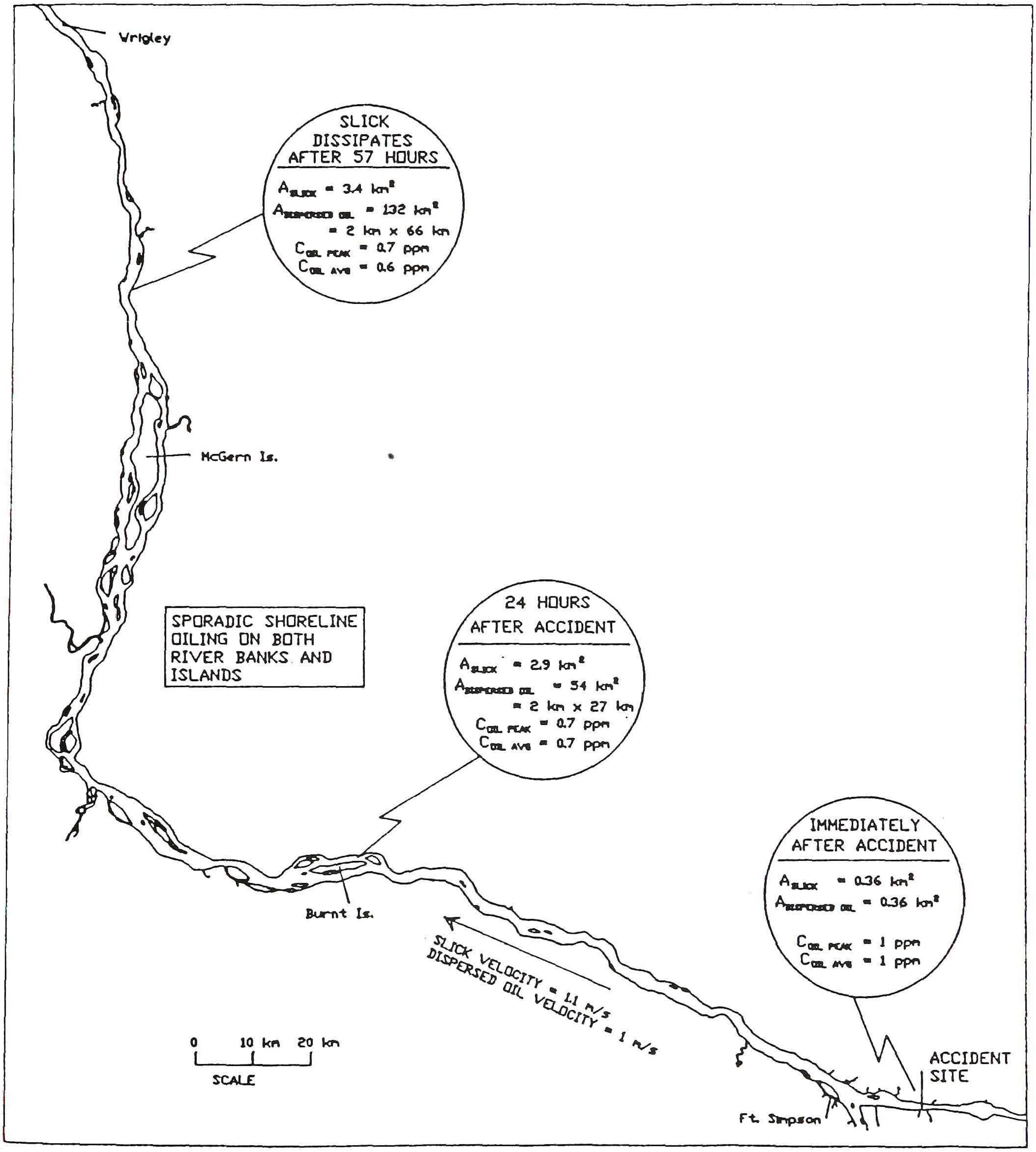

Figure 4-13: Predicted Movement of the Slick - River Pipeline Break

Summary

The following summarizes the predicted fate of the oil released from this hypothetical spill.

OIL SPILLED: 5000 bbls
OIL EVAPORATED: 1500 bbls
OIL NATURALLY DISPERSED: 2500 bbls
OIL ON SHORELINES: 1000 bbls
OIL RECOVERED: 0

4.3 Assessment Procedure used in BREAM

Prepared by
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Axys Environmental Consulting Ltd.

As emphasized in previous BREAM reports, environmental assessment is incorporated in this process as a means of helping to set priorities for research and monitoring. The preliminary assessment conducted as part of BREAM is not intended to circumvent the need for other assessment activities that may be deemed appropriate as part of future project reviews. There is considerable practical value, however, in having workshop participants evaluate whether the potential impacts that are the focus of a given hypothesis would be considered significant or insignificant or remain unknown. For example, there may be more justification in the initiation of a research program necessary to help define impacts or collect other information (e.g., baseline data, process information, effectiveness of mitigation measures, etc.) for hypotheses which are expected to be "significant" in contrast to those expected to be "insignificant". Similarly, if the potential impacts of an action/event remain "unknown", it may be very important to obtain the information necessary to evaluate whether they could be significant and the circumstances under which this could be true.

During the Project Initiation Meeting, it was concluded that the Duval and Vonk (1991) assessment procedure used in BREAM during the previous year for evaluation of some of the hypotheses dealing with routine aspects of hydrocarbon development/transportation would be used again in 1992/1993 for the impact hypotheses dealing with oil spills. It is emphasized, however, that: (1) only some of the steps in the Duval and Vonk (1991) procedure are necessary to complete the preliminary level of assessment required for BREAM; and (2) the procedure for determination of impact significance has been refined for BREAM. The Duval and Vonk (1991) method involves the use of a series of standard forms that assist in:

- identifying the activities and disturbance sources associated with a proposed project that may cause impacts, planned mitigative measures, and their anticipated success in preventing or minimizing impacts;
- identifying the environmental components that would be considered Valued Ecosystem Components (VECs) or Valued Social Components (VSCs);
- preparing matrices that identify all potential interactions between selected VECs and VSCs with project-related disturbances and activities;
- predicting in a semi-quantitative manner, the degree of spatial and temporal overlap between each VEC and each project disturbance/activity, as well as assessing potential conflicts involving each of the VSCs;
- evaluating the environmental significance of any potential and/or residual impact that might result from the project;
- recording the rationale for all decisions and conclusions through the completion of an "Audit Trail"; and
- 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.

While this procedure was primarily developed for the assessment of potential development proposals (projects), it can also be applied to events such as oil spills. As indicated above, only a portion of the complete method is used for BREAM. The first three steps in the Duval and Vonk procedure are already accomplished through the Adaptive Environmental Assessment and Management method (Holling 1978) adopted by BREAM and its predecessors.

Through the formulation of impact hypotheses, the VECs/VSCs and project disturbances/activities were already defined and the potential interactions were identified in the linkages that are part of each hypothesis. The use of the VEC also helps in definition of impact significance as this focuses the review on resources and environmental components that are important to local communities and government.

Due to the limited time available in BREAM workshops, it is not possible to rigorously evaluate temporal and spatial overlap in the manner described in Duval and Vonk (1991). Nevertheless, workshop participants are required to give adequate consideration to both of these scale elements during their assessment of potential impact significance. In a similar manner, flipcharts and detailed notes prepared by workshop facilitators and rapporteurs, respectively, are a substitute for the Audit Trail of the Duval and Vonk procedure.

The primary area where BREAM relies on the Duval and Vonk procedure is for determination of potential impact significance. The environmental significance of each project/VEC or project/VSC interaction is evaluated through the use of three questions shown in Figures 4-14 and 4-15. 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 prevents the assessment of significance and forces the participants 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 may be concluded that the significance **CAN'T BE KNOWN**. In the Duval and Vonk 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. These definitions have been adopted by BREAM workshop participants in the meetings conducted to date.

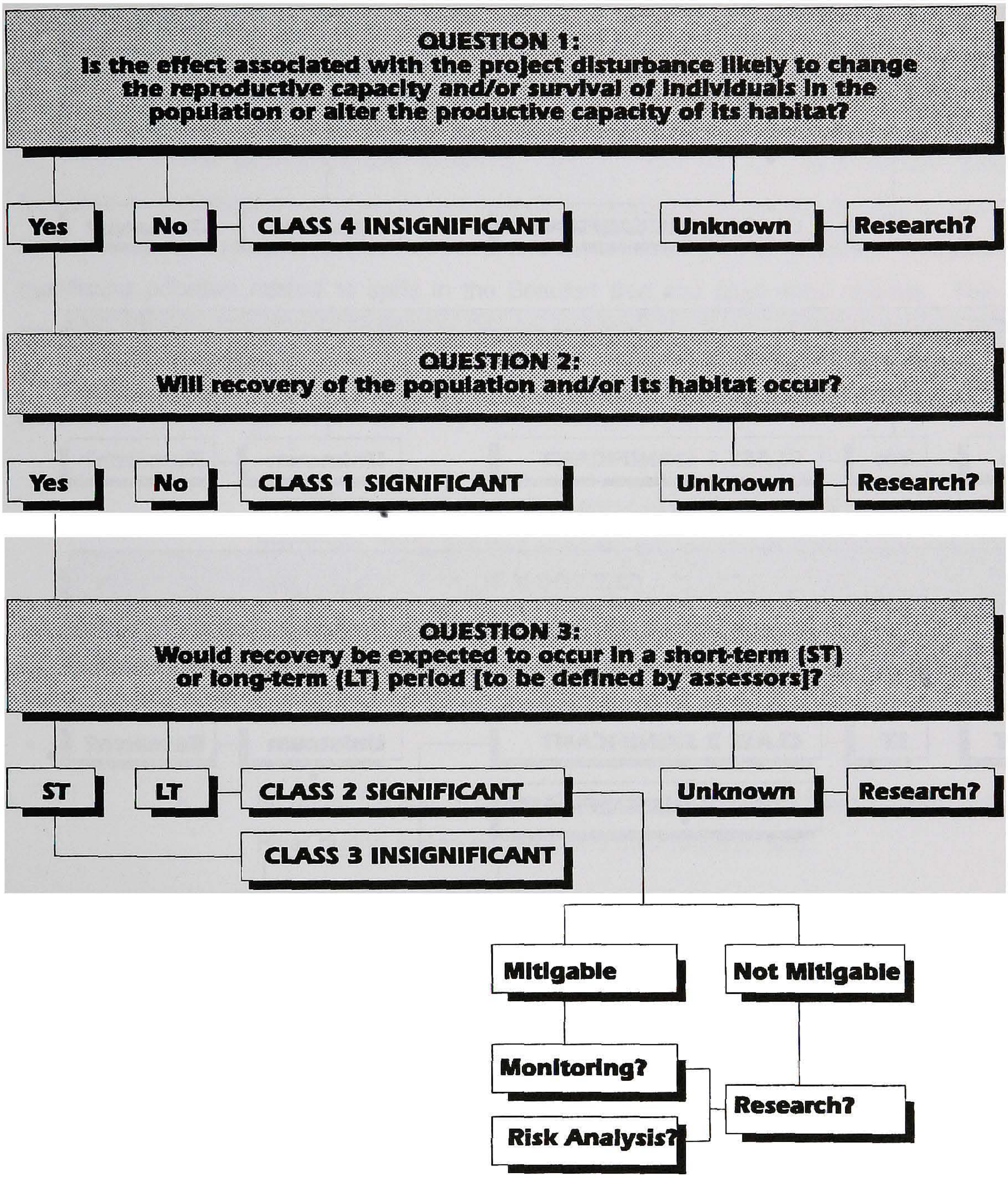

FIGURE 4-14
SPECIES VALUED ECOSYSTEM COMPONENTS
QUESTIONS OF SIGNIFICANCE

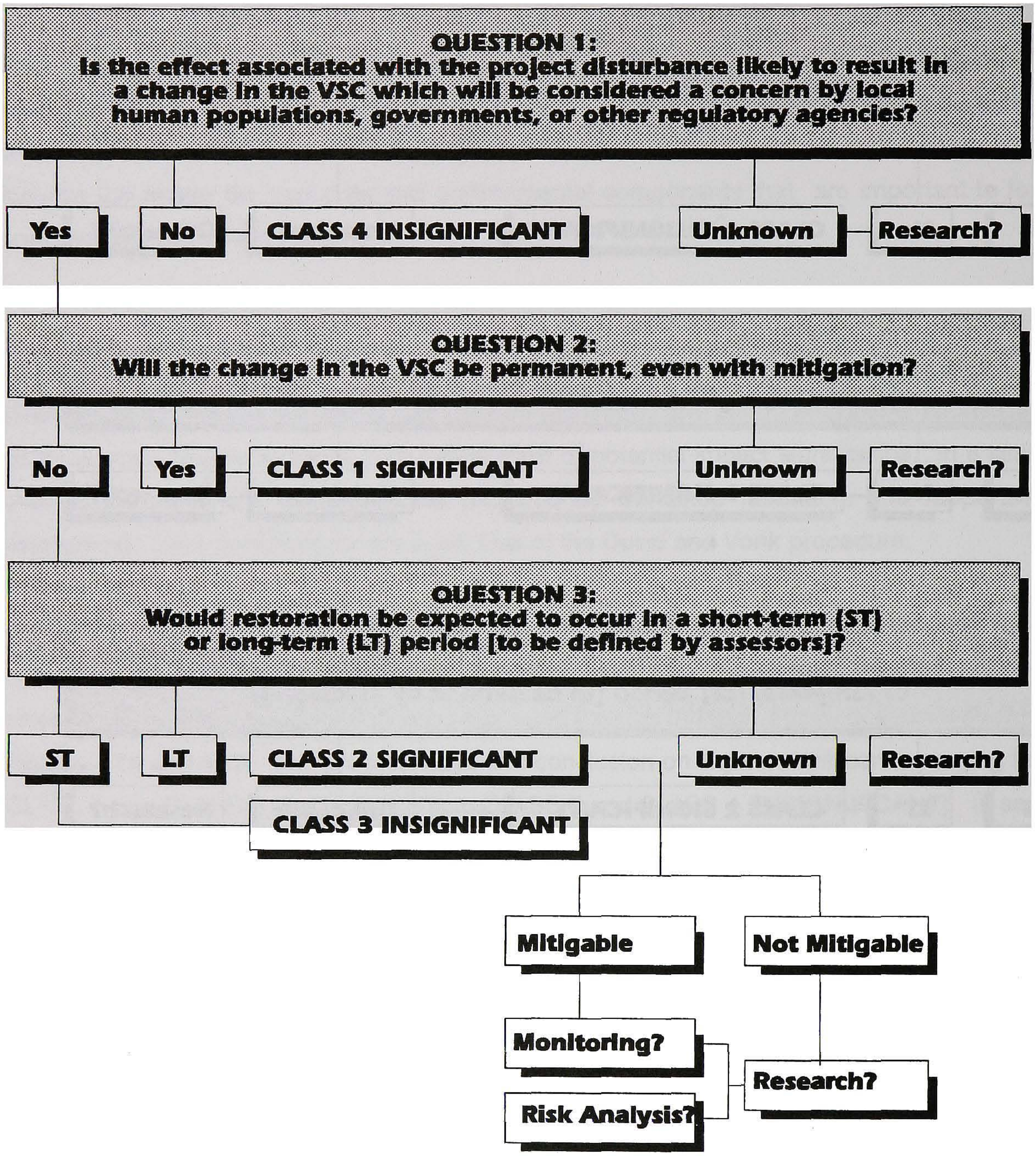

FIGURE 4-15
VALUED SOCIAL COMPONENTS
QUESTIONS OF SIGNIFICANCE

4.4 Review of Impact Hypotheses/Oil Spill Scenarios

The interdisciplinary workshop held as part of this year's BREAM program focussed on a number of complex issues specifically related to the effects of large oil spills and their cleanup on resources and resource use, and culminated in the identification of research and monitoring priorities related to spills in the Beaufort Sea and Mackenzie regions. This was accomplished through the evaluation of nine (9) impact hypotheses involving four (4) different oil spill scenarios (described previously in Section 4.2). These hypotheses considered the potential direct and indirect (i.e. spill response activities) impacts of:

- an offshore island platform blowout of crude oil during summer on marine mammals, birds, fish and semi-aquatic mammals and the harvest of these resources;

- a river barge spill of diesel fuel near Swimming Point during summer on fish and birds and their harvest;

- an under ice spill of crude oil at a pipeline river crossing in the Great Bear River during spring on birds and their harvest; and

- a pipeline spill of crude oil near Fort Simpson during summer on terrestrial and semi-aquatic mammals and their harvest.

The results of the hypothesis evaluations and preliminary assessments (described earlier in Section 4.2) are presented in the following section.

4.4.1 HYPOTHESIS C-1: The Effects of an Offshore Oil Spill on Marine Mammals

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INTRODUCTION

This hypothesis involves the possible effects of a substantial offshore blowout of crude oil on marine mammals. The linkages in the hypothesis lead from the release of oil to effects on marine mammals and on the harvest of marine mammals. The marine mammal species that were selected as Valued Ecosystem Components (VEC's) are listed below. The harvests of these species were considered to be Valued Social Components (VSC's).

Beluga Whale	Bowhead Whale
Ringed Seal	Bearded Seal
Polar Bear	

Because an oil spill would have different effects on each of the species, it was necessary to address each species individually during the workshop. Similarly, they are treated separately in this report, although it is not necessary to provide a full discussion of each link for each species.

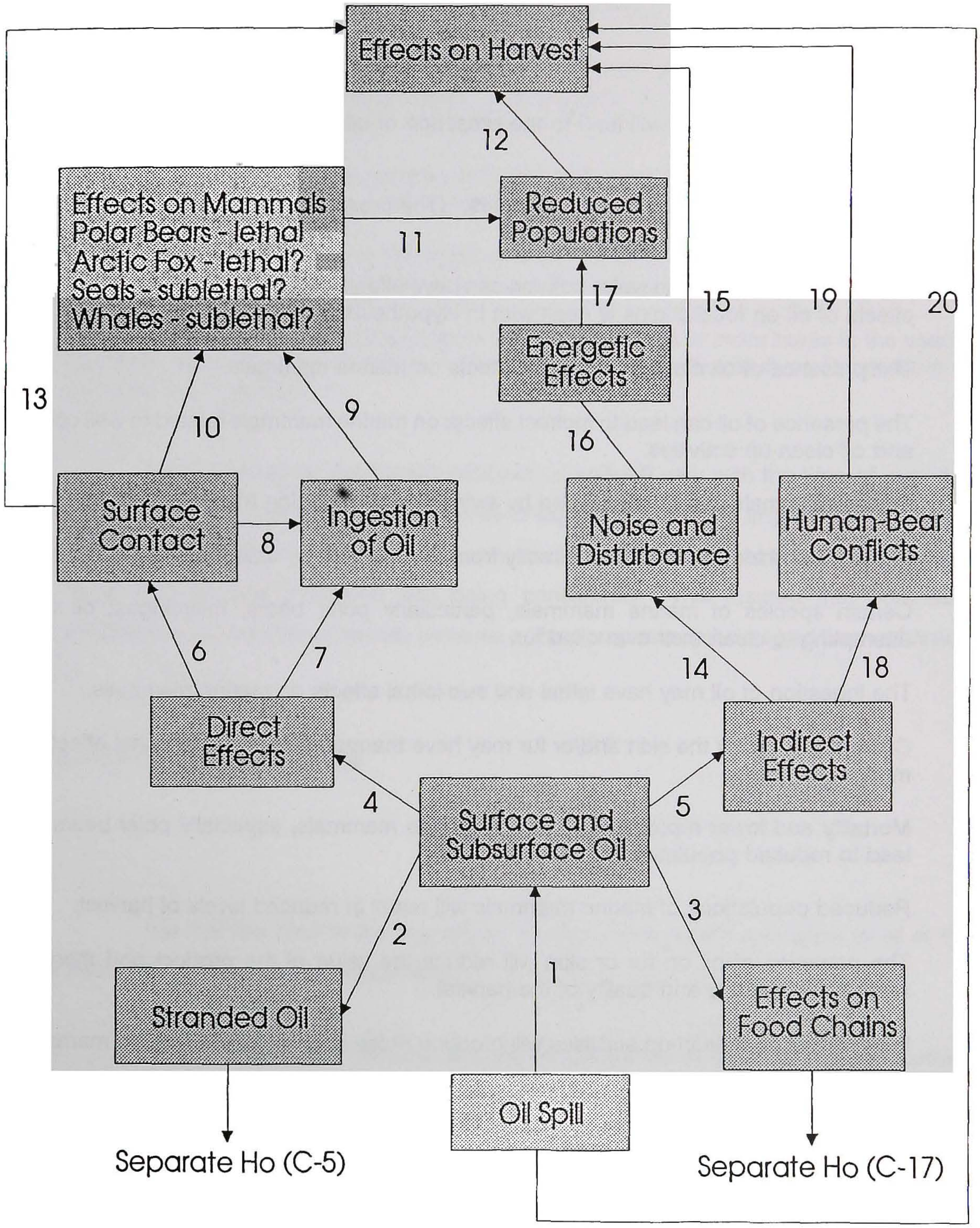

Figure 4-16: BREAM Hypothesis C-1 - Effects of an Offshore Well Blowout on Marine Mammals

LINKAGES

1. An offshore oil blowout will lead to the presence of oil on the water surface and in the water column.

2. Some oil will be stranded along shorelines. [The presence of stranded oil is dealt with in Hypothesis C-5.]

3. The presence of oil in the water column can have effects on important food chains. [The effects of oil on food chains is dealt with in Hypothesis C-17.]

4. The presence of oil can lead to direct effects on marine mammals.

5. The presence of oil can lead to indirect effects on marine mammals related to well control and oil clean-up activities.

6. Marine mammals can become oiled by swimming or surfacing through oil slicks.

7. Marine mammals can ingest oil directly from the water or by eating oiled prey.

8. Certain species of marine mammals, particularly polar bears, may ingest oil while attempting to clean their own oiled fur.

9. The ingestion of oil may have lethal and sub-lethal effects on marine mammals.

10. Contact with oil by the skin and/or fur may have thermal and other sub-lethal effects on marine mammals.

11. Mortality and lower reproductive rates in marine mammals, especially polar bears, will lead to reduced populations.

12. Reduced populations of marine mammals will result in reduced levels of harvest.

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.

14. Well control and clean-up activities will produce noise and will disturb marine mammals.

15. Noise and disturbance will cause changes in the distribution of marine mammals that will lead to changes in the harvestability of the animals.

16. Noise and disturbance will cause reductions in time available for foraging and will increase energy expenditures through increased avoidance behaviour.

17. The energetic effects of noise and disturbance will manifest themselves through reduced reproduction by the affected animals. This will lead to reduced populations. [These energetic links are discussed in more detail in BREAM Hypothesis R.1.]

18. The presence of humans associated with well control and clean-up activities will lead to conflicts between polar bears and humans.

19. Man/bear conflicts will lead to the death of several bears. This will lead to reductions in the harvest quota, rather than resulting in net population losses.

20. The occurrence of an oil spill will lead to the closure of one or more hunts in the year of the spill. [The closures could be initiated by either the Inuvialuit or Department of Fisheries and Oceans.]

The effects of an open-water offshore oil spill will vary with the time of year that it occurs. Since the purpose of the workshop was to explore the possible impacts of such a spill on the various species, the workshop participants decided to assume that the date of the spill varied depending on which species was being considered. This insured that potentially significant effects were not missed merely because an inappropriate spill date had been arbitrarily selected.

EVALUATION OF LINKAGES

General

The first five links in the hypothesis are general in nature and apply to all of the marine mammal species under consideration.

Link 1: **An offshore oil blowout will lead to the presence of oil on the water surface and in the water column.**

This link underpins the hypothesis. The scenario used to determine the amounts and characteristics of the oil on the surface and in the water column is described in Section 4.2.2 (Scenario B).

Link 2: Some oil will be stranded along shorelines.

The presence of stranded oil is dealt with in other hypotheses that examine the effects of the stranded oil on terrestrial mammals (C-5) and marine birds (C-11). Stranded oil is not considered in the present hypothesis.

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 partially addressed in Hypothesis C-17. Food chain effects affecting marine mammals were not specifically addressed but it is unlikely that the scenario outlined would produce food chain effects that would be detectable in marine mammals.

Link 4: The presence of oil can lead to direct effects on marine mammals.

Link 5: The presence of oil can lead to indirect effects on marine mammals related to well control and oil clean-up activities.

Direct effects are related to the effects of the oil itself (Link 4). 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 Link 5.

Beluga Whale

The beluga or white whale is probably the most important hunted marine mammal in the region. The oil spill was assumed to occur in early July in this scenario since large numbers of whales concentrate in the Mackenzie estuary in July; the whales are moulting and may be under stress; and the harvest of belugas by Inuvialuit hunters occurs at this time.

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.**

Links 6 and 7 were considered to be **valid**, although there are very few observations of oiled cetaceans. It was noted that belugas do not feed when they are present in the Mackenzie estuary. Therefore, ingestion of oiled food will not occur in the whale concentration areas.

Link 8: **Certain species of marine mammals, particularly polar bears, may ingest oil while attempting to clean their own oiled fur.**

This link was considered to be **invalid** for beluga whales which are structurally incapable of grooming themselves.

Link 9: **The ingestion of oil may have lethal and sub-lethal effects on marine mammals.**

The review by Geraci (1990) indicates that cetaceans would have to ingest very large amounts of oil in an acute event in order to demonstrate sub-lethal or lethal effects. Ingestion of such large amounts was not considered credible with the present scenario. Link 9 was, therefore, found to be **invalid**.

Link 10: **Contact with oil by the skin and/or fur may have thermal and other sub-lethal effects on marine mammals.**

There are several observations of whales swimming in and through oil spills on the water surface. There is no evidence, however, that suggests that whales are negatively affected by the concentrations of oil found in this scenario. Therefore, this link is considered to be **invalid**.

RECOMMENDED RESEARCH AND MONITORING

If a spill occurs, then it will be necessary to sample belugas to determine if the oil has any effect on the skin and internal organs. Therefore, it is desirable to have pre-spill baseline data. These data may be available in the samples currently being taken for DFO. It is recommended that the DFO program be reviewed to determine whether it is adequate to serve as a baseline against which to measure the effects of an oil spill. If necessary, additional specimens should be archived for future analyses.

In the event of a spill, it is recommended that the behaviour of beluga whales be monitored to determine their responses to oil and to the well control and clean-up activities.

Bowhead Whale

The bowhead whale is considered to be an endangered species. A small hunt by the Inuvialuit was resumed in 1991. The oil spill was assumed to occur in late August in this scenario since large numbers of whales often concentrate along the Yukon coast from mid August to mid September. The Inuvialuit harvest of a bowhead in 1991 occurred during this period. During this one month period, it is apparent that a very large fraction of the young subadult component of the population can be present at one time in these coastal waters. These animals are uniquely slow-growing and may be under natural energetic stress during the first several years after weaning.

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.**

Links 6 and 7 were considered to be **valid**, although there are very few observations of oiled cetaceans. It was noted that bowheads do feed when in the concentration areas along the Yukon coast. Therefore, ingestion of oiled food is possible in the whale concentration areas.

Link 8: **Certain species of marine mammals, particularly polar bears, may ingest oil while attempting to clean their own oiled fur.**

This link was considered to be **invalid** for bowhead whales which are structurally incapable of grooming themselves.

Link 9: **The ingestion of oil may have lethal and sub-lethal effects on marine mammals.**

The review by Geraci (1990) indicates that baleen whales would have to ingest enormous amounts of oil during a spill in order for mortality to occur. Ingestion of such large amounts of oil was not considered credible with the present scenario. Therefore, no mortality of bowheads was predicted. Less is known about sub-lethal effects, but the quantities of oil ingested are not likely to be high and the spill will not result in chronic ingestion of oil. This link is, therefore, considered to be **invalid**.

Link 10: **Contact with oil by the skin and/or fur may have thermal and other sub-lethal effects on marine mammals.**

There are several observations of whales swimming in and through oil spills on the water surface. There is no evidence, however, that suggests that whales are negatively affected by the concentrations of oil found in this scenario. Therefore, no effects are expected on bowhead whales. It is concluded that this link is **invalid**.

Link 11: **Mortality and lower reproductive rates in marine mammals will lead to reduced populations.**

The ingestion and/or surface contact with oil is not expected to affect the population levels of bowheads. Link 11 is, therefore, considered to be **invalid**.

Link 12: **Reduced populations of marine mammals will result in reduced levels of harvest.**

This link was considered to be **invalid** for bowheads since no reduction in the size of the population was predicted.

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 may be perceived effects that will reduce the market and/or cultural value of the product. The studies by Geraci (1990) indicate that oil does not penetrate the epidermis of cetaceans; therefore, tainting will not occur in bowheads. This link is considered **valid** for perception of effects and the significance of this was evaluated as Class 2 **Significant** for a VSC, i.e. the potential bowhead harvest.

Link 14: **Well control and clean-up activities will produce noise and will disturb marine mammals.**

This link was considered to be **valid**.

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.**

This link was considered to be **valid** and potentially important. There will be large amounts of ship, including small boats, and aircraft traffic associated with well control attempts and with clean-up efforts. These could directly interfere with bowhead hunting activities off the Yukon coast. More likely is that the distribution of bowheads will change in response to the disturbance. This may change their accessibility to the hunters. These changes could reduce or increase the harvest. Since clean-up activities might occur in years following the spill, it is possible that the effects might be long-term. This impact was rated as Class 2 **Significant** for the VSC of the bowhead harvest.

Link 16: **Noise and disturbance will cause reductions in time available for foraging and will increase energy expenditures through increased avoidance behaviour.**

This link was considered to be **valid**. The subadult bowheads that concentrate along the Yukon coast and off the Mackenzie estuary seem to feed actively. It is not known how much interference with this feeding would occur.

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.**

Since the energetic effects were unquantified, this link was considered to be **valid** for bowhead whales, but the effects were **unknown**. It was concluded that the potential effects of disturbance from a single spill were probably of much less significance than potential effects associated with long-term disturbance caused by offshore exploration and development activities. Hence, this concern is more fully addressed in BREAM Hypothesis 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 the death of a human or two.**

These links are not relevant to bowhead whales.

Link 20: **The occurrence of an oil spill will lead to the closure of one or more hunts in the year of the spill. [The closures could be initiated by either the Inuvialuit or Department of Fisheries and Oceans.]**

This link was considered to be **valid** and important. If a regulatory closure prevents the bowhead hunt for one or more years, then the effects might be classified as Class 2 **Significant**. These effects would not be mitigable.

RECOMMENDED RESEARCH AND MONITORING

In the event of a spill, it is recommended that the behaviour of bowhead whales be monitored to determine their responses to oil and to the well control and clean-up activities.

There is concern about the response of bowhead whales to noise and disturbance associated with well control and clean-up activities. However, there will be more predictable and long-lasting noise and disturbance associated with routine offshore exploration and production, than with a transitory spill event. Studies related to the effects of noise and disturbance on bowheads are more appropriately conducted in association with these routine activities where appropriate controls and sample sizes can be obtained.

Ringed Seal and Bearded Seal

The ringed seal and bearded seal were considered together during discussions of this scenario. The area of the Beaufort Sea affected by a spill at this location is not important habitat for either the ringed seal or the bearded seal. Relatively small numbers of each species are present and only a small fraction of the overall populations occur in the area. The species are not important in the harvests of the three Inuvialuit communities in the Mackenzie estuary region.

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.**

Links 6 and 7 were considered to be **valid**. There is evidence from the *Exxon Valdez* spill that the closely-related harbour seals did become oiled. It was noted however, that bearded and ringed seals do not feed intensively in the Mackenzie estuary. Therefore, ingestion of oiled food will probably be **insignificant** to the few seals that may occur in the area of the spill.

Link 8: **Certain species of marine mammals, particularly polar bears, may ingest oil while attempting to clean their own oiled fur.**

This link was considered to be **invalid** for seals.

Link 9: **The ingestion of oil may have lethal and sub-lethal effects on marine mammals.**

The small numbers of seals that occur in the spill area and the very limited feeding that occurs, indicate that only small amounts of oil are likely to be ingested by seals. These amounts are unlikely to have even sub-lethal effects (St. Aubin 1990), and therefore this link is considered to be **invalid**.

Link 10: **Contact with oil by the skin and/or fur may have thermal and other sub-lethal effects on marine mammals.**

The review by St. Aubin (1990) indicates that pinnipeds are unlikely, in normal arctic open-water conditions, to show serious sub-lethal effects or mortality from contact with surface oil from a spill. The situation where harbour seals were often re-oiled near their rookeries is not relevant to ringed and bearded seals in the Beaufort area. No lethal or sub-lethal effects to belugas are predicted, and therefore this link is considered to be **invalid**.

Link 11: **Mortality and lower reproductive rates in marine mammals will lead to reduced populations.**

The ingestion and/or surface contact with oil are not expected to have any effects on the population level of the Mackenzie estuary populations of ringed and bearded seals. This link is considered to be **invalid**.

Link 12: **Reduced populations of marine mammals will result in reduced levels of harvest.**

This link was considered to be **invalid** for seals since there are expected to be no reductions in the size of the population.

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.**

The presence of oil on the pelage of seals could reduce the value of seal skins, although the oil might wash off fairly easily. The potential for reductions in the value of few seal skins taken during the small harvest was concluded to be **valid** and rated as Class 4 **Insignificant** for the harvest.

Link 14: **Well control and clean-up activities will produce noise and will disturb marine mammals.**

This link was considered to be **valid**.

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.**

This link was considered to be **valid** but unimportant. Although, the subgroup concluded that the potential impact of this link was **Insignificant (Class 4)** due to the very small harvest of these species, it should be emphasized that even a small harvest may be important to those involved.

Link 16: **Noise and disturbance will cause reductions in time available for foraging and will increase energy expenditures through increased avoidance behaviour.**

This link was considered to be **valid** but **insignificant**. Seals are not common and do not feed actively in the spill area.

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.**

Since no energetic effects were predicted, this link was considered to be **invalid** for ringed seals and bearded seals in this scenario.

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 the death of a human or two.**

These links are not relevant to seals.

Link 20: **The occurrence of an oil spill will lead to the closure of one or more hunts in the year of the spill. [The closures could be initiated by either the Inuvialuit or Department of Fisheries and Oceans.]**

This link was considered to be **valid**. If a regulatory closure prevents the seal hunt for one or more years, then the effects would be classified as Class 4 **Insignificant**.

RECOMMENDED RESEARCH AND MONITORING

No specific research or monitoring programs were recommended for seals relating to the possibility of an offshore oil spill.

Polar Bear

The offshore blowout in the open water season would have minimal effects on polar bears, most of which are on the polar pack ice north of the spill area. Therefore, a revised scenario was devised. The blowout, from an island in approximately the same location, occurred in March. The island was surrounded by fast ice and oil accumulated on the ice surface where it was periodically burned. The zone of impact of the oil was quite constricted because the oil was contained on the ice and much of it was successfully burned.

Link 6: **Polar bears can become oiled by walking, swimming or surfacing through oil slicks.**

Link 7: **Marine mammals can ingest oil directly from the water or by eating oiled prey.**

Links 6 and 7 were considered to be **valid** and important.

Link 8: **Certain species of marine mammals, particularly polar bears, may ingest oil while attempting to clean their own oiled fur.**

This link has been demonstrated to be **valid** for polar bears.

Link 9: **The ingestion of oil may have lethal and sub-lethal effects on marine mammals.**

This link has been demonstrated to be **valid** for polar bears.

Link 10: **Contact with oil by the skin and/or fur may have thermal and other sub-lethal effects on marine mammals.**

This link has been demonstrated to be **valid** for polar bears.

Link 11: **Mortality and lower reproductive rates in marine mammals will lead to reduced populations.**

Ingestion and/or surface contact with oil is expected to cause mortality to polar bears. Since the present Beaufort Sea population of bears (about 1,800) is already harvested at maximum sustainable yield (MSY of 76), deaths from oil could have long-term population effects. This link is, therefore, considered to be **valid**. Using the agreed upon impact evaluation procedures, the ranking of this linkage was Class 2 **Significant**.

Link 12: **Reduced populations of marine mammals will result in reduced levels of harvest.**

This link was considered to be **valid** for polar bears since there could be reductions in the size of the population. The ranking of this link was **Class 3 Significant** for the VSC of bear harvest. In some circumstances (e.g. breeding females oiled), the effects on quota levels and harvests could be long term (over 1 yr), resulting in a ranking of Class 2 **Significant**.

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 may be effects that will reduce the market value of the product. The workshop concluded that this link is **valid** and evaluated the significance of these effects as Class 3 **Significant** for a VSC, i.e. the polar bear harvest.

Link 14: **Well control and clean-up activities will produce noise and will disturb marine mammals.**

This link was considered to be **invalid**. It was considered to be just as likely that bears would be attracted to the activities as they would be disturbed by them.

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.**

Since Link 14 was considered to be invalid and no disturbance effects were predicted, links 15, 16 and 17 were considered to be **invalid** for polar bears.

Link 18: **The presence of humans associated with well control and clean-up activities will lead to conflicts between polar bears and humans.**

This link was considered to be **valid** and quite likely to occur.

Link 19: **Human/bear conflicts will lead to the death of several bears.**

This link was considered to be **valid**. The deaths of a few bears would lead to compensatory reductions in bear quotas for that year, and possibly future years depending on the timing of the deaths and the age and sex classes of the animals killed. Therefore, this linkage was ranked as either Class 2 or Class 3 **Significant**.

Link 20: **The occurrence of an oil spill will lead to the closure of one or more hunts in the year of the spill. [The closures could be initiated by either the Inuvialuit or Department of Fisheries and Oceans.]**

This link was not considered to be relevant for polar bears.

RECOMMENDED RESEARCH AND MONITORING

No specific research or monitoring programs were recommended for polar bears relating to the possibility of an offshore oil spill.

4.4.2 BREAM HYPOTHESIS C-3: The Effects of a Pipeline Spill of Crude Oil during Summer on Terrestrial Mammals

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INTRODUCTION

BREAM Hypothesis C-3 involves a spill scenario where a pipeline rupture in the Mackenzie River near Fort Simpson causes up to 5000 barrels of crude oil to be released into the environment (Scenario D). This scenario was selected for evaluation of this hypothesis because it covers a larger geographic area than the barge spill scenario, and is an issue of importance to residents of the Sahtu and Deh Cho regions. The pipeline scenario helps to address concerns related to attraction of predators (i.e., grizzly and black bear, lynx, wolf, red fox, mink and wolverine) to oiled carrion, and contact of terrestrial mammals (i.e, bears, moose, and wolf) with oil during swimming. The timing of the scenario was selected to be early June to July to coincide with the period immediately following the peak flood, when high but declining water levels would expose a large area of riparian habitats to released oil, and many of the VEC species are utilizing riparian areas and islands for feeding and birth of young. Contact of these species with oil during foraging and swimming would therefore be high during this period.

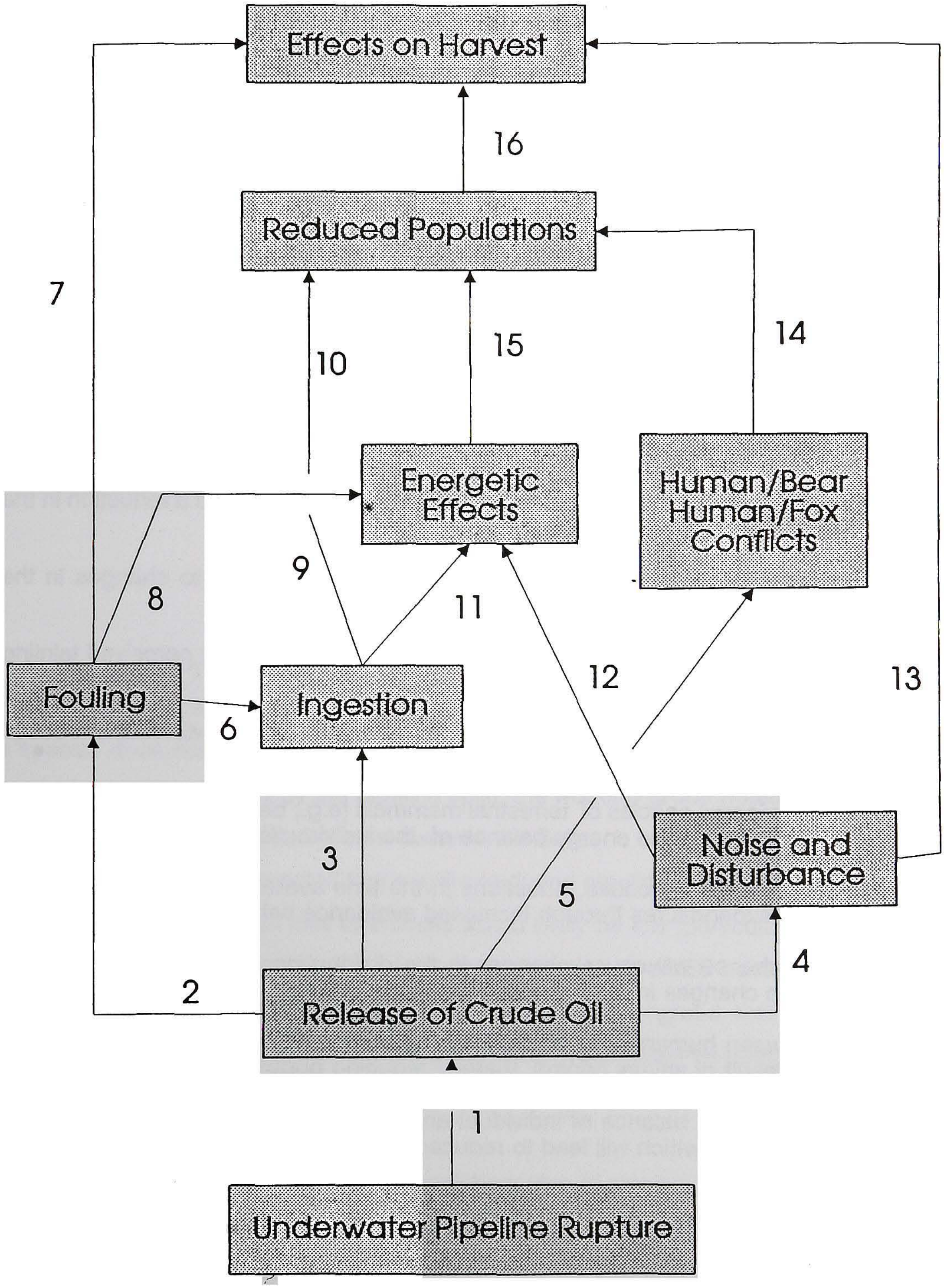

Figure 4-17: BREAM Hypothesis C-3 - Effects of an Underwater Pipeline Rupture on Terrestrial Mammals

LINKAGES

1. Rupture of the buried pipeline will release crude oil into a river.
2. The presence of spilled oil will lead to fouling of pelage of terrestrial mammals.
3. Stranded oil will be ingested by terrestrial mammals.
4. Pipeline repair, cleanup, habitat restorations, and monitoring activities will produce noise and will disturb terrestrial mammals.
5. The presence of humans involved in shoreline cleanup, habitat restorations, and monitoring programs will lead to increased interactions between humans and bears, foxes or wolves.
6. Grooming of fouled pelage will result in ingestion of some oil.
7. Fouled pelage will lead to a reduction in the harvest of the animals and a reduction in the value of the animals.
8. Fouled pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.
9. Ingestion of spilled oil by terrestrial mammals will result in tainting or perceived tainting of these animals and a change in the harvest of these species.
10. Ingestion of oil by some species of terrestrial mammals (e.g., bears) will lead to reduced populations.
11. 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.
12. Noise and disturbance will cause reductions in the time available for foraging and will increase energy expenditures through increased avoidance behaviour.
13. Noise and disturbance will cause changes in the distribution of terrestrial mammals, which will lead to changes in the harvestability of the animals.
14. Interactions between humans and bears, foxes or wolves will lead to mortality of some mammals as a result of animal control, thereby reducing populations.
15. Changes in the energy balance of individual animals will lead to reduced survival and reduced reproduction, which will lead to reduced populations.
16. Reduced populations of terrestrial mammals will result in reduced harvests of these mammals.

The following species were considered by the subgroup for evaluation of this impact hypothesis:

- Grizzly bear
- Black bear
- Moose
- Lynx
- Wolverine
- Wolf
- Red fox
- Marten
- Fisher

However, only moose, black and grizzly bears and wolf and fox were selected as VECs. The rationale for this decision is outlined in the following sections.

GRIZZLY BEAR AND BLACK BEAR

Grizzly bear utilize riparian habitat and feed on carrion and berries along the river banks during summer and, therefore, would be vulnerable to contact with spilled oil. Although this species does not occur commonly along the Mackenzie River upstream of Wrigley (i.e., in the area potentially affected by the pipeline spill), the working group noted that it does occur in relatively higher densities downstream towards the Delta. It was unknown whether bears from adjacent areas would be attracted to the spill site during pipeline repair, cleanup and monitoring activities. While the potential loss of animals would likely be low (particularly given their solitary nature), it was considered important to include this species as a VEC because of its vulnerability to oil spills and low densities in the area. The subgroup agreed that the most significant concerns related to the effects of a spill on grizzly bear would likely be human/bear conflicts and, to a lesser extent, fouling and ingestion of oil.

The subgroup agreed the black bear should also be considered as a VEC. During spring and summer, black bear occur along riverbanks of the Mackenzie to feed on fish, carrion, berries and riparian habitat (primarily horsetails). This species is abundant in the area potentially affected by the spill but is widely dispersed.

MOOSE

Most moose winter in riparian areas such as the Mackenzie River islands but move into adjacent upland areas after breakup when water levels are high. Excellent moose habitat is found along the Mackenzie River from Fort Simpson to Fort Norman (Treseder and Graf 1985). Frequent disturbances of river islands and shorelines by ice scouring, flooding and alluvial deposition maintain early successional vegetation (e.g., willows), which provides high quality browse for moose, while mature deciduous and coniferous cover on larger islands and adjacent to the river provides good winter cover and security.

By spring when water levels have dropped, moose return to the river where they feed primarily on aquatic vegetation. Calving generally occurs in May or June in the lowland riparian areas or alluvial islands (Mackenzie River Basin Committee 1981). During the summer months, moose are found primarily along the river where females and their calves tend to use the river to escape predators (e.g., black bears). Because of the vulnerability of this species (particularly females and their calves) to contact with spilled oil, moose were selected as a VEC for this hypothesis.

LYNX

The subgroup agreed that lynx should not considered as a VEC in this hypothesis because: (1) they do not appear to be abundant along the Mackenzie flood plain during the summer months; (2) they tend to avoid wet areas and, therefore, are at a low risk of contact with oiled water; and (3) they feed almost exclusively on live food at this time of year and are unlikely to scavenge on oiled prey.

WOLVERINE

Wolverines are opportunistic feeders and scavenge mainly on carrion, and are also known to prey on small mammals and birds and occasionally on caribou calf (LGL *et al.* 1986). Because wolverine may be attracted to oiled carrion, they may be vulnerable to contact with oil. However, since wolverine do not commonly occur in riparian areas along the Mackenzie River, have very large home ranges and are typically solitary, the working group felt it was unlikely that more than a few individuals may be at risk of contacting oil following a river pipeline spill. Wolverine were, therefore, not considered as a VEC for this scenario.

WOLF AND RED FOX

Wolves are not particularly abundant in the area at this time of year, but any individuals found along the river tend to be males scavenging for food. For this reason, the subgroup agreed that it was important to consider wolf as a VEC because of the potential for fouling of and ingestion of oil by females and their pups as a result of the hunters returning to the dens with oiled prey.

Red fox were also selected as a VEC. This species is very common in the area of the spill and similar mechanisms as previously described for wolves are also considered valid for fox. It was noted that although fox have a higher reproductive potential than wolves (i.e., all female fox will attempt to pup, while only one female in a wolf pack will have a litter) the survival rate of this species is poor.

MARTEN AND FISHER

Marten and fisher were not considered VECs for this hypothesis because they occur primarily in upland areas, and the risk of contact with oil would be very low.

EVALUATION OF LINKAGES - MOOSE

Link 1: Rupture of the buried pipeline will release crude oil into a river.

In this spill scenario, approximately 5000 barrels of crude oil would be released into the river. Of this total volume, about 1500 bbls of oil would evaporate and 2500 bbls would disperse naturally within the water column. The remaining 1000 bbls of oil would become stranded in widely-scattered areas along a 200-km stretch of shoreline, including both sides of the river and islands.

Link 2: The presence of spilled oil will lead to the fouling of pelage of moose.

It was assumed that two hours after the spill, the diameter of the dispersed cloud would equal the width of the river. At this time, any moose swimming in the river or foraging along the river bank within the zone of influence of the spill would likely come in contact with the oil. This link was, therefore, considered to be **valid** for moose.

Link 3: Stranded oil will be ingested by moose.

Although there appears to be no evidence to suggest that moose have the capability to detect oil and thereby avoid contaminated food, the subgroup thought it was unlikely that moose would feed on contaminated vegetation when there is alternate uncontaminated food sources available in the area. Oiling of riparian vegetation would likely be very limited due to the small volume of oil (i.e., 1000 bbls) that would be stranded over the 200-km stretch of river. The subgroup, therefore, concluded that this link is **invalid** for moose.

Link 4: Pipeline repair, cleanup, habitat restoration and monitoring activities will produce noise and will disturb moose.

It was assumed by the subgroup that spill-related activities would not likely be a major source of disturbance to moose in the area. Any noise or disturbance caused by spill response activities would likely be localized and short term, and would likely have less of an impact on moose than more gregarious animals. As noted in the MEMP Report (LGL *et al.* 1986), moose appeared to be relatively undisturbed by construction activities associated with the IPL pipeline, temporary roads or highways. In the event that avoidance of an area did occur, it is likely that the animals would temporarily move to alternate areas of suitable habitat and return once the source of disturbance ceased. The subgroup, therefore, concluded Link 4 to be **invalid.**

Link 5: **The presence of humans involved in shoreline cleanup, habitat restorations, and monitoring programs will lead to increased interactions between humans, and bears, wolves or foxes.**

This linkage does not apply to any interaction between spill-related impacts and moose populations in the area.

Link 6: **Grooming of fouled pelage will result in ingestion of some oil.**

Grooming of fouled fur, in particular the cleaning of calf fur by the mother, may cause some moose to ingest oil. This link is considered to be **valid.**

Link 7: **Fouled pelage will lead to a reduction in the harvest of the animals and a reduction in the value of the animals.**

Although a few moose are taken in June and July, the main hunt generally occurs in the fall. By this time, it would be unlikely that sufficient exposed oil would remain along the riverbanks or on the animals fur to cause hunters to take less animals or to reduce the value of the harvest . The subgroup, therefore, considered this link to be **invalid.**

Link 8: **Fouled pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.**

No information on the effects of oil fouling on moose is known, but it is reasonable to expect that fouling may result in thermal effects and skin and mucuous membrane irritation. No buoyancy effects are anticipated. The working group concluded that thermal effects during the summer period and irritant effects would not be important (i.e., moose would more likely be trying to escape the heat). This link was, therefore, considered **invalid**.

Link 9: **Ingestion of spilled oil by moose will result in tainting or perceived tainting of these animals and a change in the harvest of this species.**

It was considered unlikely that hunters would be concerned about the potential for tainting in moose as a result of an oil spill of this nature occurring several months prior to the hunt (J. Benoit, pers. comm.). The subgroup, therefore, concluded that this link was **invalid**.

Link 10: **Ingestion of oil will lead to the death of affected bears and perhaps other species, leading to reduced populations.**

Although moose may ingest some oil through grooming of fouled pelage, it was considered unlikely that the amounts would be sufficient to cause death in affected animals. The subgroup agreed that this link is probably **invalid**, but attached low confidence to this conclusion due to the lack of information regarding the toxicological effects of oil on this species.

Link 11: **Ingestion of oil by moose while trying to clean their own fur will change the energy balance of the individuals.**

Oil ingestion through grooming of fouled fur may cause a range of physiological and behavioural effects that would ultimately affect the energy balance of affected individuals. Although the subgroup was unaware of any documented evidence in support of this linkage, it was assumed that effects such as increased grooming activity, shivering and vomiting may result from contamination and subsequent cleaning of their fur. It was agreed that this is a **valid** linkage for moose.

Link 12: **Noise and disturbance will cause reductions in the time available for foraging and will increase energy expenditures through increased avoidance.**

This link is **invalid** because it is unlikely that spill response activities would represent a major source of disturbance to moose (Link 4).

Link 13: **Noise and disturbance will cause changes in the distribution of moose, which will lead to changes in the harvestability of the animals.**

This link is **invalid** for the same reasons as noted above for Link 12.

Link 14: **Interactions between humans and bears, foxes or wolves will lead to mortality of some mammals as a result of animal control, thereby reducing populations.**

Link 14 is not applicable to the evaluation of this impact hypothesis for moose.

Link 15: **Changes in the energy balance of individual animals will lead to reduced survival and reduced reproduction, which will lead to reduced populations.**

Although this linkage is **implicitly valid**, the subgroup concluded that Link 15 was **unlikely** since the number of individuals actually affected would be so low that any effect on population levels, if it occurred, would be difficult to detect. However, the lack of information on the behaviour of moose to oil contact and the implications of oil ingestion on growth, reproduction and survival of this species caused the group to attach a low confidence to this conclusion. While there is no evidence of moose mortality as a result of oil ingestion, Bourne (1979, cited in Duval 1985) reported that a Bunker C spill in the Shetland Islands indirectly contributed to the death of 50 sheep that ingested oiled seaweed when snowfall at higher elevations forced the herd to feed in shoreline areas.

Link 16: **Reduced populations of moose will result in reduced harvests of these animals.**

This link is **invalid** because its lower linkages (10, 14 and 15) were considered to be invalid.

ASSESSMENT OF IMPACTS

An assessment of impact significance was not completed for moose because the subgroup concluded that this impact hypothesis/scenario was **invalid** for this species (i.e., all of the hypothesis linkages were found to be invalid before a population or harvest level effect). The most significant effect of an oil spill of this nature and extent on moose populations in the area would likely be the ingestion of oil as a result of grooming of contaminated fur and subsequent sublethal effects.

EVALUATION OF LINKAGES - GRIZZLY AND BLACK BEAR

Link 1: Rupture of the buried pipeline will release crude oil into a river.

In this spill scenario, approximately 5000 barrels of crude oil would be released into the river. Of this total volume, about 1500 bbls of oil would evaporate and 2500 bbls would disperse naturally within the water column. The remaining 1000 bbls of oil would become stranded in widely-scattered areas along a 200-km stretch of shoreline, including both sides of the river and islands.

Link 2: The presence of spilled oil will lead to the fouling of pelage of grizzly and black bear.

It was assumed that two hours after the spill, the diameter of the dispersed cloud would equal the width of the river. At this time, any bear swimming in the river or foraging along the river bank within the zone of influence of the spill could come in contact with the oil. Although very few grizzly bear would likely be affected due to their low densities in the area, the group concluded that this link was **valid** for both species.

Link 3: **Stranded oil will be ingested by grizzly and black bear.**

Based on behavioural responses observed in polar bears (e.g., active ingestion of oil; Duval 1985), the group concluded that it is likely that any grizzly or black bear foraging along oiled sections of the shoreline would ingest some oil through consumption of oiled prey or prey containing oil.

Link 4: **Pipeline repair, cleanup, habitat restoration, and monitoring activities will produce noise and will disturb grizzly and black bear.**

There is evidence to suggest that human activity in the vicinity of bears can result in increased activity of some individuals, and cause avoidance of parts of their territory (IGBC 1987; Mattson *et al.* 1987). Studies of bear behaviour have indicated that bears actively avoid humans in parks (Herrero 1985; Mattson *et al.* 1987), and tend to avoid active drilling and staging camps by distances of 1 km (Harding and Nagy 1980, cited in LGL *et al.* 1986). However, because spill response activities would likely be very localized and short term, the subgroup concluded that this interaction is unlikely to occur. Link 4 is, therefore, considered to be **invalid** for grizzly and black bears.

Link 5: **The presence of humans involved in shoreline cleanup, habitat restorations, and monitoring programs will lead to increased interactions between human and bears, foxes or wolves.**

It has been well documented that grizzly and black bears are attracted to camps and garbage because they provide an accessible and concentrated source of food (LGL *et al.* 1986). During spill response activities, there would be the potential for interaction between humans and bears as a result of curious animals or bears searching for food. This may, in turn, cause some bears to be destroyed if they become a nuisance or a safety hazard.

Link 6: Grooming of fouled pelage will result in ingestion of some oil.

Some bears in the area of the spill may become oiled as a result of foraging along the riverbanks and swimming in the river. This, in turn, may cause those animals to ingest oil through grooming of their fur or their young. This link is considered to be **valid**.

Link 7: Fouled pelage will lead to a reduction in the harvest of the animals and a reduction in the value of the animals.

As described earlier for moose, the main hunt for grizzly and black bear occurs in the fall. By this time, it is unlikely that sufficient amounts of oil would still be detectable on the bear's fur to cause hunters to take less animals or to reduce the value of the harvest. This link was, therefore, concluded to be **invalid**.

Link 8: Fouled pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.

Although evidence exists to demonstrate that grizzly bears can become fouled through direct contact with oil and oiled prey (Lewis 1993), no information on the effects of fouling on grizzly bears is known. It is reasonable, however, to assume that fouling may result in thermal effects and skin and mucuous membrane irritation. As bears do not rely on air entrapment in their fur for buoyancy, fouling is not anticipated to affect buoyancy. The working group concluded that thermal effects during the summer period and irritant effects would not be important. This link was, therefore, considered to be **invalid**.

Link 9: Ingestion of spilled oil by grizzly and black bears will result in tainting or perceived tainting of these animals and a change in the harvest of these species.

Concerns related to tainting or perceived tainting are **not valid** for grizzly and black bear since these species are hunted primarily for their fur and are only occasionally used as a source of food by northerners (Joe Benoit, pers. comm.; S. Kotchea, pers. comm.).

Link 10: Ingestion of oil will lead to the death of affected bears and perhaps other species, leading to reduced populations.

Black and grizzly bears could potentially ingest oil through two pathways: consumption of oiled prey and prey containing oil, and grooming of fouled fur. Because they are scavengers and are known to utilize the river at this time of year, the group concluded that some bears may ingest sufficient oil to cause mortality. This is strongly supported by the studies of grizzly (brown) bears following the *Exxon Valdez* oil spill. Analyses of grizzly bear scats indicated that 4 of 27 scat samples (15%) contained hydrocarbons (Lewis 1993). In one case, a bile sample from a dead yearling bear (belonging to one of the collared female bears in the spill area) was found to have highly elevated levels of napthalene and phenanthrene in its bile. The other yearling cub of this female disappeared, but its carcass was not found. Although Lewis (1993) concluded that "survival of the bears for the first two years after the oil spill was not greatly affected", the above evidence suggests that oil ingestion may result in the death of some animals. Link 10 is therefore **valid**.

Link 11: Ingestion of oil by bears while trying to clean their own fur will change the energy balance of the individuals.

Ingestion of oil by grizzly and black bears caused by grooming of contaminated fur may cause a range of effects that would ultimately affect the energy balance of affected individuals. Although the subgroup was unaware of substantive information on the physiological and behavioural effects of oil on black and grizzly bears, it is reasonable to assume that documented effects of oil ingestion on polar bear (such as increased grooming activity, vomiting, loss of appetite, increased metabolic rates and elevated skin temperatures [Duval 1985]) may also result from contamination and subsequent cleaning of fur in these species. It was concluded that this is a **valid** linkage for black and grizzly bear.

Link 12: **Noise and disturbance will cause reductions in the time available for foraging and will increase energy expenditures through increased avoidance behaviour.**

As mentioned earlier, noise and disturbances associated with pipeline repair, cleanup, habitat restoration and monitoring programs would likely be very localized and short term. Although this may cause a few bears to avoid the immediate vicinity of the activities, the subgroup concluded that this would be insignificant due to the fact that the home ranges of both species are very large and other suitable habitat would be available within their ranges.

Link 13: **Noise and disturbance will cause changes in the distribution of black and grizzly bears, which will lead to changes in the harvestability of the animals.**

As Link 4 was found to be invalid, Link 13 is also **invalid**.

Link 14: **Interactions between humans and bears, foxes or wolves will lead to mortality of some mammals as a result of animal control, thereby reducing populations.**

As noted in the discussion related to Link 5, it is possible that some bears may be destroyed if they represent a nuisance or safety hazard to cleanup or repair crews. As mortality in the regional grizzly bear population is believed to be high due to recreational and subsistence hunting, control of problem animals, and natural causes (J. Nagy, pers. comm.), additional losses due to human/bear conflicts may exceed the sustainable limit for the population, and a gradual decline in the regional bear populations may occur. This link was, therefore, considered to be **valid**.

Link 15: **Changes in the energy balance of individual animals will lead to reduced survival and reduced reproduction, which will lead to reduced populations.**

This link is **valid**. The likelihood of black and grizzly bears ingesting sufficient amounts of oil to effect their survival and reproductive capacity was considered greater than for other VEC species evaluated in this hypothesis because they are particularly vulnerable to contact with oil (i.e., through contamination of fur during swimming, ingestion of oil by scavenging on contaminated prey or prey containing oil, and the fact that they are unlikely to avoid oil-contaminated areas). There is also anecdotal evidence that grizzly and black bears may be attracted to oil (i.e., bear ingestion of diesel and other oils). Because these species naturally have very high mortality rates and low reproductive rates (J. Nagy, pers. comm.), a further reduction in the number of cubs born and in the survival of subadult and adult bears will reduce the breeding population and cause a gradual decline in the size of the population.

Link 16: **Reduced populations of grizzly and black bears will result in reduced harvests of these animals.**

Any reported losses of animals as a result of human/bear conflicts and/or ingestion of oil could affect quotas in subsequent years if present harvest levels for grizzly and black bear are at the maximum sustainable yield. This link was considered to be **valid**.

ASSESSMENT OF IMPACTS

Given the oil spill scenario used for evaluating this impact hypothesis, the group concluded that the linkage related to reduced populations of grizzly and black bear as a result of human/bear conflicts was **valid** and **significant**. Because of the low reproductive rates and high mortality rates of these populations, the effect of any loss of individuals would likely be long term. However, through the use of bear detection and deterrent techniques, this effect could be mitigated. The effect of any loss of animals on the harvest was considered to be **significant** for grizzly bear (Class 2) but **insignificant** for black bear (Class 3) due primarily to the fact that grizzly bear occur in such low densities in the area potentially affected by the oil spill.

While the group concluded that the linkages relating ingestion of oil to mortality of individuals was **valid**, they attached low confidence to this conclusion due to the lack of knowledge within the group on the toxicological effects of oil on bears. As a result, the group concluded that more information was needed to properly assess the significance of this pathway on bear populations and the harvest of these animals.

EVALUATION OF LINKAGES - WOLVES AND FOXES

Link 1: Rupture of the buried pipeline will release crude oil into a river.

In this spill scenario, approximately 5000 barrels of crude oil would be released into the river. Of this total volume, about 1500 bbls of oil would evaporate and 2500 bbls would disperse naturally within the water column. The remaining 1000 bbls of oil would become stranded in widely-scattered areas along a 200-km stretch of shoreline, including both sides of the river and islands.

Link 2: The presence of spilled oil will lead to the fouling of pelage of wolves and foxes.

It was assumed that two hours after the spill, the diameter of the dispersed cloud would equal the width of the river. At this time, any wolf or fox foraging along the river bank within the zone of influence of the spill could come in contact with the oil. Although very few wolf would likely be affected due to their low densities in the area, the group concluded that this link was **valid** for both species.

Link 3: Stranded oil will be ingested by wolves and foxes.

This is link is **valid**. As noted earlier, most wolf and fox that are found along the riverbanks of the Mackenzie River at this time of year are males scavenging for food, which they will take back to the dens to feed the female and her pups.

Link 4: Pipeline repair, cleanup, habitat restoration, and monitoring activities will produce noise and will disturb wolf and fox.

The subgroup concluded that spill response activities would not likely represent a major source of disturbance to wolf and fox in the area since activities would be relatively localized and short term. This link is, therefore, **invalid**.

Link 5: **The presence of humans involved in shoreline cleanup, habitat restorations, and monitoring programs will lead to increased interactions between humans and bears, foxes or wolves.**

The working group considered this link to be **invalid** for wolves and foxes because the potential for interactions with humans would be very low given the short duration and localized nature of the spill response activities, and the relatively low abundance of animals in the area.

Link 6: **Grooming of fouled pelage will result in ingestion of some oil.**

Some wolf and fox may come in contact with oil as a result of scavenging for food along the river banks and swimming in the river and, in turn, may ingest oil through grooming of their fouled fur. This link is **valid**.

Link 7: **Fouled pelage will lead to a reduction in the harvest of the animals and a reduction in the value of the animals.**

This link is **invalid** because there is very little temporal overlap between the harvest of wolf and fox and the occurrence of oil in the river. The main harvest of these species occurs during early to late winter (November to March). As animals will have undergone a complete moult between the time of the spill and the start of the trapping season, it is unlikely that sufficient numbers of pelts would be damaged by oil, thereby affecting the value of the fur and the intensity and location of trapping.

Link 8: **Fouled pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.**

No information on the effects of fouling on wolf and fox is known. It is reasonable, however, to assume that fouling may result in thermal effects and skin and mucuous membrane irritation. As these two canids do not rely on air entrapment in their fur for buoyancy, fouling is not anticipated to affect buoyancy. The working group concluded that thermal effects during the summer period and irritant effects would not be important. This link was, therefore, considered to be **invalid**.

Link 9: **Ingestion of spilled oil by wolves and foxes will result in tainting or perceived tainting of these animals and a change in the harvest of these species.**

Concerns related to tainting or perceived tainting are **not valid** for wolves and foxes because these species are hunted exclusively for their fur (Joe Benoit, pers. comm.; S. Kotchea, pers. comm.).

Link 10: **Ingestion of oil will lead to the death of affected wolves and foxes, leading to reduced populations.**

Wolves and foxes could potentially ingest oil through two pathways: consumption of oiled prey and prey containing oil, and grooming of fouled fur. Because they are scavengers and are known to utilize the river at this time of year, the group concluded that some individuals may ingest sufficient amounts of oil to cause mortality. This link is, therefore, **valid**.

Link 11: **Ingestion of oil by wolves and foxes while trying to clean their own fur will change the energy balance of the individuals.**

Ingestion of oil through grooming of fouled fur may cause a range of physiological and behavioural effects in wolves and foxes that would ultimately affect the energy balance of affected individuals. Although the subgroup was unaware of any documented evidence to support this linkage, it was assumed that effects such as increased grooming activity, shivering and vomiting may result from contamination and subsequent cleaning of their fur. It was concluded that this is a **valid** linkage for wolf and fox.

Link 12: **Noise and disturbance will cause reductions in the time available for foraging and will increase energy expenditures through increased avoidance behaviour.**

Link 12 is **invalid** because its lower linkage (Link 4) was found to be invalid.

Link 13: **Noise and disturbance will cause changes in the distribution of wolves and foxes, which will lead to changes in the harvestability of the animals.**

Link 4 is invalid, therefore this link is also **invalid**..

Link 14: **Interactions between human and bears, foxes or wolves will lead to mortality of some animals as a result of animal control, thereby reducing populations.**

As Link 5 was found to be invalid, this linkage is also **invalid**.

Link 15: **Changes in the energy balance of individual animals will lead to reduced survival and reduced reproduction, which will lead to reduced populations.**

This link is **valid**. Although it is unlikely that many wolves or foxes would be affected, it was considered possible that some individuals may ingest sufficient amounts of oil to affect their survival and reproductive capacity due to the fact that these animals are scavengers.

Link 16: **Reduced populations of wolves and foxes will result in reduced harvests of these animals.**

Any reported losses of animals as a result of ingestion of oil could affect quotas in subsequent years if present harvest levels are at the maximum sustainable yield. This link was considered to be **valid**.

ASSESSMENT OF IMPACTS

Given the oil spill scenario used to evaluate this impact hypothesis, the working group concluded that the only pathway that is valid for wolves and red foxes relates to the effects of oil ingestion (through grooming of fouled fur and ingestion of contaminated prey) on the populations and harvest of these animals. Because wolves and foxes are known to scavenge along the river banks, the potential for an individual to ingest oil would high. However, due to the relatively low abundance of these species in the area at the time of the spill, the group agreed that only a very small proportion (i.e., < 1%) of the regional populations would likely be affected by the spill. Because of the lack of knowledge within the group on the toxicological effects of oil on these species, the group was unable to further assess the significance of potential toxic effects on these two species.

RECOMMENDED RESEARCH AND MONITORING

The group recommended that a review of existing information related to the chronic and acute effects of oil on terrestrial mammals (grizzly bear, moose, wolves and foxes) be undertaken. Any information gaps in the database should be noted and opportunistic research conducted with a priority on grizzly bear due to their low densities in the region and the economic value of this species.

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4.4.3 BREAM HYPOTHESIS C-5: The Effects of an Island Platform Blowout of Crude Oil during Summer on Semi-aquatic Mammals

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INTRODUCTION

BREAM Hypothesis C-5 involves a blowout on an artificial island. The blowout flows from the drillpipe at a rate of 2050 m^3/d of Adgo oil and 277,000 m^3/d of natural gas. The flow continues unabated for six days until killed by the installation of a valve on the drill pipe.

This scenario was selected to address concerns related to the effects of an offshore blowout on semi-aquatic mammals 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 wetlands along the coastal fringe of the Mackenzie Delta . Muskrat and mink are the key species for assessment, as they 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.

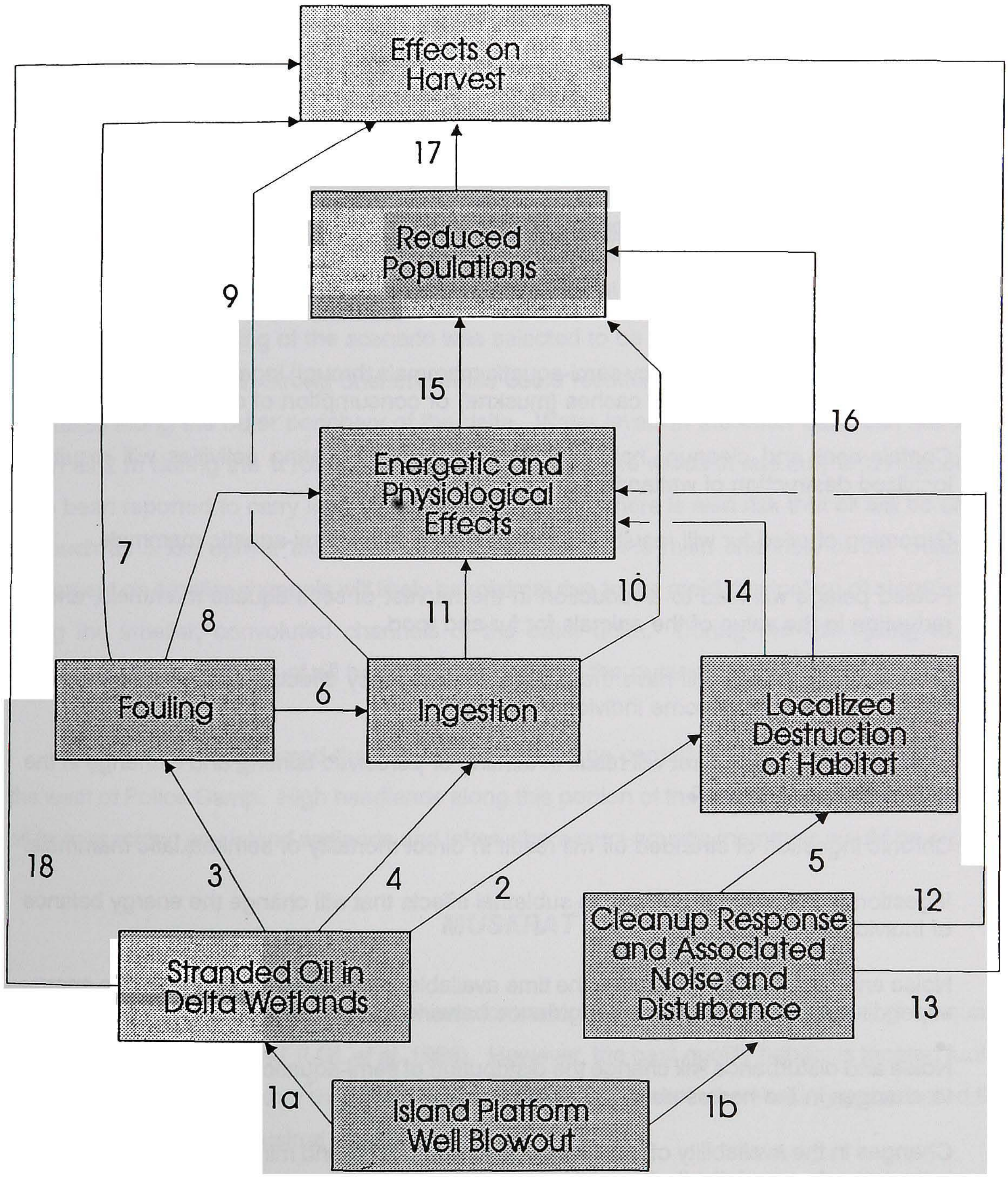

Figure 4-18: BREAM Hypothesis C-5 - Effects of an Offshore Well Blowout on Semi-Aquatic Mammals

LINKAGES

1. An offshore oil blowout will result in: (a) the stranding of oil on coastal shorelines and in delta wetlands; and (b) a cleanup response with associated noise and disturbance.

2. The presence of stranded oil will damage or kill wetland vegetation that provides important habitat for semi-aquatic mammals.

3. The presence of stranded oil in the delta wetlands will lead to fouling of pelage of semi-aquatic mammals.

4. Stranded oil will be ingested by semi-aquatic mammals through ingestion of oiled aquatic vegetation or fouling of food caches (muskrat) or consumption of oiled prey (mink).

5. Containment and cleanup, habitat restoration and monitoring activities will result in localized destruction of wetlands.

6. Grooming of oiled fur will result in the ingestion of oil by semi-aquatic mammals.

7. 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.

8. Fouling of the pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.

9. Ingestion of oil by muskrat will result in tainting or perceived tainting and a change in the harvest of these animals.

10. Chronic ingestion of stranded oil will result in direct mortality of semi-aquatic mammals.

11. Ingestion of stranded oil will lead to sublethal effects that will change the energy balance of individuals.

12. Noise and disturbance will reduce the time available for foraging and will increase energy expenditures through increased avoidance behaviour.

13. Noise and disturbance will change the distribution of semi-aquatic mammals that will lead to changes in the harvestability of the animals.

14. Changes in the availability of habitat and food for muskrat and mink will result in changes in the behaviour and distribution of these animals which will have energetic consequences for these individuals.

15. Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction that will lead to reduced populations.

16. Localized losses of wetland habitat will result in reduced populations of semi-aquatic furbearers.

17. Reduced populations of semi-aquatic mammals will result in reduced harvests of these animals.

18. The presence of oil in wetlands and in river channels, in combination with the cleanup activities will change the distribution and/or success of the harvest.

The timing of the scenario was selected to be September. High tides during the fall, in combination with strong onshore winds could result in the transport of oil into wetlands and lakes along the outer periphery of the delta. Water levels in the outer delta can rise by as much as 2 m during the 1:100 year storm surges. Onshore winds in late July and August also have been reported to carry logs as far inland as 15 m. There is also risk that oil will be carried as much as 5 km upriver along the straight sections of the main channels of the Delta. Oil movement on smaller channels will likely be minimal due to the rapid dissipation of storm surges along the smaller, convoluted channels of the outer delta. During the late spring to early summer, there is little risk of oil being transported into the outer delta due to the landfast ice.

It was assumed that very little oil would be carried onland along the coastline to the west of Police Camp. High headlands along this portion of the coastline would likely prevent oil from reaching any inland wetlands and lakes where semi-aquatic mammals would be present.

MUSKRAT

The Mackenzie Delta is known for having the highest concentration of good quality muskrat habitat in the NWT (LGL *et al.* 1986). However, the best quality habitat is located further upstream on the Delta rather than in the outer Delta. Participants in the working group noted that there is no significant muskrat habitat west of the Blow River.

Muskrat numbers fluctuate widely in the Delta region and there may be some cyclic patterns in these fluctuations (Martell *et al.* 1984; LGL *et al.* 1986). Muskrat may produce two litters in some areas of the Delta, with the young being born between mid-May and June.

Survival of the young is very low, particularly during the winter months.

Muskrat are trapped from April to May 15 for their pelts. Generally, there is no harvest after mid-May because the quality of the pelts has deteriorated by this time. However, a rifle hunt of muskrat takes place in July. This hunt is primarily conducted for food.

MINK

Mink occur throughout the Delta year round and are generally found in the same areas as muskrat (muskrat are an important prey species of mink). Mink are also known to use the coastal zone for foraging on small birds and fish. Although mink are carnivorous animals, they may also feed on some plant material. Mink do not generally scavenge but may be attracted to dead oiled fish and birds.

In the Mackenzie Delta, the trapping season for mink extends from the beginning of November to the end of February. This species is harvested exclusively for their fur. Harvesting is concentrated mainly in the inland areas of the delta; coastal areas are not harvested as intensively. In the trapping season of 1991/92, 600-700 mink were harvested in the Delta. This was perceived as a poor harvest, as 7000-8000 animals have been harvested in good years.

EVALUATION OF LINKAGES - MUSKRAT

Link 1: **An offshore oil blowout will result in: (a) the stranding of oil on coastal shorelines and in delta wetlands.; and (b) a cleanup response with associated noise and disturbance.**

Based on the oil spill scenario, it is estimated that 60,000 bbls of oil emulsion (75% water) will be stranded on shorelines between Kay Point and Whitefish Station, and 56,000 bbls of emulsion will be stranded between Whitefish Station and Avoknar Channel. As noted earlier, it is likely that oil will also be stranded in wetlands along the outer edge of the delta and along shorelines of the main delta channels due to transport of the oil by high tides during the fall period in combination with strong onshore winds. Link 1 is **valid**.

Link 2: The presence of stranded oil will damage or kill wetland vegetation that provides important habitat for semi-aquatic mammals.

A review of 100 marine oil spills by Duval *et al.* (1981) indicated that 41 of the spills resulted in mortality and damage to marsh vegetation and intertidal algae. Mortality resulted from (1) direct contact (suffocation), (2) direct toxic effects and (3) physical effects (e.g., dislodging, cleanup activities). Damage resulted from interference with photosynthesis, growth and reproduction. Link 2 is considered to be **valid**.

Link 3: The presence of stranded oil in the delta wetlands will lead to fouling of pelage of semi-aquatic mammals.

It is assumed that a combination of high tides during late August and September in combination with strong onshore winds would result in the stranding of oil in wetlands along the outer perimeter of the Delta. Oil may also become stranded on the shorelines of some river channels.

The working group assumed that in a worst case, oil might be stranded within most wetlands and along channel shorelines within 5 km of the outer edge of the Delta. As most high quality habitat for muskrat is located in the southern portion of the Delta, it was concluded that oil would affect less than 1% of the total muskrat habitat in the Delta. Fouling of fur during late summer and fall would be of concern, because the summer moult would largely be complete and fouling could persist into the fall and winter when thermal effects on muskrat would be most severe. Link 3 is **valid**.

Link 4: Stranded oil will be ingested by semi-aquatic mammals through ingestion of oiled aquatic vegetation or fouling of food caches (muskrat) or consumption of oiled prey (mink).

The working group was not aware of any evidence to suggest that muskrat would avoid consuming contaminated vegetation or contacting floating or stranded oil in their habitats. The validity of this linkage is, therefore, **unknown**.

However, recent evidence from the post-spill monitoring programs for the *Exxon Valdez* oil spill suggest that contact of semi-aquatic mammals with oil and subsequent ingestion via prey and grooming will occur. Sea otter in the vicinity of the *Exxon Valdez* spill did not change their eating habitats to avoid contaminated prey, and continued to rely heavily on clams and mussels as prey regardless of the oiling status (Gorbic 1993). There was also limited evidence of oil ingestion by river otters resulting in mortality and long-term sub-lethal effects. Although it is recognized that the ecology of these two species of otters differs from that of muskrat, it was believed that muskrat would also be at risk due to their feeding habitats (e.g., use of aquatic and emergent plants) and high reliance of water bodies and watercourses for feeding, movements, and protection from predators.

Muskrat could potentially ingest oil through direct consumption of oiled vegetation, as well as through consumption of vegetation that has become contaminated through uptake of certain hydrocarbon compounds. It was, therefore, concluded that Link 4 is likely to be **valid**, but confidence in this conclusion was low.

Link 5: Containment and cleanup, habitat restoration and monitoring activities will result in localized destruction of wetlands.

The working group concluded that most cleanup activities would be restricted to the outer shoreline of the Delta, and perhaps the shorelines of the major channels in the Delta. In addition, it was thought likely that booms would be deployed along the outer coastline of the Delta to prevent oil from entering major embayments of importance to waterbirds (e.g., the west side of Richards Island). As a result, the working group concluded that there would be little spatial overlap between the cleanup and monitoring activities and muskrat. Link 5 is, therefore, considered **invalid**.

Link 6: **Grooming of oiled fur will result in the ingestion of oil by semi-aquatic mammals.**

As noted in Link 4, the working group concluded that it is likely that muskrat will contact oil in wetlands or along river channels in the outer delta, and that animals will ingest oil during grooming of themselves and conspecifics (including young of the year). Link 6 is therefore considered to be **valid**.

Link 7: **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.**

The working group concluded that this link is intuitively **valid**. Although the primary harvest for muskrat occurs in May and June, fouling and/or staining of fur from an offshore oil blowout in August or September could persist throughout the winter, as most of the animals would have their winter pelage by the time of the spill. In addition, it is likely that some animals will contact stranded oil or oil flocs in wetlands during the winter.

Link 8: **Fouling of the pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.**

In muskrat, the fur plays an important role in both thermal regulation and buoyancy. Laboratory studies with other semi-aquatic mammals such as sea otters have confirmed that oiling of the fur can result in decreased insulative capacity of the fur, increased heat loss and subsequent death of animals (Kooyman *et al.* 1977, cited in Duval 1985). Link 8 is considered **valid**.

Link 9: Ingestion of oil by muskrat will result in tainting or perceived tainting and a change in the harvest of these animals.

The working group concluded that muskrat may ingest oil through consumption of contaminated vegetation (Link 4) and/or grooming of oiled fur (Link 6), but were uncertain as to the whether ingestion would result in tainting or perceived tainting of muskrat meat, and subsequent effects on the harvest of muskrat for food. It was concluded, however, that tainting or perceived tainting may occur, thereby affecting the harvest of animals, particularly in the outer fringes of the Delta. It is quite probable that compensatory increases in hunting would occur in the southern portion of the Delta. Link 9 was therefore concluded to be **valid**, but confidence in this conclusion was low.

Link 10: Chronic ingestion of stranded oil will result in direct mortality of semi-aquatic mammals.

The working group again questioned whether muskrat would ingest contaminated vegetation. Monitoring studies for the *Exxon Valdez* oil spill have documented physiological and reproductive effects in sea otters. Seas otters in the spill area showed higher mortality in prime-age animals, higher pup mortality and lower pupping rates than animals in control areas (Exxon Valdez Oil Spill Trustees 1992). Baker *et al.* (1981, cited in Duval 1985) also showed that exposure of sea otters to bunker fuel and ingestion of oil-contaminated prey may have resulted in the death of five otters. Autopsies of the five animals indicated that death of all of the animals was due to hemorrhagic gastro-enteropathy. Four of the animals also had oil in their intestines. Although these mustelids are ecologically different from muskrat, it is possible that similar effects may occur in muskrat. The group concluded that Link 10 is **valid**, but attached low confidence to this conclusion.

Link 11: Ingestion of oil will lead to sublethal effects that will change the energy balance of individuals.

As noted in Link 10, evidence from the *Exxon Valdez* oil spill confirmed that sublethal effects did occur in sea otters and river otters (Faro 1993; Gorbic 1993). Blood samples from sea otters in the vicinity of the *Exxon Valdez* oil spill suggested that long-term exposure to hydrocarbons had resulted in systemic hypersensitivity reactions in exposed animals (Exxon Valdez Oil Spill Trustees 1992; Gorbic 1993). River otters in oiled areas were found to be smaller (i.e., length, body weight) and have a lower dietary diversity than river otters in unoiled areas (Faro 1993). Analysis of bile and blood samples from river otters also showed accumulations of petroleum hydrocarbons (Exxon Valdez Oil Spill Trustees 1992). Although sea otters and river otters are physiologically different from muskrat, the working group believed that similar changes in blood chemistry and physiology would likely occur in muskrat. Link 11 was concluded to be **valid**.

Link 12: Noise and disturbance will reduce the time available for foraging and will increase energy expenditures through increased avoidance behaviour.

As Link 5 is invalid, Link 12 is also **invalid**.

Link 13: Noise and disturbance will change the distribution of semi-aquatic mammals that will lead to changes in the harvestability of the animals.

As Link 5 is invalid, Link 13 is also **invalid**.

Link 14: Changes in the availability of habitat and food for muskrat and mink will result in changes in the behaviour and distribution of these animals which will have energetic consequences for these individuals.

Because muskrat are a mobile species, the working group believed that localized changes in the availability of food and habitat would have inconsequential effects on the energetics of muskrat. However, evidence from monitoring studies of river otters following the *Exxon Valdez* Oil Spill indicated that river otters expanded their home range, suggesting that animals had to forage over a larger area to obtain adequate food (Exxon Valdez Oil Spill Trustees 1992). Although river otters are ecologically different from muskrat, it is possible that similar changes could occur in the feeding range of muskrat.. Link 14 was concluded to **valid**, but confidence in this conclusion was low.

Link 15: **Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction that will lead to reduced populations.**

Link 15 is considered to be **valid**. Although the reproductive potential of muskrat is high (i.e., a single female would likely give birth to at least one litter comprised of 6 to 8 young), entire litters could be lost as a result of direct contact and/or ingestion of oil. If adults are energetically stressed as a result of oil ingestion, direct oil contact, and changes in food availability and habitat, overwinter survival and/or reproduction (the following spring) could be negatively affected.

Link 16: **Localized losses of wetland habitat will result in reduced populations of semi-aquatic furbearers.**

Link 16 is implicitly **valid**. Unless habitat is below its carrying capacity, any loss of habitat will result in changes in the numbers and distribution of muskrat and other wildlife. The working group agreed, however, that the loss of habitat associated with an offshore oil blowout and subsequent stranding of oil in the Delta would be very small (i.e., <1% of the available muskrat habitat in the Delta) and short-term (i.e., one year). As discussed in MEMP (LGL *et al.* 1986), where muskrat have been intensively harvested in a localized areas, or where habitat has been altered or disturbed, muskrat numbers typically return to pre-disturbance levels within a short period once suitable habitat has been established.

Link 17: **Reduced populations of semi-aquatic mammals will result in reduced harvests of these animals.**

The working group considered Link 17 to be implicitly **valid**.

Link 18: **The presence of oil in wetlands and in river channels, in combination with the cleanup activities will change the distribution and/or success of the harvest.**

Trappers and hunters would likely avoid the area directly affected by the stranded oil, as well as a buffer area around the affected area as a result of concerns related to fouling of fur, tainting of meat, and fouling of equipment (e.g., traps, boats). As a result of real or perceived concerns, trappers and hunters are likely to shift their harvest to other areas (e.g., the southern portion of the Delta)(J. Benoit, pers. comm.). Link 18 is therefore **valid**.

ASSESSMENT OF IMPACT SIGNIFICANCE

The working concluded that there are 4 valid impact pathways for muskrat associated with an offshore oil blowout and subsequent onshore transport of oil.

EFFECTS OF FOULING ON POPULATIONS AND HARVESTING

The effects of fouling of fur on populations were considered to be **insignificant** (Class 3) due to the small magnitude and short duration of the impact on the regional population. The temporal overlap between fouling and populations was considered to be 100%. It was assumed that most oil would be contained by offshore booms (and be collected) or would be removed during onshore cleanup. However, some oil would likely persist in wetlands and along the shorelines, even after cleanup operations. In particular, oil may not be removed from wetlands, as cleanup activities would likely cause more damage than the presence of the oil. Because most of the prime muskrat habitat is in the southern portion of the Delta, spatial overlap was estimated to be in the range of 1 to 5% for muskrat populations.

Effects of fouling on muskrat harvesting were concluded to be **significant** (Class 2). In the event of a spill, the HTC would likely initiate a monitoring program for muskrat. If more than 10% of the regional population was affected, harvesting in the affected area may be suspended for one year or more (J. Benoit, pers. comm.). The perception of fouling may also extend beyond the predicted duration of direct effects on fouling on muskrat (i.e., 1 year).

Temporal overlap of fouling with the muskrat harvest was estimated to be 100% (see above re: persistence of oil), and spatial overlap was estimated to likely be in the range of 1 to 5% of the regional harvesting area.

It was recommended that in the event of an oil blowout and onshore transport of oil that muskrat populations and harvesting activities be monitored to determine the effect of the spill on both the population and the harvest.

OIL INGESTION

Although the working group concluded that muskrat were likely to ingest oil through consumption of contaminated vegetation and grooming, the significance of this impact to the survival and reproductive capacity of the muskrat population in the Delta is uncertain. As noted above for fouling, temporal overlap was estimated to be 100%, and spatial overlap was estimated to be 1 to 5%.

Effects of oil ingestion on harvesting were concluded to be **significant** (Class 2), because tainting or the perception of tainting may persist for more than one year. As compensation for reduced harvesting opportunities in the outer Delta, harvesting (for meat and fur) may increase in the southern portion of the Delta (J. Benoit, pers. comm.).

Information is required on the physiological effects of oil on muskrat, and the fate and effects of hydrocarbon portions in muskrat. It was suggested that a review of existing information on the fate and effects of oil in mammals be completed and, if important data gaps are identified, that additional research be initiated.

HABITAT LOSS

Effects of an offshore oil spill on habitat availability and the regional muskrat population were concluded to be **insignificant** (Class 3). Temporal overlaps between habitat losses, and habitat availability and the population were considered to be 100%, because some oil would likely persist along shorelines. Oil in wetlands may also not be removed, because cleanup may result in greater habitat losses than leaving the oil in-situ. Cleanup would depend on the amount of oil transported and the duration that the oil may persist (L. Johnson, pers. comm.; W. Van de Pypekamp, pers. comm.). There was discussion that salt water intrusion during the fall storm surges may have a greater effect on habitat and muskrat than the oil presence (J. Benoit, pers. comm.). Storm surges may also help to flush oil from coastal wetlands (J. Nagy, pers. comm.). Spatial overlap would likely be less than 1% of the muskrat habitat in the Delta.

Effects of habitat losses on the regional harvest of muskrat were considered to be significant, as actual and perceived effects on the harvest may persist for more than one year (i.e., perhaps as long as 2 to 3 harvesting seasons). Temporal overlap of habitat losses with harvesting would be 100% (i.e., more than one harvesting season). Although the spatial overlap of habitat losses with the regional harvest is small (<1%), the HTC would likely consider any habitat loss to be important (J. Benoit, pers. comm.).

OIL PRESENCE

The presence of oil would have a **significant** (Class 2) impact on harvesting due to real and perceived concerns by residents related to fouling of pelts, tainting of meat, and fouling of boats and equipment. Temporal overlap of habitat losses with harvesting would be 100% (i.e., more than one harvesting season). Spatial overlap would likely be in the range of 1 to 5%, because hunters and trappers would likely avoid a larger area than the area actually affected by oil (J. Benoit, pers. comm.).

EVALUATION OF LINKAGES - MINK

Link 1: **An offshore oil blowout will result in: (a) the stranding of oil on coastal shorelines and in delta wetlands; and (b) a cleanup response with associated noise and disturbance.**

As described for muskrat, Link 1 is **valid**.

Link 2: **The presence of stranded oil will damage or kill wetland vegetation that provides important habitat for semi-aquatic mammals.**

This link is considered **valid** for mink, assuming that habitat includes important prey species such as muskrat and fish. Based on the conclusions reached for muskrat, as well as for fish in the delta area (see Hypothesis C-17), losses of important prey species for mink may occur. However, these effects are expected to be short term (i.e., < 1 year) and localized.

Link 3: **The presence of stranded oil in the delta wetlands will lead to fouling of pelage of semi-aquatic mammals.**

Mink that swim or forage in wetlands containing stranded oil are likely to contact oil films and sheens, as well as oil mousses. Oiling of the pelage of sea otters (Gorbic 1993) and river otters (Faro 1993) following the *Exxon Valdez* oil spill supports this conclusion. Although only a small portion of the regional mink population is expected to commonly utilize wetlands in the outer fringe of the Delta, the working group concluded that Link 3 is **valid**.

Link 4: **Stranded oil will be ingested by semi-aquatic mammals through ingestion of oiled aquatic vegetation or fouling of food caches (muskrat) or consumption of oiled prey (mink).**

Based on the documentation of consumption of oiled prey by both sea otters (Gorbic 1993) and river otters (Faro 1992) following the *Exxon Valdez* oil spill, the working group considered it likely that some mink would ingest oil as a result of feeding on muskrat and/or fish that have been oiled or contaminated by oil, as well oiled carrion. Link 4 is **valid**.

Link 5: Containment and cleanup, habitat restoration and monitoring activities will result in localized destruction of wetlands.

In relation to mink, wetland habitats were defined as areas supporting important prey species (e.g., muskrat, fish). As discussed previously for muskrat, the working group assumed that most cleanup activities would be restricted to the outer shoreline of the Delta, and perhaps the shorelines of the major channels in the Delta. It is also likely that booms would be deployed along the outer coastline of the Delta to prevent oil from entering major embayments of importance to waterbirds (e.g., the west side of Richards Island). Cleanup activities are not expected to affect muskrat distributions within the outer fringe of the Delta. It was also assumed that fish distributions in lakes and the Delta channels would not be affected. As a result, the working group concluded that mink habitat, as defined by its prey base, would not change significantly in response to cleanup activities. Link 5 is therefore **invalid**.

Link 6: Grooming of oiled fur will result in the ingestion of oil by semi-aquatic mammals.

As noted in Link 4, it is considered likely that mink will contact oil in wetlands or along river channels in the outer delta, and that animals will ingest oil during grooming of themselves and conspecifics. Link 6 is therefore considered **valid**.

Link 7: 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.

The working group concluded that this link was intuitively **valid**. As the trapping season extends from 1 November to February, it is probable that oiling and/or staining of pelts would persist until the trapping season. In addition, because mink are active in air pockets and channels under the river ice or in deeper wetlands and lakes, it is likely that some animals will contact stranded oil or oil flocs during the winter. Fresh oiling may then occur during the trapping period.

Link 8: **Fouling of the pelage will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.**

Grooming by mink is essential in maintaining the insulative and water-repellent properties of their fur. Entrapment of air in their pelage is also important to maintaining buoyancy. Although no information on the direct effects of oiling on mink fur exists, a laboratory study on sea otters showed that oiling resulted in decreased insulative capacity of the fur, increased heat loss and subsequent death of animals (Kooyman *et al.* 1977, cited in Duval 1985). To compensate for the increased heat loss, the animals increased their average metabolic rate through shivering, and increased swimming and grooming. Link 8 is considered **valid.**

Link 9: **Ingestion of oil by muskrat will result in tainting or perceived tainting and a change in the harvest of these animals.**

As mink are not harvested for food, this link is **invalid.**

Link 10: **Chronic ingestion of stranded oil will result in direct mortality of semi-aquatic mammals.**

The working group concluded that it is unknown whether mink would consume sufficient amounts of oil to cause death. However, given the predatory nature of this species and the likelihood that some mink will feed on oiled carrion, this link is considered to be **valid.**

As noted earlier in the assessment of Link 10 for muskrat, sea otters in areas affected by the *Exxon Valdez* spill showed higher mortality in prime-age animals, higher pup mortality and lower pupping rates than animals in control areas (Exxon Valdez Oil Spill Trustees 1992). Baker *et al.* (1981, cited in Duval 1985) also showed that exposure of sea otters to bunker fuel and ingestion of oil-contaminated prey may have resulted in the death of five otters. Although mink are ecologically different from sea otters (e.g., use of aquatic and terrestrial habitats; broader prey base), it is possible that similar effects may occur in mink. Link 10 was concluded to be **valid**, but confidence in this conclusion is low.

Link 11: **Ingestion of oil will lead to sublethal effects that will change the energy balance of individuals.**

Following the *Exxon Valdez* oil spill, a laboratory study was conducted to determine the effects of oil ingestion on ranch mink (Exxon Valdez Oil Spill Trustees 1992). Animals were fed food mixed with small, sub-lethal dose amounts of weathered oil. No change in reproduction rates or success were detected. However, oiled food was passed through the intestines more rapidly than unoiled food, suggesting that less nutritional value was provided to the animals. More obvious sublethal effects were documented in sea otters and river otters (Faro 1993; Gorbic 1993). Male sea otters in the vicinity of the *Exxon Valdez* oil spill showed significant differences in blood chemistry (i.e., higher eosinophil counts, total hemocrits, and hemoglobin concentrations) from animals in unoiled areas (Gorbic 1993). Analysis of bile and blood samples from river otters showed accumulations of petroleum hydrocarbons (Exxon Valdez Oil Spill Trustees 1992). River otters in oiled areas were also found to be smaller (i.e., length, body weight) and have a lower dietary diversity than river otters in unoiled areas (Faro 1993). As river otters are ecologically similar to mink, the working group believed that similar changes in blood chemistry and physiology would likely occur in mink in the Delta. Link 11 is considered **valid**.

Link 12: **Noise and disturbance will reduce the time available for foraging and will increase energy expenditures through increased avoidance behaviour.**

Mink and other mustelids are known to be sensitive to human disturbances, and may avoid intensively used areas by distances of at least 200 to 500 m (see Sopuck *et al.* 1979 for a review). It was, therefore assumed that human and mechanical disturbances associated with the cleanup, restoration and monitoring activities would result in short-term (likely several days to 1-2 months during the fall and again in the spring following the spill) sensory disturbance to mink, depending on the intensity and duration of human and mechanical activity in an area. Link 12 is **valid**.

Link 13: Noise and disturbance will change the distribution of semi-aquatic mammals that will lead to changes in the harvestability of the animals.

As noted in Link 12, mustelids have been observed to avoid centres of human activity. However, habitat avoidance would likely only be short term (several days to months during the subsequent fall and spring) and only affect a very small area of the regional habitat available to mink (i.e., << 1%). In addition, animals are expected to return shortly after the cessation of activities in an area. As a result, because the trapping season (i.e., November to February) will not temporally overlap with the cleanup activities in the fall and late spring, the working group concluded that habitat avoidance would not affect the trapping harvest. Link 13 is **invalid**.

Link 14: Changes in the availability of habitat and food for muskrat and mink will result in changes in the behaviour and distribution of these animals which will have energetic consequences for these individuals.

Although the loss of prey species is expected to be short term and highly localized, it is likely that some mink will have to forage over a larger area to obtain sufficient food. This is supported by evidence from the *Exxon Valdez* oil spill where river otters in the spill zone expanded their home range (Exxon Valdez Oil Spill Trustees 1992). Because river otters are ecologically similar to mink, Link 14 is expected to be **valid**.

Link 15: Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction that will lead to reduced populations.

Link 15 is considered **valid**. Although direct evidence for mink is lacking, monitoring studies of sea otters and river otters from the *Exxon Valdez* oil spill suggest that sublethal affects of oil as well as direct effects resulted in increased pup mortality and lower pupping rates (Exxon Valdez Oil Spill Trustees 1992). However, as the outer fringes of the Delta are not considered to be high quality mink habitat, and mink are widely dispersed in this portion of the Delta, the working group did not believe that the regional population would be significantly affected by these losses.

Link 16: **Localized losses of wetland habitat will result in reduced populations of semi-aquatic furbearers.**

Link 16 is implicitly **valid**. However, as the abundance and distribution of important prey species for mink in the outer Delta is not known, and effects of the oil spill on prey are difficult to quantify, it is not known if changes in prey availability and/or quality will result in decreased numbers of mink in the outer Delta. The working group believed that changes in mink numbers would not be important relative to the regional abundance of this species.

Link 17: **Reduced populations of semi-aquatic mammals will result in reduced harvests of these animals.**

The working group considered Link 17 to be implicitly **valid**.

Link 18: **The presence of oil in wetlands and in river channels, in combination with the cleanup activities will change the distribution and/or success of the harvest.**

Although there would be little temporal overlap between the oil spill and the trapping season for mink, trappers and hunters would likely avoid the area directly affected by the stranded oil, as well as a buffer area around the affected area as a result of concerns related to fouling of fur, tainting of meat, and fouling of equipment (e.g., traps)(J. Benoit, pers. comm.). As a result of real or perceived concerns, trappers are likely to shift their harvest to unaffected, adjacent areas. Link 18 is therefore **valid**.

ASSESSMENT OF IMPACT SIGNIFICANCE

The working concluded that there are 5 valid impact pathways for mink associated with an offshore oil blowout and subsequent onshore transport of oil.

EFFECTS OF FOULING ON POPULATIONS AND HARVESTING

The effects of fouling of fur on mink populations were considered to be **insignificant** (Class 3) due to the small magnitude and short duration of the impact on the regional population. As some oil may persist in wetlands and along shorelines for at least one year (see Muskrat above), the temporal overlap between fouling and mink was considered to be 100%. Because the outer Delta fringe is not high quality habitat for mink, spatial overlap with the regional mink population was estimated to be less than 1%.

Effects of fouling on trapping of mink were also concluded to be **insignificant** (Class 3). Temporal overlap of fouling with the trapping season could be as high as 100%, as some oil may persist over the winter and spring. However. it was assumed by the working group that almost all oil would be removed during the following spring and summer through spot cleanups. Spatial overlap was estimated to be in the range of 1 to 5% of the regional harvesting area.

OIL INGESTION

Following the oil spill, it is likely that some mink would ingest oil through consumption of contaminated prey and oiled carrion. However, the significance of this impact to the survival and reproductive capacity of the mink population in the Delta is uncertain. As noted above for fouling, temporal overlap was estimated to be 100%, and spatial overlap was estimated to be less than 1%. It was noted that because mink are territorial and oiling of prey would likely be spotty, impacts to the regional population would be small (J. Nagy, pers. comm.).

The group concluded that the effects of oil ingestion on trapping would be **insignificant** (Class 3) because: (1) it is very unlikely that a sufficient number of mink would die to affect the local or regional harvest; and (2) mink flesh is not commonly eaten and tainting would not be an issue. Although the temporal overlap of this effect would be 100%, this is expected to affect less than 1% of the regional population.

SPILL RESPONSE ACTIVITIES

Human and mechanical disturbances associated with the spill response activities are considered valid but **insignificant** (Class 3). As mink would likely avoid the immediate area of the spill response for the duration of the actual cleanup activities, temporal overlap of the spill response with mink would be small (i.e., 33% of the year; maximum of two months in the fall and two months in the spring). As spill response activities would be highly localized at any one time, it was estimated that much less than 1% of the regional population would be affected.

Effects of the spill response activities on mink trapping were considered to be **insignificant** (Class 4) since cleanup activities would not overlap temporally with the trapping season, and only a very small portion of the regional trapping area would be affected at any one time (i.e., <<1%).

HABITAT LOSS

An offshore oil spill and stranding of oil would affect mink habitat primarily through changes in the availability, quality and distribution of the primary prey species. Although the primary prey species of mink -- muskrat and fish -- would be affected by the oil spill, impacts to mink are expected to be **insignificant** (Class 3) given the restricted distribution of the oil within the outer Delta, the low quality of the outer delta as mink habitat, the availability of prey in adjacent areas, and the probable rapid response of prey through immigration and reproduction. Temporal overlap between habitat loss and mink is expected to be 100% because some prey may be contaminated by oil for at least one year. However, spatial overlap would likely be much less than 1% of the available mink habitat in the Delta region.

Effects of habitat loss on trapping would also be **insignificant** (Class 3), given that most trapping for mink occurs south of the affected area in the outer Delta. Because prey contamination and resulting sublethal effects may persist for more than one harvesting season, temporal overlap of habitat losses with harvesting would be 100%. However, it is expected that much less than 1% of the regional trapping areas would be affected.

OIL PRESENCE

Effects of oil presence on trapping of mink are considered to be **insignificant** (Class 3) because only a small portion of the regional trapping areas would be affected or would be perceived to have been affected (i.e., 1-5% spatial overlap). Although oil may foul some trapping equipment and pelts during the first year, it is considered unlikely that the presence of oil will have an effect on subsequent trapping seasons (J. Benoit, pers. comm.).

RECOMMENDED RESEARCH AND MONITORING

In the event of an offshore well blowout, a monitoring program should be initiated to determine the extent to which populations of semi-aquatic mammals (mink, muskrat) become fouled with oil.

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4.4.4 BREAM HYPOTHESIS C-6: The Effects of a Pipeline Spill of Crude Oil during Summer on Semi-Aquatic Mammals

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INTRODUCTION

BREAM Hypothesis C-6 involves a spill scenario where a pipeline rupture in the Mackenzie River near Fort Simpson causes up to 5000 barrels of crude oil to be released into the environment (Scenario D). This scenario was selected to address concerns related to contact of semi-aquatic mammals (i.e, mink, muskrat, and beaver) with oil stranded along the shoreline and disturbances associated with spill response activities. The timing of the scenario was selected to be May to coincide with the birthing periods of, and hunting activities for these VEC species.

MUSKRAT

Wetland and riverine areas of the Mackenzie River and its tributaries provide year-round habitat for muskrat and are also important for harvesting of these animals (J.Benoit, pers. comm.). Muskrat are known to occur along the mainstem in the area affected by the oil spill, but are most abundant downstream of Burnt Island particularly within the braided channels. The area between the pipeline crossing and Burnt Island is characterized by rocky shores and a lack of islands and, therefore, provides little quality habitat. Muskrat are most commonly found along

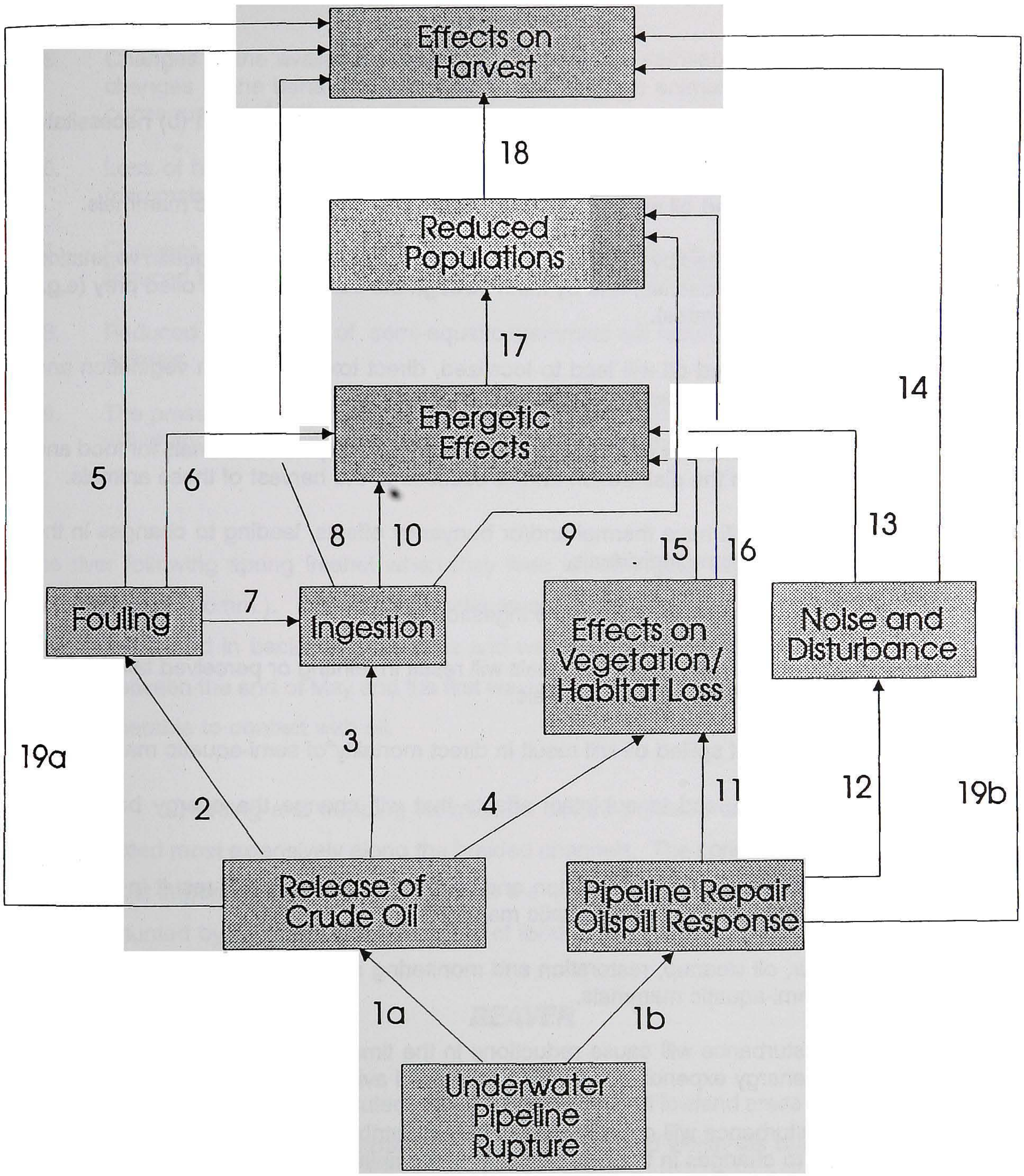

Figure 4-19: BREAM Hypothesis C-6 - Effects of an Underwater Pipeline Rupture on Semi-Aquatic Mammals

LINKAGES

1. Rupture of the buried pipeline will: (a) release crude oil into a river; and (b) necessitate pipeline repairs and an oilspill response.

2. The presence of spilled oil will lead to fouling of the fur of semi-aquatic mammals.

3. Spilled oil will be ingested by muskrat and beaver through ingestion of aquatic vegetation and/or fouling of food caches, and by mink through the consumption of oiled prey (e.g., muskrat, fish, invertebrates).

4. The presence of spilled oil will lead to localized, direct toxic effects on vegetation and subsequent localized losses of habitat.

5. Fouled pelage will lead to a reduction in the value of semi-aquatic mammals for food and fur, and a change in the distribution and/or success of the harvest of these animals.

6. Fouling of the fur will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.

7. Grooming of fouled fur will result in the ingestion of oil.

8. Ingestion of oil by semi-aquatic mammals will result in tainting or perceived tainting and a change in the harvest of these animals.

9. Chronic ingestion of spilled oil will result in direct mortality of semi-aquatic mammals.

10. Ingestion of oil will lead to sublethal effects that will change the energy balance of individual animals.

11 Pipeline repair, oil cleanup, restoration and monitoring activities will result in localized disturbances of habitat for semi-aquatic mammals.

12. Pipeline repair, oil cleanup, restoration and monitoring activities will produce noise and will disturb semi-aquatic mammals.

13. Noise and disturbance will cause reductions in the time available for foraging and will increase the energy expenditures through increased avoidance behaviour.

14. Noise and disturbance will cause changes in the distribution of semi-aquatic mammals that will lead to changes in the harvestability of the animals.

15. Changes in the availability of habitat and food for semi-aquatic mammals will result in changes in the behaviour and distribution of these animals, which will have energetic consequences for these individuals.

16. Loss of habitat will result in changes in the numbers and distributions of semi-aquatic mammals.

17. Changes in the energy balance of individual animals will lead to reduced survival and reduced reproduction, which will lead to reduced populations.

18. Reduced populations of semi-aquatic mammals will result in reduced harvests of these animals.

19. The presence of oil in the river in combination with pipeline repair and cleanup activities will change the distribution and/or success of the harvest.

the river following spring freshet when they feed on emerging vegetation and horsetails (S. Kotchea, pers. comm.). Due to high water levels at this time of year, the potential for oil to become stranded in backwater channels and wetlands would be greatest. Birthing generally occurs between the end of May and the first weeks of June, and therefore, their young would be most vulnerable to contact with oil.

Hunting and trapping for muskrat occurs primarily during April and May and is concentrated most extensively along the braided channels. The spring harvest is considered to be the most important trapping period due to the quality of the fur at this time of year. Muskrat are also hunted by northerners as a source of food.

BEAVER

Beaver are distributed widely in floodplain and lowland areas along the river in the area affected by the spill, most notably at Camsell Bend and within the braided channel region (INAC 1976). These areas provide important hunting and trapping for beaver in spring. While marten and mink are the principal species trapped during winter, beaver and muskrat make up the majority of the harvest in April and May. Breeding generally takes place from March through

April, and the young are born in June.

MINK

Mink occur along the river year-round, but tend to prefer the smaller tributaries and backwater areas on shore. They feed predominantly on fish, although muskrat are also a seasonally important food source. In winter, mink are seldom seen because they live under the shoreline ice ledge, which forms as the water level recedes after freezeup.

The trapping season for mink extends from the beginning of November to the end of February. This species is harvested by northerners exclusively for its fur.

EVALUATION OF LINKAGES - MUSKRAT AND BEAVER

Link 1: Rupture of the buried pipeline will: (a) release crude oil into a river, and (b) necessitate pipeline repairs and an oilspill response.

The scenario used to evaluate this impact hypothesis involves a catastrophic rupture of an oil pipeline at a crossing 13 km upriver of Fort Simpson. Prior to shutdown of the pipeline, about 350 bbls of oil are released into the river. Within 2 hours of shutdown, an additional 4650 bbls drain out of the pipe between the closed safety valves. It is implicit in the scenario that: (1) oil will enter the river; and (2) the event would dictate a need for both pipeline repair activities and an oilspill response.

Link 2: The presence of oil in the river will lead to fouling of the fur of muskrat and beaver.

Of the 5000 bbls of oil released into the river, about 1000 bbls would become stranded along both shores of the river and the islands for 200 km downstream of the accident site. Because of high water levels at the time of the spill, it was assumed that floodplain and lowland areas that provide important year-round habitat for both muskrat and beaver (i.e, near Camsell Bend and in the braided channels area) would become oiled to some extent, and oil may persist for some period of time in backwater areas along the downstream side of the islands and mainstem.

The subgroup assumed that oil would probably extend about one mile inland on both shores of the river. While this could affect 65-70% of the total area of suitable muskrat and beaver habitat, only 5-10% of this area would likely become oiled due to the small volume of oil that would reach the shoreline and its discontinuous distribution. Due to the widespread distribution and mobility of muskrat and beaver, it was assumed that less than 10% of the regional populations would come in contact with oil either while foraging for food or swimming in the river. It was noted that because the timing of the spill would coincide with the birthing period, young would be particularly vulnerable (and likely most sensitive) to oil contact. This link is, therefore, considered **valid**.

Link 3: **Spilled oil will be ingested by muskrat and beaver through ingestion of aquatic vegetation and/or fouling of food caches.**

The subgroup was unaware of any evidence to suggest whether muskrat and beaver are capable of detecting and avoiding contaminated prey, and therefore concluded that the validity of this linkage is **unknown** for these species. However, evidence of oil ingestion by both river and sea otters resulting in mortality and long-term sublethal effects following the *Exxon Valdez* spill suggests that there might also be the potential for oil ingestion by muskrat and beaver. Studies initiated after the Exxon spill showed that sea otter did not change their eating habits to avoid contaminated prey, but continued to rely heavily on clams and mussels as prey regardless of the oiling status (Alaska Department of Fish and Game 1993). Although sea otters are more vulnerable to contact and ingestion of oil due to the fact that they rely predominately on benthic prey and are exclusively aquatic, muskrat and beaver would also be at risk due to their feeding habits and semi-aquatic nature.

Beaver feed extensively on leaves and shoots of willow and poplar during summer and on the barks of these trees during the remainder of the year. They also feed on the rhizomes of water lilies when available. About mid to late August, beaver begin building food caches at their dens for winter. Although it is highly unlikely that oil would still be detectable on the water at this time, fouling of caches may occur as a result of oil persistence in lowlands and backwater areas and resuspension of oil during higher flow events.

Muskrat could potentially ingest oil through consumption of vegetation fouled with stranded oil as well as consumption of vegetation that has become contaminated through the uptake of hydrocarbons through the root systems. Muskrat rely on aquatic plants (particularly on the rhizomes of horsetails) during spring, and will feed on emergent plants (horsetail and sedges) as water levels drop during summer. In winter, they extend their foraging under ice by constructing pushups, where they feed on submerged plants.

Link 4: **The presence of spilled oil will lead to localized, direct toxic effects on vegetation and subsequent localized losses of habitat.**

Numerous laboratory and field studies have shown that oil can cause a range of sublethal effects in intertidal vegetation and marsh grasses (see Duval 1985). Depending on the species and exposure conditions, oil exposure can cause changes in the rate of photosynthesis, growth and reproduction. Oil penetration and retention in the sediments and its subsequent availability to rhizomes of plants can be the cause of long-term toxic effects. Mortality of intertidal plants and marsh grasses has also been observed following actual oil spill events. Mortality can result from coating and suffocation of the plant, direct toxic effects, dislodging of plants due to the added weight of the stranded oil, and damage or removal during shoreline cleanup activities.

While Link 4 is considered **valid**, it is expected that less than 1% of the regional habitat of muskrat would be altered or lost as a result of direct effects of spilled oil. Because beaver do not rely as extensively on aquatic vegetation as muskrat, this would likely represent only a partial loss of habitat for this species.

Link 5: **Fouled pelage will lead to a reduction in the value of muskrat and beaver for food and fur and a change in the distribution and/or success of the harvest.**

The subgroup considered this link to be intuitively **valid**. The majority of muskrat and beaver are harvested in May after breakup. Although only a small proportion of the regional populations is expected to become fouled with oil, this could represent a large percentage of the total annual harvest. [It was noted that a barge spill of diesel fuel involving the release of 100 bbls of oil at Norman Wells in August 1982 may provide further information related to this linkage (J. Hayes, pers. comm.).]

Link 6: **Fouling of fur will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.**

In furbearers, the fur plays an important role in thermoregulation of the animal. As shown in laboratory studies involving sea otters (Kooyman *et al.* 1977, cited in Duval 1985), oiling of the fur can cause an increase in the rate of heat loss and, in turn, a decrease in it's insulative capacity, which can lead to chilling and subsequent death of the animal. Air retention in the underfur is also important in maintaining buoyancy in muskrat and beaver. Since oil fouling and sheens can affect the water repellency of the fur, exposure to oil can result in water logging of the fur and loss of buoyancy. Link 6 is considered **valid**.

Link 7: **Grooming of fouled fur will result in the ingestion of oil.**

Muskrat and beaver groom their fur to maintain its insulative and buoyancy properties. Contact with sheens of oil on the water surface or stranded oil on vegetation may cause some animals to groom more often and, thereby, consume oil. For example, studies initiated after the *Exxon Valdez* spill indicated that when sea otters became fouled with oil, they began grooming obsessively (Alaska Department of Fish and Game 1992).

Link 7 is considered **valid** for both muskrat and beaver. However, it was noted that a larger number of muskrat could be potentially affected through this pathway because they communally groom, causing some unfouled animals to also ingest oil.

Link 8: Ingestion of oil by muskrat and beaver will result in tainting or perceived tainting and a change in the harvest of these animals.

The working group concluded that muskrat and beaver could conceivably ingest oil through grooming of fouled fur and consumption of contaminated vegetation but were uncertain as to the validity of the linkage relating ingestion to tainting or perceived tainting and subsequent effects on the harvest of these animals. It was noted that if tainting or the perception of taint occurred, this could lead to an actual increase in the number of animals taken in an effort to maximize the success of the harvest. The wording of the linkage was subsequently changed to reflect this.

Link 9: Chronic ingestion of spilled oil will result in direct mortality of muskrat and beaver.

While there is no available information regarding the effects of oil ingestion on muskrat and beaver, studies on river and sea otter carcasses found after the Exxon spill indicated that many of these animals may have died as a result of oil ingestion (Exxon Valdez Oil Spill Trustees 1992). It is recognized that these results may not be directly applicable to muskrat and beaver because they are not predators. Analysis of river otter bile and blood samples showed accumulations of petroleum hydrocarbons and a lingering toxic effect of oil on this species. Baker *et al.* (1981, cited in Duval 1985) also showed that exposure of sea otters to bunker fuel and ingestion of oil-contaminated prey may have been the cause of death in five otters. Autopsies of these animals indicated that death of all five otters was due to hemorrhagic gastro-enteropathy; four of the otters also had oil present in their intestines.

Assuming that effects of oil ingestion on muskrat and beaver are similar to those reported for otters, this link is considered **valid**.

Link 10: Ingestion of oil will lead to sublethal effects that will change the energy balance of individual animals.

Although there appears to be no information on the sublethal effects of oil on muskrat and beaver, studies of river and sea otters initiated following the *Exxon Valdez* spill provide some information that might be applicable to these species. Analysis of blood samples from oil-exposed sea otters suggest that heavy initial and continuing long-term exposure to petroleum hydrocarbons are likely causing systemic hypersensitivity reactions in exposed animals (Exxon Valdez Oil Spill Trustees 1992). A higher proportion of mortality in prime-age animals, and higher mortality and lower pupping rates were also found in sea otter populations exposed to the spilled oil.

Studies conducted on river otters also indicate long-term sublethal effects as a result of continued exposure to toxic oil substances in the habitat as well as prey. As late as 1991, body lengths, body weights and dietary diversity were found to be lower in river otters from oiled areas than unoiled areas (Faro 1993).

The working group concluded that this link is likely **valid** for muskrat and beaver.

Link 11: Pipeline repair, oil cleanup, restoration and monitoring activities will result in localized disturbances of habitat for muskrat and beaver.

While localized disturbance of habitat (i.e., damage or removal of vegetation) for muskrat and beaver will likely occur as a result of oil cleanup, restoration and monitoring activities, it is unlikely that pipeline repair will have a significant effect since there is little quality habitat for either species within the vicinity of the pipeline crossing. As stated earlier, the banks of the Mackenzie River downriver of Burnt Island do not provide prime habitat for muskrat and beaver due to the rocky shoreline and lack of islands. The working group, therefore, concluded the link to be **valid** only for cleanup, restoration and monitoring activities.

Link 12: **Pipeline repair, oil cleanup, restoration and monitoring activities will produce noise and will disturb muskrat and beaver.**

Due to the lack of quality habitat for muskrat and beaver in the vicinity of the accident site, it is unlikely that pipeline repair activities will represent a source of disturbance to these animals. While cleanup, restoration and monitoring could produce sufficient noise to cause muskrat and beaver to avoid the area, disturbances associated with these spill response activities will likely be localized and short term due to the relatively small volume of oil that would become stranded along the shoreline (i.e., 1000 bbls). This link is considered to be **valid** only for cleanup, restoration and monitoring activities.

Link 13: **Noise and disturbance will cause reductions in the time available for foraging and will increase energy expenditures through increased avoidance behaviour.**

Link 14: **Noise and disturbance will cause changes in the distribution of muskrat and beaver that will lead to changes in the harvestability of the animals.**

The working group concluded that both Links 13 and 14 are **likely to be valid** because cleanup and habitat restoration efforts would be focussed along the shoreline and lowland areas, where there would be the potential for conflict with muskrat and beaver. The zone of influence of disturbances associated with spill response is expected to be much smaller than that of oil (i.e., < 1% of the regional population) and, therefore, very localized changes in the distribution and harvestability of muskrat and beaver are expected. Because these activities would likely occur over a short time frame (i.e., 1-2 months in total with only hours to days of activity in any one locale), this impact is also expected to be of short-term duration.

Link 15: **Changes in the availability of habitat and food for muskrat and beaver will result in changes in the behaviour and distribution of these animals, which will have energetic consequences for these individuals.**

It was noted that, because muskrat are a mobile species, localized changes in the availability of habitat and food would likely have inconsequential effects on the energetics of this species. Animals would likely move to adjacent unoiled areas that provide similar habitat.

However, information from the *Exxon Valdez* studies suggests that changes in the availability of food and habitat had a significant effect on the behaviour and distribution of river otter, which like muskrat are also a very mobile species. Studies of radio-tagged animals in Prince William Sound showed that home ranges of river otter in oiled areas were twice that of unoiled areas, suggesting that in oiled areas the otters needed to forage over a larger area to obtain sufficient food (Alaska Department of Fish and Game 1992).

Based on this evidence, the working group concluded that this linkage is likely **valid** for muskrat and beaver.

Link 16: Loss of habitat will result in changes in the numbers and distributions of muskrat and beaver.

Link 16 is implicitly **valid**. Unless the habitat is below its carrying capacity, any loss of habitat will result in changes in the numbers and distribution of these species. However, the working group agreed that the loss of habitat associated with the direct toxic effects of oil and spill response activities would be very small (i.e., < 10% of the regional muskrat habitat, and < 1% of beaver habitat) and short term (i.e., one year). As discussed in MEMP (LGL *et al.* 1986), in localized areas where muskrat have been extensively harvested or where habitat has been altered or disturbed, populations typically return to normal levels within a short period once suitable habitat has been re-established.

Link 17: Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction, which will lead to reduced populations.

The link is considered to be **valid** (see discussion of Link 10). Although the reproductive potential of muskrat is high, survival of newborn young and juveniles is low. Any oiled animal that loses their young would not likely reproduce that summer (J. Benoit, pers. comm.), which would result in lower recruitment of young into the breeding population.

Link 18: **Reduced populations of muskrat and beaver will result in reduced harvests of these animals.**

The working group considered Link 18 to be implicitly **valid**.

Link 19: **The presence of oil in the river in combination with the pipeline repair and cleanup activities will change the distribution and/or success of the harvest.**

The presence of oil (as well as odour of oil), and the presence of response personnel and equipment may deter northerners from hunting. While disturbances associated with cleanup activities would be relatively localized due to discontinuous oiling of the shoreline, the temporal overlap between these activities and the harvest could be significant given that hunting occurs over a short period of time (i.e., <1 month) and cleanup and restoration would probably require at least 1 month. As discussed in Links 11 and 12, this linkage is **valid** for cleanup and restoration but **invalid** for pipeline repair activities.

ASSESSMENT OF IMPACT SIGNIFICANCE

Given the oil spill scenario used for evaluating this impact hypothesis, the group concluded that there are five major pathways that are valid for muskrat and beaver.

FOULING OF FUR, PRESENCE OF OIL AND OIL SPILL PERSONNEL ON POPULATIONS AND HARVESTING

The effects of: (1) fouling of fur on the populations and harvest of these animals; and (2) presence of oil and spill response personnel on the success and distribution of the harvest were concluded to be **insignificant** (Class 3) due primarily to the short-term nature of the impacts. The temporal overlap between fouling of animals and disturbance of cleanup activities, and the harvest of muskrat and beaver could possibly be 100 % due to the fact that the harvest occurs only for one month after spring breakup. However, the working group expected that these effects would last for only one harvesting season and would likely affect less than 10 % of the regional populations of muskrat and beaver due to their widespread distribution and the sporadic nature of shoreline oiling. Because of the high reproductive capacity of muskrat, recovery of individuals into the population was expected to occur over 1 generation (i.e., 1 year from birth to reproductive age). However, it was assumed that recovery of beaver could possibly take two years due to the lower reproductive rate and high mortality rate of this species.

OIL INGESTION

Although the group concluded that beaver and muskrat are likely to ingest oil through grooming of fouled fur and consumption of contaminated food, the significance of this to the survival and reproductive capacity of these populations and the harvestability of the animals was **unknown**. The working group was unaware of any information related to the toxicological effects or potential for tainting in these species of semi-aquatic mammals.

SPILL RESPONSE ACTIVITIES

The effects of noise and disturbance associated with spill response activities on muskrat and beaver populations and their harvest were considered to be valid but **insignificant.** Due to the fact that cleanup and restoration would likely occur over a 1-2 month period in very localized areas, any changes in the distribution of these populations are also expected to be very localized and short term.

LOSS OF HABITAT

The working group concluded that the presence of spilled oil along the shores of the river and islands could lead to localized, direct toxic effects on vegetation and subsequent losses of habitat for both muskrat and beaver. However, due to the small volume of oil (1000 bbls) that is expected to become stranded in backwater and lowland areas, it is unlikely that more than 1% of the regional habitat for muskrat would be affected. Because beaver feed primarily on poplar, it is expected that this would represent only a partial loss of habitat (<< 1%), which would not substantially alter the productive capacity of its habitat. Consequently, this pathway was considered to be **insignificant** for both VEC species.

EVALUATION OF LINKAGES - MINK

Link 1: **Rupture of the buried pipeline will: (a) release crude oil into a river; and (b) necessitate pipeline repairs and a cleanup response.**

This link is considered **valid** for the same reasons as provided for muskrat and beaver.

Link 2: **The presence of oil in the river will lead to fouling of the fur of mink.**

It was assumed that two hours after the spill, the diameter of the dispersed cloud would equal the width of the river. At this time, any mink swimming or foraging in the river or along the river bank within the zone of influence of the spill could come in contact with the oil. Although very few individuals (probably < 1% of the regional population) would likely be affected due to sporadic oiling of the shoreline and their widespread distribution in the area, the group concluded that this link was **valid** for this species.

Link 3: **Spilled oil will be ingested by mink through consumption of oiled prey.**

Although the subgroup was uncertain as to whether mink would be capable of detecting and avoiding oil, it was considered possible that some individuals may ingest oil as a result of foraging on oiled muskrat and oil-contaminated fish (see earlier discussion on muskrat and Hypothesis C18-B). Studies initiated after the *Exxon Valdez* oil spill suggest that sea otters did not appear to change their eating habits to avoid contaminated prey, but continued to rely heavily on clams and mussels as prey regardless of the oiling status (Alaska Department of Fish and Game 1993).

The potential for ingestion of oil through consumption of oiled prey or prey containing oil may be greater for those mink whose fur has been fouled. Davis *et al.* (1988) found that sea otters increased their metabolic rate 1.9 times to compensate for the loss of insulation caused by oil contamination of their fur. An increase in the metabolic rate may require the animal to consume larger quantities of food each day to sustain the higher rates and, thereby, increase the potential for ingestion of oiled prey.

Link 4: **The presence of spilled oil will lead to localized, direct toxic effects on vegetation and subsequent localized losses of habitat.**

This link is considered **valid** for mink provided that habitat includes its prey (i.e., fish and muskrat). Based on the conclusions reached for muskrat as well as for fish resources in the river (see Hypothesis C18-B), losses of both prey species as a result of direct effects of oil may occur; however, these impacts are expected to be short term (i.e., less than 1 year) and localized.

Link 5: **Fouled pelage will lead to a reduction in the value of mink for food and fur, and a change in the distribution and/or success of the harvest.**

Mink are trapped from the beginning of November to the end of February and are used by northerners exclusively for their fur. Given the timing of the spill (May), it is unlikely that there would be any temporal overlap with the trapping season. This link is, therefore, considered **invalid**.

Link 6: **Fouling of the fur will have thermal and/or buoyancy effects, leading to changes in the energy balance of some individuals.**

Like other furbearers, mink depend on air trapped within their dense fur for insulation and buoyancy. Oil contamination of their fur would eliminate the air layer, allowing water to penetrate to the skin, and reduce its insulative capability. The consequences of this to the energy balance of an individual is unknown. However, information gained from studies on sea otters may be applicable to this species. Davis *et al.* (1988) have shown that oiling of otter fur increased thermal conductance 1.8 times. To compensate for the loss of insulation and maintain a normal body core temperature, the otters increased average metabolic rate through shivering and voluntary activity. The time spent grooming and swimming also increased dramatically.

Based on evidence for sea otters, the group concluded that this link is likely to be **valid** for mink.

Link 7: Grooming of fouled fur will result in the ingestion of oil.

Grooming activity by mink is essential to maintain the water-repellent quality of the fur. It is reasonable to assume that mink which have become fouled with oil will consume some quantity of oil during grooming. This link is **valid**.

Link 8: Ingestion of oil by mink will result in tainting or perceived tainting and a change in the harvest of these animals.

Because mink are not used as a food source by northerners, this link is **invalid**.

Link 9: Chronic ingestion of spilled oil will result in direct mortality of mink.

Given the spill scenario, the subgroup concluded that it is unknown whether mink would ingest sufficient amounts of oil to cause death. However, the group considered it likely given the predatory nature of this species (See Link 9 related to muskrat and beaver).

It is estimated that 3500 to 5500 sea otters died from acute exposure to oil following the *Exxon Valdez* spill (Exxon Valdez Oil Spill Trustees 1992). Ingestion of oil through grooming of fouled fur and consumption of oiled prey, loss of thermoregulation, and inhalation of toxic aromatic compounds evaporated shortly after the spill were suspected causes of death in these animals. Investigations of oiled sea otters indicated that in some circumstances, mortality of animals was correlated with petroleum hydrocarbons in the blood. Abnormal patterns of mortality continued through to 1991, when a high proportion of carcasses of prime-age otters were found on beaches. Continued declines in the abundance of sea otters in oiled areas of Prince William Sound and higher mortality and lower pupping rates suggest prolonged spill-related effects on this population. Based on this evidence, Link 9 is considered to be **valid**.

Link 10: **Ingestion of oil will lead to sublethal effects that will change the energy balance of individual animals.**

To determine if mink reproduction may have been affected by oil in their diet as a result of the *Exxon Valdez* spill, a laboratory exposure study of ranch-bred mink was conducted (Exxon Valdez Oil Spill Trustees 1992). The mink were fed small, non-lethal amounts of weathered oil. While no changes in reproductive rates or success resulted from this exposure, oil-contaminated food moved though the intestines of the animals at a more rapid rate than did uncontaminated food, possibly providing less nutritional value to the animals.

Although oil contamination of food species may occur, effects will likely be discontinuous due to the nature of shoreline oiling. Therefore, the group concluded that this link is likely to be **valid** for mink, but that probably less than 1 percent of the regional population would be affected.

Link 11: **Pipeline repair, oil cleanup, restoration and monitoring activities will result in localized disturbances of habitat for mink.**

As mentioned earlier, localized disturbance of prey species of mink (i.e., fish and muskrat) will likely occur as a result of cleanup, restoration and monitoring activities. This link is **valid**.

Link 12: **Pipeline repair, oil cleanup, restoration and monitoring activities will produce noise and will disturb mink.**

Link 13: **Noise and disturbance will cause reductions in the time available for foraging and will increase energy expenditures through increased avoidance behaviour.**

Link 13 is considered to be **valid**. Cleanup, restoration and monitoring activities could produce sufficient noise to cause mink to avoid the area. However, this disturbance would likely be very short term (i.e., 1-2 months in total with only hours to days of activity in any one locale) and localized. Less than 1 percent of the regional population of mink is expected to be affected by spill response activities due to the discontinuous oiling of the shoreline and widespread distribution of this species.

Link 14: **Noise and disturbance will cause changes in the distribution of mink that will lead to changes in the harvestability of animals.**

Any changes in the distribution of mink are expected to be short term and, therefore, unlikely to affect the harvest in the fall. This link is considered to be **invalid**.

Link 15: **Changes in the availability of habitat and food for mink will result in changes in the behaviour and distribution of these animals, which will have energetic consequences for these individuals.**

Although the loss of prey species is expected to be very localized and short term, this may cause some mink to forage over a larger area to obtain sufficient food. Following the *Exxon Valdez* oil spill, the home ranges of river otters in oiled areas were found to be twice as large as in unoiled areas (Alaska Department of Fish and Game 1993). Based on this evidence, Link 15 is considered to be **valid**.

Link 16: **Loss of habitat will result in changes in the numbers and distributions of mink.**

This link is considered implicitly **valid**.

Link 17: **Changes in the energy balance of individuals will lead to reduced survival and reduced reproduction, which will lead to reduced populations.**

Although this link is implicitly **valid**, the subgroup considered it questionable whether changes in the survival and reproductive capacity of the population leading to changes in the abundance of mink would occur as a result of this spill.

Link 18: **Reduced populations of mink will result in reduced harvests of these animals.**

The subgroup considered this link to be implicitly **valid**.

Link 19: **The presence of oil in the river in combination with the pipeline repair and cleanup activities will change the distribution and/or success of the harvest.**

This link is considered **invalid** because it is unlikely that there would be any temporal overlap between the trapping season for mink and presence of oil in the river or spill response activities.

ASSESSMENT OF IMPACT SIGNIFICANCE

Given the oil spill scenario used to evaluate this impact hypothesis, the subgroup concluded that there are four dominant pathways that are valid for mink populations.

FOULING OF FUR

The subgroup concluded that fouling of mink fur could lead to changes in the energy balance of individuals but were uncertain as to its implications on the survival and reproductive capacity of the population. It was estimated that given the small volume of spilled oil, less than 1 percent of the regional population would likely be affected through this pathway and recovery would likely be short term. The group, therefore, concluded that this impact is **insignificant** (Class 3).

OIL INGESTION

Although the group concluded that mink are likely to ingest oil through grooming of fouled fur and consumption of contaminated prey, the significance of this to the survival and reproductive capacity of these populations is **unknown**.

SPILL RESPONSE ACTIVITIES

The effects of noise and disturbance associated with spill response activities on the mink population is considered valid but **insignificant** (Class 4). Due to the fact that cleanup and restoration would likely occur over a 1-2 month period in very localized areas, any changes in the distribution of these populations are also expected to be very localized (< 1%) and temporary.

LOSS OF HABITAT

The working group concluded that the presence of spilled oil in the river and along the shoreline could lead to localized, direct toxic effects on prey species of mink (muskrat and fish). However, this impact is **not expected to be significant** (Class 3) given the small volume of spilled oil, and expected rapid recovery of these prey populations due to immigration of individuals from adjacent areas and high fecundity and reproductive rates of these species.

RECOMMENDED RESEARCH AND MONITORING

The working group recommended that a review of existing information related to the chronic and acute effects of oil on semi-aquatic mammals (mink, muskrat and beaver) be undertaken. Any information gaps in the database should be noted and opportunistic research be conducted.

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4.4.5 BREAM HYPOTHESIS C-8: The Effects of an Oil Pipeline Rupture and Associated Countermeasures at a River Crossing in Spring on Birds and their Harvest

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INTRODUCTION

Oil Spill Scenario

This hypothesis addresses the possibility that a late-winter or spring rupture in a pipeline carrying crude oil under a river might release several thousand barrels of oil into the river before breakup. This oil would be expected to move downstream along the underside of the ice. During breakup, the oil would migrate to the surface of the ice and/or collect in open water areas. At that time, waterbirds engaged in stopovers during their spring migration might contact the oil.

The specific scenario considered at the workshop assumed that such a spill occurred at a crossing of the Great Bear River just upstream from its confluence with the Mackenzie River. In this case, the oil would be expected to move into the frozen Mackenzie and then downstream near its eastern edge. It was assumed that the spill would consist of a 100 barrel per day leak for 60 days (prior to detection), plus an additional 154 barrels representing the amount of oil between the shut-off valves on each side of the river. Some workshop participants indicated that this was an unrealistically high amount of oil, since a leak of 100 bbl/d should be detectable by pipeline monitoring instruments. However, the group decided to retain the above assumptions as being representative of a "worst case" situation.

Prior to breakup, the oil would form a long, narrow swath along the undersurface of the river ice. Some oil might reach shorelines during breakup, probably in the form of sheen. However, some oil-contaminated blocks of ice might be forced up onto land. It was considered unlikely that oil would reach the shorelines of islands located close to the west side of the Mackenzie River near and downstream of the mouth of the Great Bear River, e.g., Windy Island.

It was assumed that countermeasures, including oil spill cleanup and/or bird scaring, might be used in local areas of oil-contaminated open water prior to general breakup. A small area of open water is present at the mouth of the Great Bear River throughout the winter. Some of the oil released upstream of this area might be detectable and perhaps collectable in that open area prior to general breakup. Bird scaring measures (Koski *et al.* 1993) might be employed along any stretches of contaminated shoreline that might be present during and after breakup. However, it was assumed that, after breakup, there would be little shoreline oiling and thus little opportunity for cleanup and little need for bird scaring measures.

Valued Ecosystem and Valued Social Components (VECs and VSCs)

The valued birds that might be affected by the spill consisted of certain geese, ducks, Tundra Swans, and raptors. During spring, many geese (Snow, Canada and White-fronted Geese) stop on and near islands in the Mackenzie River (Boothroyd 1985, 1986; Alexander *et al.* 1991:95). The most extensively used islands are too far downstream to be at risk in this scenario. However, flocks of geese sometimes stop along the edges of Windy Island, in the central-western part of the Mackenzie River about 3-6 km downstream from the mouth of the Great Bear River (Figure 4-20, from Boothroyd 1986:20). Snow Geese stage at Windy Island during May of low-water years. Numbers present will vary greatly from day to day and year to year. Total numbers stopping here during a spring season are unknown, but no doubt larger than the numbers present on any one day. It was considered unlikely that any oil from the spill hypothesized above would cross the main channel of the Mackenzie to reach Windy Island. However, disturbance associated with oilspill response activities might affect geese there.

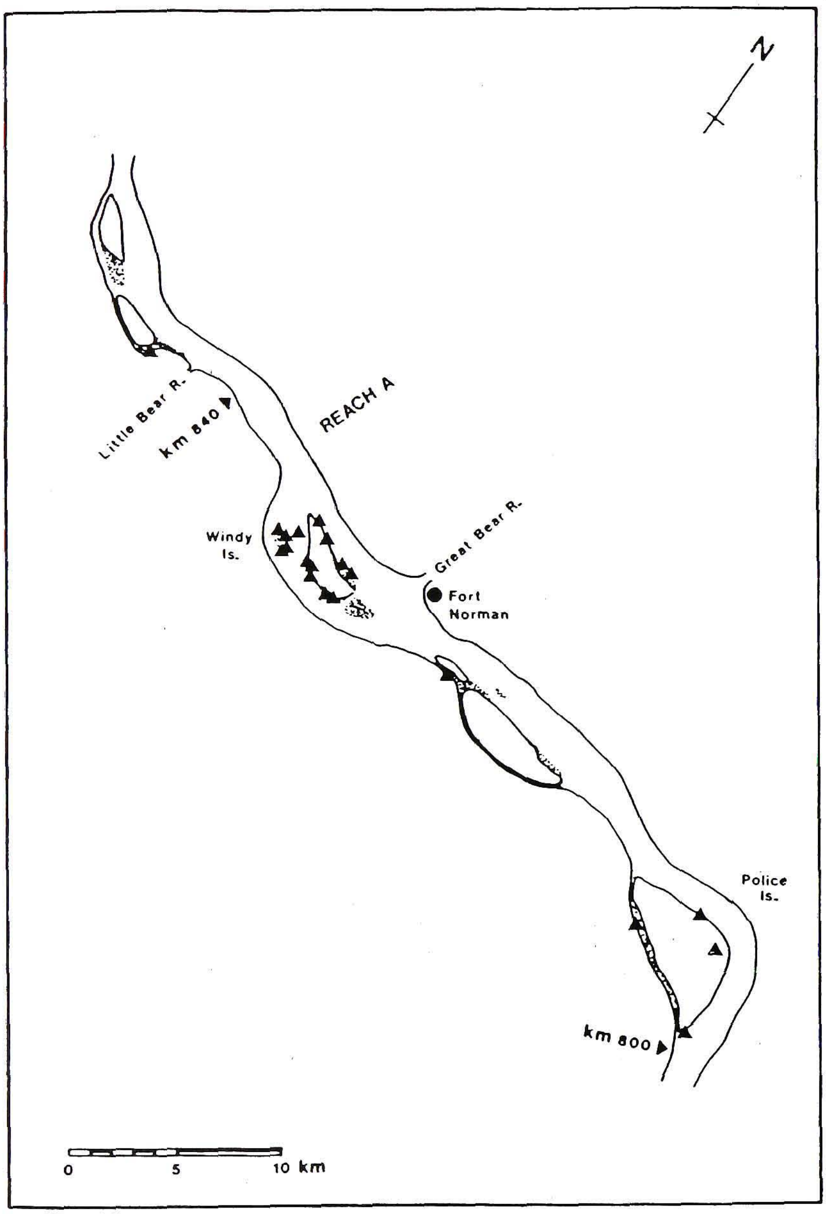

Figure 4-20: Locations of Snow Geese observed during aerial surveys flown by various researchers during the springs of 1972, 1980, 1981, 1983, 1984 and 1985, as compiled by Boothroyd (1986:20). Note the many sightings at Windy Island in the central-west portion of the Mackenzie River just downstream of the mouth of the Great Bear River.

Smaller numbers of other species of waterbirds, especially Tundra Swans and dabbling ducks, may also stop in the area (Boothroyd 1985, 1986). Swans, like geese, spend most of their time on land or on the ice, but are expected to go into the water occasionally. Ducks spend more of their time in the water. It was assumed that during breakup the main ducks present would be dabbling ducks such as Mallards, Pintails, American Widgeon, and Green-winged Teal. Some of these might occur near the eastern shore of the Mackenzie River where they could encounter oil. Most diving ducks and loons migrate through this area later in the spring, after breakup and after the oil would have largely dissipated.

Some raptors, including Peregrine Falcons and Bald Eagles, occur in the area. It is possible that they might feed on oil-contaminated waterbirds.

Workshop participants did not have specific information about the types and numbers of waterfowl harvested in the Fort Norman area during spring. They assumed that some of the geese and ducks that might be oiled are harvested locally during spring. These waterfowl are also hunted elsewhere.

Linkages

The 1991/1992 final report for BREAM (Axys *et al.* 1992:330ff) included first drafts of linkage diagrams for the effects of various oilspill scenarios on birds. However, discussions before the 1993 workshop led to the idea that a generic "oil vs. birds" linkage diagram could be formulated to incorporate all linkages that might occur in any oil spill scenario relevant to BREAM. It appeared that the basic linkages would be similar for all scenarios of interest. A generic linkage diagram applicable to all spill scenarios would have the advantages greater consistency across scenarios, and greater applicability to scenarios differing somewhat from any of those specifically covered in the workshop (Figure 4-21).

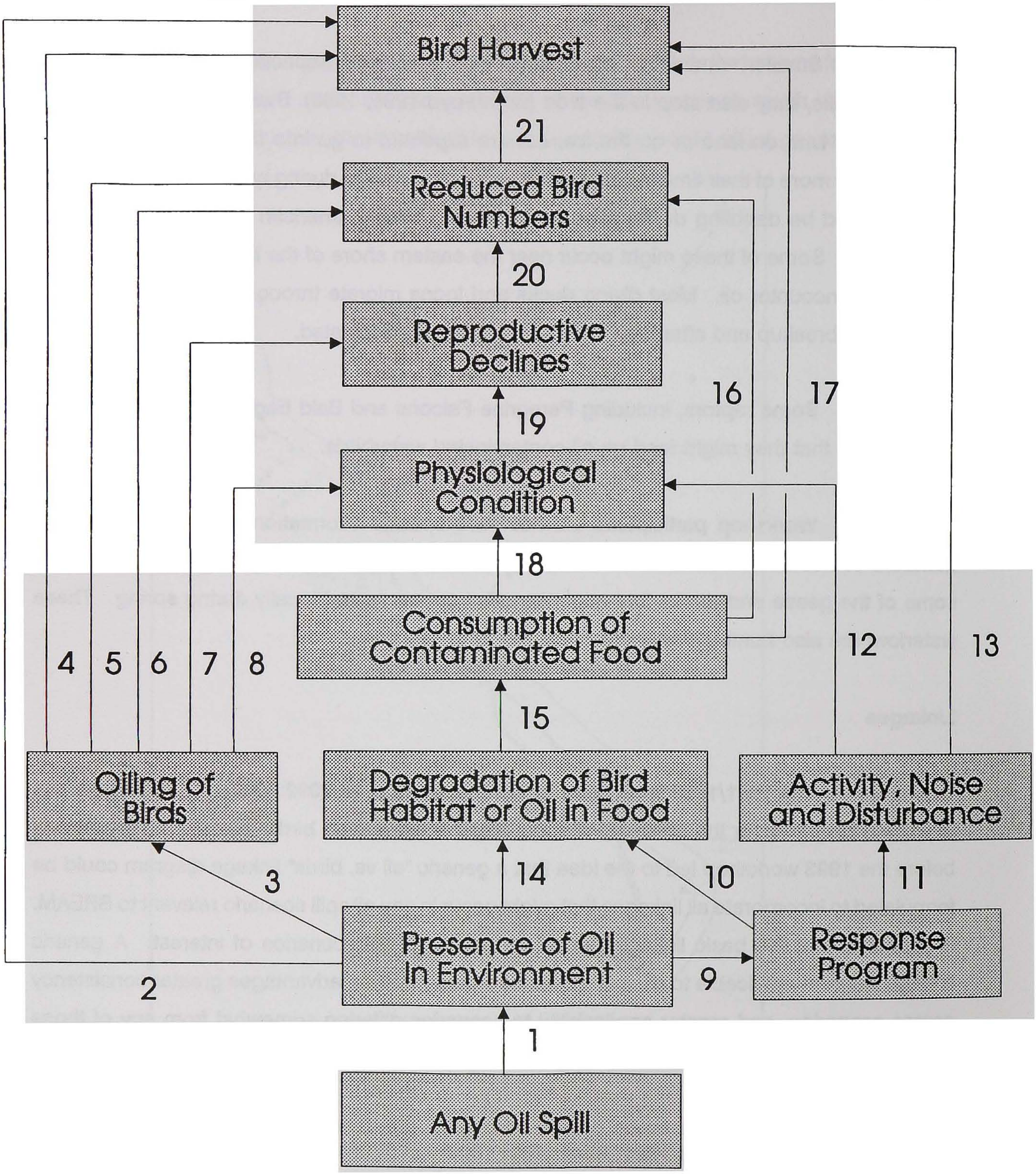

Figure 4-21: BREAM Bird Hypotheses - Effects of Any Type of Oil Release on Bird Numbers and Harvest

Participants in the 1993 workshop found that this approach was satisfactory. The generic linkage diagram formulated before the 1993 workshop was updated slightly during discussion of BREAM Hypothesis C-8. The updated generic hypothesis considers the effects of both the oil spill *per se* and the oil spill response effort. Spill response includes both oil spill cleanup measures and bird scaring measures that might be applied in attempts to keep birds out of oil-contaminated areas. The generic hypothesis also considers both the valued wildlife populations and the valued resource uses (primarily hunting in this case).

The updated generic hypothesis seemed suitable not only for Hypothesis C-8 but also for Hypotheses C-9 and C-11 (see later). In each case, Link 1 was scenario-specific, but all 20 subsequent links were common to all scenarios. The following are the links as defined during the 1993 workshop, including the version of "Link 1" appropriate for Hypothesis C-8. As indicated by the subheadings, most of the linkages can be categorized into three major chains of linkages, with some cross-links from chains *A* and *B* to chain *C* via linkages 5, 6, 7, 8, 10 and 12:

Link 1: An oil pipeline spill as described in this scenario will cause oil to be present in the Great Bear River (spill site) and the Mackenzie River at the time of breakup.

Link 2: Presence of oil in the environment will result in reduction of traditional harvests of birds because of the possibility or perception that birds might be oiled or tainted.

Links Based on Direct Oiling of Birds

Link 3: Presence of oil in the environment will result in direct oiling of birds.

Link 4: Ingestion of oil by birds while preening oiled plumage will result in changes in their palatability and a reduced harvest of birds.

Links 5,6: Direct oiling of birds' feathers will result in bird mortality and reduced bird numbers via two mechanisms: (Link 5) loss of buoyancy and hypothermia, and (Link 6) ingestion of lethal doses of oil during preening.

Link 7: Birds with non-lethal doses of oil on their feathers will transfer oil to their eggs, which will kill or deform embryos and thereby reduce hatching success.

Link 8: Birds with non-lethal doses of oil on their feathers will ingest non-lethal doses of oil during preening, which will affect their physiological condition.

Links Based on Spill Response Program and Related Disturbance

Link 9: Presence of oil in the environment will trigger industry- and government-sponsored oil spill response plans.

Link 10: Oil spill cleanup activities involving crews and equipment in coastal and terrestrial areas will cause degradation of bird habitats.

Link 11: Oil spill response (spill cleanup and/or bird deterrence) will involve intensive activity, noise, and disturbance to feeding, resting, nesting, migrating, and/or brood-rearing birds.

Link 12: Activity, noise and disturbance associated with oil spill response activities will cause birds to be stressed and will result in non-lethal effects on their physiological condition.

Link 13: Activity, noise and disturbance associated with oil spill response activities will cause birds to be disturbed and displaced, and will result in a reduced harvest of birds.

Links Based on Habitat Degradation and Oil Ingestion

Link 14: Presence of spilled oil will lead to degradation of bird habitats (e.g. water surface, benthic communities, shorelines, adjacent terrestrial wetlands), including oil contamination of plant and animal foods of birds.

Link 15: Degradation of bird habitats through oiling, and contamination of plant and animal foods of birds through oiling, will result in ingestion of oil-contaminated foods by birds.

Link 16: Ingestion of oil-contaminated food by birds will have lethal effects that will reduce bird numbers.

Link 17: Ingestion of non-lethal amounts of oil-contaminated food by birds will result in changes in their palatability and a reduced harvest of birds.

Link 18: Ingestion of non-lethal amounts of oil-contaminated food will affect birds' physiological condition, including growth and development of young-of-the-year.

Link 19: Non-lethal effects on the physiological condition of birds will cause declines in their reproductive output.

Link 20: Reproductive declines in birds will result in reduced bird numbers.

Link 21: Reduced bird numbers will result in reduced harvest of birds.

EVALUATION OF LINKAGES

Table 4-2 summarizes, for each VEC/VSC and linkage, the workshop's evaluation of the

- validity of the link,
- confidence that can be placed in that assessment of validity, and
- probability that the link will occur in the stated scenario.

Link 1 **An oil pipeline spill as described in this scenario will cause oil to be present in the Great Bear River (spill site) and the Mackenzie River at the time of breakup.**

This "scenario specific" link was considered to be **valid**. However, as discussed above, the most numerous waterbirds in the area in spring are geese, and it is unlikely that much (if any) oil would reach the areas where geese concentrate. Some other types of birds, especially ducks, are more likely to encounter the oil.

Link 2 **Presence of oil in the environment will result in reduction of traditional harvests of birds because of the possibility or perception that birds might be oiled or tainted.**

Although the workshop group had no information about hunting activities in this area in spring, it was assumed that some waterfowl hunting occurs. If so, some hunters likely would be hesitant to eat ducks or geese that might have been exposed to oil. Thus, this was judged to be a logically **valid** link for those groups. However, its likelihood of occurrence in the present scenario was considered low, given that oil is unlikely to reach islands where geese concentrate. This link was **invalid for raptors**, which are not hunted.

TABLE 4-2
EVALUATION OF LINKAGES FOR HYPOTHESIS C-8

	Dabbling Ducks			Geese & Swans			Raptors		
Link	Valid?	Confid?	Likely?	Valid?	Confid?	Likely?	Valid?	Confid?	Likely?
1	Valid	High	Certain	Valid	High	Certain	Valid	High	Certain
2	Valid	High	Not Likely	Valid	High	Not Likely	Invalid	High	-
3	Valid	High	Likely	Invalid	Medium	-	Valid	Med-High	Variable
4	Valid	High	Unknown	-	-	-	Invalid*	High	-
5	Valid	High	Likely	-	-	-	Variable	Low	Unknown
6	Unknown	-	-	-	-	-	Unknown	-	-
7	Valid	High	Not Likely	-	-	-	Valid	High	Unknown
8	Valid	High	Likely	-	-	-	Valid	Medium	Likely
9	Valid	High	Likely	Valid	High	Likely	Valid	High	Likely
10	Valid	High	Not Likely	Invalid	High	-	Invalid	High	-
11	Valid	High	Not Likely	Valid	High	Likely	Valid	High	Likely
12	Valid	High	Not Likely	Valid	High	Likely	Valid**	High	Likely
13	Invalid	High	-	Valid	High	Likely	Invalid*	High	-
14	Valid	Low	Not Likely	Invalid	Medium	-	Valid	High	Likely
15	Valid	High	Not Likely	-	-	-	Valid	High	Likely
16	Invalid	Medium	-	-	-	-	Unknown	-	-
17	Valid	High	Not Likely	-	-	-	Invalid*	High	-
18	Valid	High	Not Likely	-	-	-	Valid	High	Likely
19	Valid	High	Likely	Valid	High	Not Likely	Valid	High	Likely
20	Valid	High	Not Likely	Valid	High	Not Likely	Valid	High	Likely
21	Unknown	-	-	Valid	High	Not Likely	Invalid*	High	-

* Invalid because this species is not harvested

** Peregrine falcons might desert their nest in response to disturbance

Links Based on Direct Oiling of Birds

Link 3 Presence of oil in the environment will result in direct oiling of birds.

Link 3 is **valid** for ducks that might land on the east side of the Mackenzie River where oil could occur, and for raptors that might take oil-contaminated prey there. However, the number of ducks or raptors that will be oiled is very difficult to predict and could be low.

Link 3 is probably **invalid** for geese and swans that concentrate on islands on the west side of the Mackenzie. Consequently, links 4, 5,b, 7 and 8, which depend on link 3, are presumed to be irrelevant for geese and swans under this scenario.

Link 4 Ingestion of oil by birds while preening oiled plumage will result in changes in their palatability and a reduced harvest of birds.

Birds preen their plumage when it is fouled. It is likely that some ducks would contact sufficient oil to foul parts of the plumage but not enough to be lethal. If such a duck were taken by a hunter, it would likely be judged to be unpalatable based either on its appearance or on its taste. As a result, hunters would probably reduce their harvesting effort in the area where the oil-contaminated bird was taken. Thus, link 4 was considered **valid for ducks**. However, the number of birds likely to be affected under the present scenario could be low, possibly to the degree that it would be unlikely that hunters would take any of them. Also, it is not known how much oil must be ingested for the flesh to become noticeably tainted. Thus, the likelihood of occurrence of this link under this scenario was judged to be unknown. This link is **invalid for raptors** because they are not hunted, and irrelevant for geese because they probably would not be oiled.

Link 5 **Direct oiling of birds' feathers will result in bird mortality and reduced bird numbers via loss of buoyancy and hypothermia.**

There is abundant evidence that this link is **valid**. Some ducks and possibly some raptors are likely to be oiled and killed via this mechanism under the present scenario. The numbers of birds that would be killed in this way are unknown but probably low. Few ducks are likely to contact oil under this scenario. With the possible exception of eagles, raptors would not enter oiled water. However, they could theoretically be oiled by contact with oiled prey or oiled habitat. (Note: many Bald Eagles apparently were killed by the *Exxon Valdez* oil spill, but the mechanism of this mortality is not evident from the information released to date.)

Link 6 **Direct oiling of birds' feathers will result in bird mortality and reduced bird numbers via ingestion of lethal doses of oil during preening.**

Link 6 was judged to be of unknown validity for ducks and raptors. Most heavily-oiled waterbirds die because of the buoyancy and hypothermia problems noted in link 5. It is unclear whether some birds would survive those problems but die from the toxic effects of oil ingested during preening. It is well established that various types of waterbirds can consume a significant amount of crude oil and survive. However, many oiled waterbirds that are captured and cleaned die during or after cleaning, even if kept warm. This suggests that link 6 might be correct in some cases. However, if those birds had not been captured and cleaned, they probably would have died from hypothermia and buoyancy problems before the ingested oil would have been lethal. For these reasons, the validity of link 6 is **unknown for ducks and raptors**. It is **invalid for geese and swans**, which would not be oiled in this scenario.

Link 7 **Birds with non-lethal doses of oil on their feathers will transfer oil to their eggs, which will kill or deform embryos and thereby reduce hatching success.**

There is much evidence that this phenomenon occurs in various types of waterbirds. The group was not aware of evidence for this phenomenon in raptors, but assumed that the effect would occur in that group as well. Thus, this link was considered **valid for ducks and raptors**. The link is **invalid for geese**, which are not expected to be oiled in this scenario.

Link 8 **Birds with non-lethal doses of oil on their feathers will ingest non-lethal doses of oil during preening, which will affect their physiological condition.**

This phenomenon is well documented, and was considered **valid** and likely in the ducks and raptors that might contact small amounts of oil.

Links Based on Spill Response Program and Related Disturbance

Link 9 **Presence of oil in the environment will trigger industry- and government-sponsored oil spill response plans.**

This was considered to be a **valid** assumption, although the extent of the clean-up effort might be limited in this scenario. At minimum, there would be increased helicopter traffic to provide for surveillance of the spill. Bird scaring measures might also be implemented. These would be designed to reduce the numbers of birds contacting oil, and thus to reduce bird mortality (Koski *et al*. 1993). However, the noise and disturbance associated with scaring measures could lead to sub-lethal negative effects via Links 11 and 12, and to reduced waterbird harvest via Link 13.

Link 10 **Oil spill cleanup activities involving crews and equipment in coastal and terrestrial areas will cause degradation of bird habitats.**

Although this link is theoretically possible, under the present scenario it was considered **unlikely for ducks** and **invalid for the other valued types of birds**. Oil would not reach the island habitat of geese and swans or the mainly terrestrial habitat of raptors.

Link 11 **Oil spill response (spill cleanup and/or bird deterrence) will involve intensive activity, noise, and disturbance to feeding, resting, nesting, migrating, and/or brood-rearing birds.**

Link 12 **Activity, noise and disturbance associated with oil spill response activities will cause birds to be stressed and will result in non-lethal effects on their physiological condition.**

Oilspill reconnaissance and (if attempted) cleanup would involve aircraft and human disturbance. Bird deterrent efforts (if implemented) could include various other noisy or otherwise disturbing activities. Disturbance can lead to physiological stress. Thus, Links 11 and 12 were considered **valid** for all valued groups of birds. (Note, however, that waterfowl would not be nesting or brood-rearing in this area during May.) These links were considered likely for snow geese and at least some raptors because they often react to noisy activities even when those activities are a considerable distance away. However, snow geese are less sensitive to helicopter disturbance during spring staging along the Mackenzie River (Boothroyd 1985, 1986) than was found during earlier studies in autumn.

Link 13 **Activity, noise and disturbance associated with oil spill response activities will cause birds to be disturbed and displaced, and will result in a reduced harvest of birds.**

Disturbance effects have the potential to result in reduced local harvest of geese. This is not likely in the case of ducks, given the lesser anticipated responses of these birds and their more variable distribution. This link is invalid for raptors, which are not hunted.

Links Based on Habitat Degradation and Oil Ingestion

Link 14 **Presence of spilled oil will lead to degradation of bird habitats (e.g. water surface, benthic communities, shorelines, adjacent terrestrial wetlands), including oil contamination of plant and animal foods of birds.**

Link 15 **Degradation of bird habitats through oiling, and contamination of plant and animal foods of birds through oiling, will result in ingestion of oil-contaminated foods by birds.**

Links 14 and 15 were considered to be **valid in the cases of ducks and raptors**, whose habitats had some likelihood of being contacted by the oil. These links were considered **invalid for geese and swans**, since oil probably would not reach their main habitat on and near the islands.

Link 16 **Ingestion of oil-contaminated food by birds will have lethal effects that will reduce bird numbers.**

Link 16 was considered **invalid for ducks** because the amount of crude oil that might be consumed while eating oiled food would be too small to be lethal. This link is also **invalid or irrelevant for geese and swans** because of their assumed lack of contact with oiled habitat.

The validity of this link for raptors is **unknown**. Raptors often consume many feathers when eating avian prey. It is not known whether raptors would eat prey that are oiled to a degree sufficient to be lethal to the raptor.

Link 17 **Ingestion of non-lethal amounts of oil-contaminated food by birds will result in changes in their palatability and a reduced harvest of birds.**

This link was considered **valid but unlikely in the case of ducks**. Small numbers of them might contact oil, and one or more oiled individuals might be killed by hunters. The link is **invalid** for geese and swans (no contact with oil) and for raptors (not hunted).

Link 18 Ingestion of non-lethal amounts of oil-contaminated food will affect birds' physiological condition, including growth and development of young-of-the-year.

This link is known to be **valid** for waterfowl that consume contaminated food (some of the ducks in this scenario). It also can be assumed to be valid for raptors that consume oil-contaminated prey. In this scenario it is **invalid** for geese and swans (no contact with oiled food).

Link 19 Non-lethal effects on the physiological condition of birds will cause declines in their reproductive output.

This link was considered **valid and likely** for ducks and raptors, and **valid but not likely** for geese and swans. For the former two groups, physiological condition could be impaired by two factors: ingested oil (Links 8, 18) and by disturbance from oilspill response activities (Link 12). For geese and swans, disturbance from the oilspill response (Link 12) might cause some physiological deterioration. Degraded physiological condition is known to reduce reproductive capacity in various birds, including arctic-nesting geese.

Link 20 Reproductive declines in birds will result in reduced bird numbers.

This link was considered **valid** for all valued bird groups, and likely for raptors. Reproductive declines are possible as a result of Link 19 (all valued groups) and perhaps Link 7 in ducks and raptors.

Link 21 Reduced bird numbers will result in reduced harvest of birds.

This link was considered **valid for geese and swans**, but unlikely to have a significant effect. Two of the prerequisite links (19, 20) are, for geese and swans, unlikely to occur in this scenario. The validity of this link is unknown for ducks, given their lesser responses to disturbance and given the small numbers likely to contact oil. This link is **invalid for raptors** (not hunted).

CONCLUSIONS

Table 4-3 summarizes the workshop group's evaluation of the validity of the impact hypothesis for the "river spill in spring" scenario as applied to each of the valued groups of birds that were considered. These evaluations are described in more detail below.

TABLE 4-3
VALIDITY OF HYPOTHESIS C-8

	Hypothesis Validity		Significance Class using the Duval and Vonk (1991) method (ref. to Figures 4-13 and 4-14)	
Bird Group	Reduced Numbers	Reduced Harvest	VEC	VSC
Dabbling Ducks	Valid (few)	Invalid	3-Insignificant	-
Geese (Snow, Canada, White-fronted)	Invalid	Valid	-	3-Insignificant
Tundra Swans	Invalid	Unknown	-	Unknown
Raptors	Valid	Invalid (not harvested)	2-Significant or 3-Insignificant for Peregrine 3-Insignificant for others	2-Significant or 3-Insignificant for Peregrine -

Dabbling Ducks

Duck Numbers: In the case of dabbling ducks, the generic impact hypothesis as applied to the "river spill in spring" scenario is ***valid*** with respect to the possibility of causing a reduction (probably small) in bird numbers. Oil release is likely to change the reproductive capacity and/or survival of at least a few individuals. Recovery of the population and habitat will occur, probably in the short term (less than one generation). Based on this, the impact would be judged **insignificant** by the method of Duval and Vonk (1991).

Duck Harvest: For dabbling ducks, there are many invalid and "valid but unlikely" links along the chains of linkages between "oil release" and "bird harvest". Thus, this hypothesis is of quite ***dubious validity*** with respect to causing reduced bird harvest unless this occurs as a result of a perception that ducks might be oiled, independent of any actual evidence of oiling (Link 2). If such an effect were perceived to have occurred, it would be a concern to the local population and regulators. This effect would not be permanent. Whether the perception of an effect would end within 1 year is unknown. However, any effects on harvest other than via the "perceived effect" linkage would be, at most, short term and thus **insignificant** by the Duval and Vonk method.

Geese and Swans

Goose and Swan Numbers: The hypothesis that the "river spill in spring" scenario would lead to reduced bird numbers is considered ***invalid***. These birds are not expected to be oiled. Although disturbance associated with oilspill response activities could affect the physiological condition of geese and swans (Link 12), this is not likely to have a significant effect on bird numbers. The disturbance would be minor because of the distance between the spill (east side of Mackenzie River) and the waterfowl concentration area (island on central and western side of river). The lower sensitivity of snow geese to aircraft disturbance in spring relative to autumn (Boothroyd 1985, 1986) is an important consideration in drawing this conclusion.

Goose Harvest: This hypothesis is considered ***valid*** with respect to effects on goose harvest. Spill response activities might exert sufficient disturbance influence on geese at Windy Island to reduce numbers of geese there (Link 13). This is likely even though it is unlikely that disturbance would affect physiological condition sufficiently to reduce bird numbers (Links 12, 19, 20). This effect on harvest is likely to result in concern among local people and regulators. The reduction in harvest would not be permanent, and should last no more than one year. Thus, the effect would be **insignificant** according to the method of Duval and Vonk (1991).

Swan Harvest: The validity of this hypothesis in relation to swan harvest is ***unknown*** because of insufficient information about swan harvest and swan sensitivity to disturbance in spring.

Raptors

Raptor Numbers: The hypothesis that the "river spill in spring" could reduce raptor numbers is ***valid***. Oil exposure via contact with oiled habitat (e.g. Bald Eagles) or oiled prey could lead to direct mortality or reproductive declines. Disturbance associated with the spill response could cause reduced reproductive capacity or nest abandonment. These effects could lead to reduced raptor numbers. Recovery would occur. This would be within one generation for most raptor species. However, it is possible that a Peregrine Falcon nest site might not be re-occupied within one Peregrine generation. For an endangered species like the Peregrine, prolonged vacancy of even a single nest site would be **significant**.

Raptor Harvest: Raptors are not harvested, so the hypothesis is ***not valid*** in relation to oil effects on bird harvest. However, the Peregrine may be considered a valued social component for reasons other than harvest. If so, it would be one of the VSCs on which the hypothesized spill could have an impact. As noted above, this impact could be classed as either **significant or insignificant**, depending on how long the local population might require to recover (Table 4-3).

RECOMMENDED RESEARCH AND MONITORING

Pre-spill

Pre-spill research specifically related to this "river spill in spring" scenario was judged to be a relatively low priority. The low priority is a result of the low numbers of birds likely to be affected and the "insignificant" nature of most predicted effects. Although the low priority was recognized, the workshop identified several information needs during consideration of this hypothesis:

1. Better understanding of oil fate under river ice, at least initially based on review of existing information and of ongoing studies. Of particular concern are oil/particle interactions in the river and the possibility that oil would surface through the ice in the days before breakup. These types of information would assist in predicting the likelihood, degree and circumstances of exposure of birds, their habitats and their foods to oil from a river spill under ice (Links 1, 3, 9, 10 and many other links that depend on those ones).

2. More information about waterbird harvests in the Fort Norman area. It is assumed that a harvest study may be done as part of the land claims settlement process, and that such studies are not part of BREAM *per se*.

3. More information about potential oil effects on raptors, at least initially based on review of existing information and of ongoing studies. At the time of the BREAM workshop, no detailed data were available on the Bald Eagle deaths that have been attributed to the *Exxon Valdez* spill.

4. More information about aspects of oil uptake by birds. This is a generic information need, relevant to any spill scenario where significant numbers of birds could be oiled. This point is discussed in detail under Hypothesis C-11,

Recommended Research, Item 1.

Post-Spill

Several types of post-spill bird monitoring should be initiated immediately after any spill in which a significant number of birds might be affected. This would include a "river spill in spring". This generic recommendation is discussed under Hypothesis C-11, Recommended Research, Item 3. Observations of the foraging behavior of raptors in and near oil-contaminated areas should be included.

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4.4.7 BREAM HYPOTHESIS C-9: Effects of a Diesel Spill on the Mackenzie River from a Barge on the number and harvests of birds

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INTRODUCTION

Oil Spill Scenario

This hypothesis addresses the effects on birds of a spill of 300 T (2300 barrels) of diesel fuel as a result of a barge accident in the Mackenzie Delta during summer. The spill was assumed to occur in the East Channel near Lousy Point, just upstream of Kittigazuit Bay. A portion of the spilled fuel was assumed to move as far as Kittigazuit Bay, resulting in an intermittent surface sheen and sporadic oiling of mainland and island shores. (Initially the spill had been postulated to occur farther upstream, at Lower Island. However, if the diesel fuel spill occurred that far upstream, the spill would not be expected to reach the locations where many birds concentrate. Hence, the postulated spill was moved downstream to provide a more useful scenario to evaluate.) Even with a spill as far downstream as Lousy Point, little if any diesel fuel would be expected to reach beyond Kittigazuit Bay to Hendrickson Island, Kidluit Bay or Mason Bay, which are portions of Kugmallit Bay where various birds tend to concentrate in mid-summer (Alexander *et al.* 1988:73).

This spill was assumed to disperse rapidly. Little diesel fuel would be detectable 3 days after the spill or more than about 105 km downstream of the spill. Because of the rapid dissipation of such a spill, it was assumed that cleanup measures would be limited. There would be aerial reconnaissance in an attempt to locate the spilled fuel. However, the fuel would presumably disperse and evaporate before cleanup gear could be moved into place.

Valued Ecosystem and Valued Social Components (VECs and VSCs)

Relatively few birds concentrate in the area that might be affected by the spill, even after the postulated spill site was moved downstream to Lousy Point. For purposes of evaluation, the following were identified as the valued species or groups occurring in significant numbers in the area:

- ***"Terrestrial" geese (Snow, Canada and White-fronted Geese):*** Occur mostly on "uplands", but occasionally near edge of river; low probability of contact with the spilled oil, except if a storm tide moves oil-contaminated water onto uplands. Snow Geese are hunted in the general area during the late summer-autumn period.

- ***Tundra Swan:*** Mostly on ponds on "uplands"; some in areas that could be inundated by storm tides. Because the potential for exposure of swans to the diesel spill was similar to that for "terrestrial geese", these two groups were evaluated together.

- ***Brant:*** A species of goose that tends to occur along or near marine shorelines; more likely than other geese to contact the diesel spill.

- ***Red-throated Loon:*** A few swim and dive in search of fish in river channels during summer.

For reviews of the distribution and habits of these species in the area, see Alexander *et al.* (1988) and Johnson and Herter (1989). Dickson (1992) gives detailed information on the Red-throated Loon in the general area.

Ducks were not considered in this scenario because relatively few occur in waters susceptible to the present type of spill. (Under this scenario, little or no diesel fuel would be expected to reach Kidluit and Mason Bays, where some ducks congregate to moult.) Sea ducks are considered under Hypothesis C-11 (offshore spill), where far more ducks could be affected. Dabbling ducks are considered under Hypothesis C-8 (river spill in spring).

Shorebirds and raptors were not considered in this scenario because relatively few would be affected. (Under this scenario, little or no diesel fuel would be expected to reach Hendrickson Island, where some shorebirds congregate: Alexander *et al.* 1988:73). Phalaropes (a subset of the shorebirds) are considered under Hypothesis C-11 (offshore spill). Raptors are considered under Hypothesis C-8 (river spill in spring).

Linkages

As discussed under Hypothesis C-8, a generic "oil vs. birds" linkage diagram was developed and used for all such scenarios (Figure 4-21). Link 1 is scenario-specific. In this case it is as follows:

Link 1 — A barge spill of diesel fuel in the Mackenzie Delta in summer, as described in this scenario, will cause diesel fuel to be present in parts of East Channel and Kittigazuit Bay for a few days during summer.

All 20 of the subsequent links in the generic "oil vs. birds" hypothesis are common to all scenarios. Most of the linkages can be categorized into three major chains of linkages, with some cross-links between chains:

- Links based on direct oiling of birds
- Links based on spill response program and related disturbance
- Links based on habitat degradation and oil ingestion

The wording of each individual link is given in the next section.

EVALUATION OF LINKAGES

Given the large number of linkages and the several groups of birds recognized as VECs and VSCs, we discuss the linkages in groups whenever possible. Table 4-4 summarizes, for each VEC/VSC and linkage, the workshop's evaluation of the

- validity of the link,
- confidence that can be placed in that assessment of validity, and
- probability that the link will occur in the stated scenario.

Link 1 **A barge spill of diesel fuel in the Mackenzie Delta in summer, as described in this scenario, will cause diesel fuel to be present in parts of East Channel and Kittigazuit Bay for a few days during summer.**

This "scenario specific" link was assumed to be **valid**. It is unlikely that diesel fuel would reach the areas where most "terrestrial" geese and Tundra Swans concentrate. However, small proportions of the birds of these groups, and larger proportions of the Brant and the Red-throated Loons in the area would be likely to encounter oil.

TABLE 4-4
EVALUATION OF LINKAGES FOR HYPOTHESIS C-9

	Terrestrial Geese and Swans			Brant			Red-throated Loons		
Link	Valid?	Confid?	Likely?	Valid?	Confid?	Likely?	Valid?	Confid?	Likely?
1	Valid	High	Certain	Valid	High	Certain	Valid	High	Certain
2	Valid	High	Likely	Valid	High	Likely	Invalid*	High	-
3	Valid	High	Variable**	Valid	High	Likely	Valid	High	Likely
4	Valid	High	Not Likely	Valid	High	Not Likely	Invalid*	High	-
5	Valid	High	Variable**	Valid	Low	Likely	Valid	Low	Likely
6	Unknown	-	-	Unknown	-	-	Unknown	-	-
7	Invalid**	High	-	Invalid**	High	-	Invalid**	High	-
8	Valid	High	Variable	Valid	High	Likely	Valid	High	Likely
9	Valid	High	Likely	Valid	High	Likely	Valid	High	Likely
10	Invalid	High	-	Valid	High	Not Likely	Invalid	High	-
11	Valid	High	Likely	Valid	High	Likely	Valid	High	Likely
12	Valid	High	Likely	Valid	High	Likely	Invalid	High	-
13	Valid	High	Likely	Valid	High	Likely	Invalid*	High	-
14	Valid	High	Not Likely	Valid	High	Likely	Valid	High	Likely
15	Valid	High	Not Likely	Valid	High	Likely	Valid	High	Likely
16	Unknown	-	-	Unknown	-	-	Unknown	-	-
17	Valid	High	Not Likely	Valid	High	Not Likely	Invalid*	High	-
18	Valid	Low	Not Likely	Valid	Low	Likely	Valid	High	Likely
19	Valid	Low	Not Likely	Valid	Low	Not Likely	Valid	Low	Not Likely
20	Invalid**	High	-	Invalid**	High	-	Invalid**	High	-
21	Invalid	High	-	Invalid	High	-	Invalid*	High	-

* Invalid because this species is not harvested

** Invalid because spill occurs after breeding, and unlikely to have an effect on next year's breeding

Link 2 **Presence of oil in the environment will result in reduction of traditional harvests of birds because of the possibility or perception that birds might be oiled or tainted.**

This link was considered **valid for geese** (including Brant), which are hunted. This link was considered **invalid for Red-throated Loons**, which are rarely if ever hunted.

Links Based on Direct Oiling of Birds

Link 3 **Presence of oil in the environment will result in direct oiling of birds.**

This link was considered **valid** for all of the valued species and groups under consideration. Direct oiling would be more likely for Brant and Red-throated Loons than for the more terrestrial species (Canada Geese, White-fronted Geese, and especially Snow Geese and Tundra Swans).

Link 4 **Ingestion of oil by birds while preening oiled plumage will result in changes in their palatability and a reduced harvest of birds.**

This was considered to be a **valid link for the hunted species** (geese and swans), as discussed under Hypothesis C-8. However, the group considered it unlikely that a hunter in the Beaufort Sea region would actually encounter an unpalatable bird, and that the harvest would subsequently be reduced. (Note: The workshop did not consider the harvest in southern areas.) This link is **invalid for loons** because they are rarely hunted.

Link 5 **Direct oiling of birds' feathers will result in bird mortality and reduced bird numbers via loss of buoyancy and hypothermia.**

There is abundant evidence that this link is **valid** for any birds that are coated by a significant amount of oil. Some geese, swans and loons could be oiled and killed via this mechanism under the present scenario. The numbers of birds that would be killed in this way are unknown but probably low for Snow Geese and swans.

Link 6 **Direct oiling of birds' feathers will result in bird mortality and reduced bird numbers via ingestion of lethal doses of oil during preening.**

This link is of **unknown** validity for all valued groups of birds under consideration, for the reasons discussed under Hypothesis C-8.

Link 7 **Birds with non-lethal doses of oil on their feathers will transfer oil to their eggs, which will kill or deform embryos and thereby reduce hatching success.**

This link is considered **invalid** for all valued groups of birds under consideration. This scenario is set in summer, after the period when the birds are incubating eggs. Oiled birds that survived until the next breeding season would have moulted their oiled plumage in the interim.

Link 8 **Birds with non-lethal doses of oil on their feathers will ingest non-lethal doses of oil during preening, which will affect their physiological condition.**

This link is considered **valid** for all valued groups of birds under consideration. Contact with oil (and thus ingestion of oil during preening) is probably less likely for Snow Geese and Tundra Swans than for Canada and White-fronted Geese. Oil contact and ingestion is especially likely for Brant and loons.

Links Based on Spill Response Program and Related Disturbance

Link 9 **Presence of oil in the environment will trigger industry- and government-sponsored oil spill response plans.**

This link was considered **valid** for all valued groups of birds under consideration. As discussed above under "Oil Spill Scenario", it is unlikely that the diesel spill would persist long enough to allow a meaningful containment and cleanup program. However, it is inevitable that aerial reconnaissance would take place, and it is probable that containment and cleanup operations would be triggered even if they could not be implemented in time to be effective.

Link 10 **Oil spill cleanup activities involving crews and equipment in coastal and terrestrial areas will cause degradation of bird habitats.**

This link is considered **valid** (but unlikely) for Brant, which concentrate in shoreline areas. It is possible that cleanup operations might be initiated there, and that these might cause shoreline degradation. This link is considered **invalid** for "terrestrial" geese and swans, and for Red-throated Loons. It is unlikely that on-the-ground cleanup operations would be needed or attempted in inland habitats. Any spill containment operations that might be attempted in the open waters where loons forage would cause no long-lasting degradation of their habitat.

Link 11 **Oil spill response (spill cleanup and/or bird deterrence) will involve intensive activity, noise, and disturbance to feeding, resting, nesting, migrating, and/or brood-rearing birds.**

Link 12 **Activity, noise and disturbance associated with oil spill response activities will cause birds to be stressed and will result in non-lethal effects on their physiological condition.**

Link 13 **Activity, noise and disturbance associated with oil spill response activities will cause birds to be disturbed and displaced, and will result in a reduced harvest of birds.**

Links 11, 12 and 13 are **valid** for "terrestrial" geese, Tundra Swans, and Brant. Aerial reconnaissance and any shoreline-cleanup operations that might be triggered will result in aircraft disturbance, and possibly other types of human disturbance, to geese and swans (Link 11). Snow Geese, in particular, are very sensitive to aircraft disturbance during late summer and autumn (Davis and Wiseley 1974; Salter and Davis 1974). Aircraft and other disturbance near shorelines is expected to cause some waterfowl to leave these areas, which will result in some energetic cost, probably very limited (Link 12) and a potential reduction in harvest (Link 13).

Link 11 is considered **valid for loons.** However, loons do not seem as disturbed by aircraft overflights as are geese. They are not expected to be stressed, so Link 12 is considered **invalid**. They are not hunted, so Link 13 is **invalid**.

Links Based on Habitat Degradation and Oil Ingestion

Link 14 **Presence of spilled oil will lead to degradation of bird habitats (e.g. water surface, benthic communities, shorelines, adjacent terrestrial wetlands), including oil contamination of plant and animal foods of birds.**

Link 15 **Degradation of bird habitats through oiling, and contamination of plant and animal foods of birds through oiling, will result in ingestion of oil-contaminated foods by birds.**

Link 16 **Ingestion of oil-contaminated food by birds will have lethal effects that will reduce bird numbers.**

For each of the valued groups of birds under consideration, Links 14 and 15 are considered **valid**, and the validity of Link 16 is considered **unknown**. In each case, bird habitats and foods could be oiled, and oil-contaminated food could be ingested (Links 14 and 15). This is most likely for Brant concentrating and feeding along coasts, and least likely for other geese and Tundra Swans feeding on land.

The validity of Link 16 is **unknown** because it is not known whether birds could eat enough contaminated food to obtain a lethal dose of diesel fuel. Some species of waterbirds can consume considerable oil without dying. Of the groups considered here, Brant probably have the potential for consuming the largest amount of diesel fuel with their food.

Link 17 **Ingestion of non-lethal amounts of oil-contaminated food by birds will result in changes in their palatability and a reduced harvest of birds.**

This link is **valid** but unlikely for geese and swans. Only a low proportion of the "terrestrial" geese and swans are likely to be affected. A higher proportion of Brant might be affected, but few Brant are harvested. This link is **invalid for loons** because they are not harvested.

Link 18 **Ingestion of non-lethal amounts of oil-contaminated food will affect birds' physiological condition, including growth and development of young-of-the-year.**

Link 19 **Non-lethal effects on the physiological condition of birds will cause declines in their reproductive output.**

Link 20 **Reproductive declines in birds will result in reduced bird numbers.**

Links 18 and 19 are **valid** for all valued bird groups under consideration. However, link 18 is unlikely for terrestrial geese and swans, given that little diesel fuel is likely to be carried onto the terrestrial vegetation that forms most of their food. Link 19, although **valid**, is unlikely for all groups. The postulated spill is after the breeding season. It is not likely that physiological effects would be severe enough to impair reproductive output during the following year.

Link 20 is considered **invalid** for all valued bird groups under consideration. The two linkages that might cause reproductive declines are either invalid (Link 7) or unlikely (Link 19).

Link 21 **Reduced bird numbers will result in reduced harvest of birds.**

This link is also considered **invalid** for all valued bird groups under consideration. Not enough terrestrial geese (or swans) would be killed by any plausible diesel spill to result in a significant reduction in harvest. The Brant harvest in the Canadian Beaufort region is variable and small; any reduction due to reduced Brant numbers would not be distinguishable from natural variability. Loons are not harvested.

CONCLUSIONS

Table 4-5 summarizes the workshop group's evaluation of the validity of the impact hypothesis for the "diesel spill in Mackenzie Delta in summer" scenario as applied to each of the valued groups of birds. These evaluations are described in more detail below.

TABLE 4-5
VALIDITY OF HYPOTHESIS C-9

	Hypothesis Validity		Significance Class using the Duval and Vonk (1991) method (ref. to Figures 4-13 and 4-14)	
Bird Group	Reduced Numbers	Reduced Harvest	VEC	VSC
"Terrestrial" Geese (Snow, Canada, Wh-fr.) plus Tundra Swans	Valid, but not likely for Snow Geese	Valid	3-Insignificant	3-Insignificant
Brant	Valid	Valid, but not likely	2-Significant or 3-Insignificant	2-Significant or 3-Insignificant
Red-throated Loons	Valid	Invalid because not harvested	3-Insignificant	-

Snow, Canada and White-fronted Geese; Tundra Swans

Numbers: The generic "oil vs. birds" impact hypothesis, as applied to the "diesel spill in Mackenzie Delta in summer" scenario, is ***valid*** with respect to causing a reduction (probably small) in numbers of these waterfowl. Some birds could be killed by oiling (via Links 1, 3 and 5). However, the risk of this, and the proportion of the local population that might be killed, are low because it is unlikely that much diesel fuel would be carried into the terrestrial areas where these waterfowl spend most of their time in summer. Recovery of the populations and their habitats will occur within one generation. Based on this, the impact would be judged "**Insignificant**" by the method of Duval and Vonk (1991).

Harvest: The hypothesis is also ***valid*** with respect to causing reduced goose (and swan) harvests. Reduced waterfowl numbers (via the links just noted) could lead directly to reduced harvest. Reduced harvest could also occur for other reasons: because of a perception that the waterfowl might be oiled, i.e. Link 2; or because of disturbance caused by aerial reconnaissance or (less likely) spill response activities, i.e. Link 13. This reduction in harvest would be perceived as a concern, but it would not be permanent. Recovery is expected to occur within a year. Therefore, the impact would be judged "**Insignificant**" by the Duval and Vonk method.

Brant

Brant Numbers: The hypothesis is also ***valid*** with respect to a reduction in Brant numbers. Mortality by oiling (Links 1, 3 and 5) could involve a larger proportion of the population than is likely for the more "terrestrial" species of waterfowl. The number that might be killed is unpredictable; it would depend on the number of migrating Brant that happen to stop in the spill area during the critical time. Brant are not abundant in the western Canadian Arctic, and they are subject to heavy hunting pressure when they migrate south. Although recovery of the population in the western Canadian Arctic is expected, this might not be within one generation in the unlikely event that the numbers killed by the diesel fuel were large. Thus, the impact could be either "**Significant**" (Class 2, unlikely) or "**Insignificant**" (Class 3, more likely) according to the Duval and Vonk method. This impact is potentially mitigatable through use of bird scaring measures (Koski *et al.* 1993). These could be used to keep Brant away from oil-contaminated areas.

Brant Harvest: The hypothesis is also ***valid*** with respect to causing reduced Brant harvests. Reduced numbers (via the links just noted) could lead directly to reduced harvest. Reduced harvest could also occur for other reasons: because of a perception that Brant might be oiled, i.e. Link 2; or because of disturbance caused by aerial reconnaissance or (less likely) spill response activities, i.e. Link 13. This reduction in harvest would be perceived as a concern. Recovery is expected; it likely would be within one year, but might not be, depending on the severity of impact. Thus, this impact could also be either "**Significant**" (Class 2, unlikely) or "**Insignificant**" (Class 3, more likely) by the Duval and Vonk method. Bird scaring measures could be used to mitigate the long-term effect, but they might further disrupt the harvest during the year of the spill.

Red-throated Loons

Loon Numbers: The hypothesis is ***valid*** with respect to a reduction in Red-throated Loon numbers. Mortality by oiling (Links 1, 3 and 5) could affect a small number of loons that feed on the potentially oiled part of the Mackenzie River. It is unlikely that many loons would be killed, given the postulated small size and brief duration of this spill, and the low density of loons feeding on the river. Recovery of the population would occur, probably within a generation. Hence the impact would be judged "**Insignificant**" (Class 3) by the Duval and Vonk criteria.

Loon Harvest: Loons are not regularly harvested, so the hypothesis is ***not valid*** in relation to oil effects on bird harvest.

RECOMMENDED RESEARCH AND MONITORING

Pre-Spill

1. The highest-priority research identified by the workshop in relation to this scenario was to determine the stopover and turnover patterns of Brant geese migrating along the Beaufort Sea coast in late summer. Do significant proportions of the Canadian Beaufort population stop in any one coastal or offshore area that might be oiled? When flocks of Brant are seen in a particular area for prolonged periods, are the same birds present throughout, or is there rapid turnover such that the total numbers using the area far exceed the number present at any one time? This information is also needed in relation to offshore spill scenarios that might result in oiling of the Beaufort Sea coast (see Hypothesis C-11, Recommended Research, Item 4).

2. Information is needed about various aspects of oil uptake by birds. This is a generic information need, relevant to any spill scenario where significant numbers of birds could be oiled. This point is discussed in detail under Hypothesis C-11, Recommended Research, Item 1.

3. Better information about bird use of East Channel, the main barge channel through the Mackenzie Delta, would also be helpful in predicting impacts. However, this is not a high priority, given the rather small numbers of waterbirds believed to occur on this part of the river, and the fact that barge spills would be small in comparison to some potential offshore spills.

Post-Spill

Several types of post-spill bird monitoring should be initiated immediately after any spill in which a significant number of birds might be affected. This would include a diesel fuel spill in summer. This generic recommendation is discussed under Hypothesis C-11, Recommended Research, item 3. Observations of the foraging behavior of geese in oil-contaminated areas should be included.

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4.4.8 BREAM HYPOTHESIS C-11: Effects of an Offshore Platform Blowout on Bird Numbers and Harvest

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INTRODUCTION

Oil Spill Scenario

During the open water season, while drilling a well from an artificial island at 69°39'N, 136°00'W, a blowout occurs due to failure of the blowout preventer. The blowout flows at the rate of 12,900 bbl/day (2050 m3/d) of Adgo crude oil plus 277,000 m^3/d of natural gas. The blowout continues for six days. Gas exiting from the drill pipe at 340 m/s shatters the oil into droplets with mean diameter 175 μm, and shoots them to a height of 30 m above sea level. They rain out onto the sea downwind of the artificial island in a slick that is initially 750 μm thick and 100 m wide. While in the air, the oil droplets lose 18% of their volume to evaporation, and cool to ambient temperature.

For purposes of considering potential impacts on a variety of types of birds, a variety of alternative wind directions are considered, e.g.

- N to NE winds, moving oil toward the Yukon coast and impacting coastal birds; vs.
- SE or S winds, moving oil alongshore or offshore and impacting birds offshore.

In any case, wind direction is assumed to remain within a 45° sector for the six day period. It is also assumed that wind speed averages 5.5 m/s during the 6-day blowout, and the air and sea temperatures are both 6°C.

The oil slick drifts away from the island in a generally downwind direction at 0.25 m/s. As it drifts slowly away, it spreads, thins, evaporates, emulsifies and naturally disperses. Once a portion of the slick has drifted a few kilometres, it breaks into patches of thicker emulsified oil surrounded by sheen. This further breaks up into thick patches of heavily-weathered emulsion (mousse) surrounded by sheen and uncontaminated water. If the slick does not contact land, 99% of it would dissipate by evaporation and natural dispersion in just over 200 km.

With N to NE winds, oil would come ashore on the western part of the outer Mackenzie Delta and on the eastern part of the Yukon coasts. Distances from the hypothesized spill site to some of the closest points of land are as follows: 43 km SSE to Pelly Island; 70 km SE of Richards Isl.; 120 km SSW to Yukon coast. Assuming that, over the 6-d event, the wind blows at 5.5 m/s from the north for 2.5 d and from the NE for 3.5 d, about 56,000 bbl of emulsion (75% water) might be stranded on the outer Delta between Whitefish Station and Avoknar Channel, and another 60,000 bbl of emulsion (75% water) along the Yukon coast between Kay Point and Whitefish station. These figures are based on the following estimates:

- Over the 6-d blowout period, 77,400 bbl of oil would be released and 19,400 bbl of this would evaporate.
- It is assumed that 25,000 bbl are recovered by cleanup measures (about 32% recovered). The Beaufort Sea Co-op's Response Barge is assumed to be deployed and operating down-drift of the blowout within 24 h of the event. The 25,000 bbl estimate takes account of the physical capabilities and limitations of this equipment, and the assumed properties of the slick.

- With N-NE winds, 4000 bbl would disperse naturally in the water column and 29,000 bbl would move onto shore in the form of 116,000 bbl of emulsion.

With northerly winds, most oil-water emulsion is expected to strand along the shoreline. However, if a storm surge coincided with the spill, emulsion could be carried inland in certain low-lying areas by as much as several kilometres (Henry and Heaps 1976; Harper *et al.* 1988). Thus, emulsion could be left in scattered patches over hundreds of square kilometres of coastal tundra, including the tundra itself and in ponds within that area.

Valued Ecosystem and Valued Social Components (VECs and VSCs)

A total of eight species or species-groups of valued birds were identified for consideration in this scenario. These included two groups that occur mainly in "terrestrial" areas: Tundra Swans plus the "terrestrial" geese (Snow, Canada and White-fronted Geese). The other six species or species-groups are largely coastal or marine birds, or are birds that are most vulnerable to an offshore spill during parts of the late summer or early autumn when they concentrate in marine waters: loons, Brant, eider ducks (Common and King Eiders), other ducks, alcids (Black Guillemots and Thick-billed Murres), and shorebirds (especially phalaropes). The seasonal distributions of these birds are summarized in Alexander *et al.* (1988, 1991). Johnson and Herter (1989) summarize the life history of each species, including the seasonal activity patterns and habitat dependencies.

As noted above, the groups used a "flexible" description of the wind conditions prevailing during the spill scenario, so as to allow a meaningful evaluation of potential effects on a variety of valued species. For similar reasons, we also provided for a flexible blowout date within the mid-summer through early fall period of open water. With SE or S winds, effects on birds in offshore waters could be substantial, but there would be little or no effect on birds near the shoreline. With northerly winds, coastal birds would be affected, along with marine birds in offshore waters south of the blowout site; however, there would be little or no effect on marine birds farther offshore. Our assessment for each valued bird group assumes that the spill occurs at the date and under wind conditions when that group would be most vulnerable. For any one wind condition and 6-day period, only the valued bird groups that are most vulnerable in that situation would suffer impacts as severe as those discussed below.

Linkages

As discussed under Hypothesis C-8, a generic "oil vs. birds" linkage diagram was developed and used for all "oil vs. birds" scenarios (Figure 4-21). Only Link 1 is scenario-specific. All 20 of the subsequent links in the generic "oil vs. birds" hypothesis are common to all scenarios. Most of the linkages can be categorized into three major chains of linkages, with some cross-links between chains:

- Links based on direct oiling of birds
- Links based on spill response program and related disturbance
- Links based on habitat degradation and oil ingestion

The wording of each individual link is given in the next section.

EVALUATION OF LINKAGES

Given the large number of linkages (21) and the eight species or species-groups of birds recognized as VECs and VSCs, we discuss the linkages and the species in groups whenever possible. Table 4-6 summarizes, for each of the 168 linkage vs. VEC/VSC combinations, the workshop's evaluation of the validity of the link. We do not attempt to tabulate the workshop participants' assessments of

- confidence in link validity and
- likelihood that the link will occur in the stated scenario.

Although these topics were addressed in the workshop, the 168 assessments of confidence and

TABLE 4-6
VALIDITY OF LINKAGES FOR HYPOTHESIS C-11

Link	Loons	"Terr." Geese	Tundra Swans	Shore Birds	Brant	Eiders	Other Ducks	Alcids
1	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
2	Invalid*	Valid	Valid	Invalid*	Valid	Distant**	Valid	Invalid*
3	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
4	Invalid*	Valid	Valid	Invalid*	Valid	Distant**	Valid	Invalid*
5	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
6	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
7	Invalid***	Invalid***	Invalid***	Invalid***	Invalid***	Invalid***	Invalid***	Invalid***
8	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
9	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
10	Invalid	Valid	Valid	Valid	Valid	Invalid	Valid	Invalid
11	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
12	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
13	Invalid*	Valid	Valid	Invalid*	Valid	Invalid	Valid	Invalid*
14	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
15	Valid	Valid	Valid	Valid	Valid	Unknown	Valid	Unknown
16	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
17	Invalid*	Valid	Valid	Invalid*	Valid	Distant**	Valid	Invalid*
18	Valid	Valid	Valid	Valid	Valid	Unknown	Valid	Unknown
19	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
20	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
21	Invalid*	Valid	Valid	Invalid*	Valid	Distant**	Valid	Invalid*

* Invalid because this species is not harvested
** Not valid locally, but might affect harvest elsewhere
*** Invalid because spill occurs after breeding, and is unlikely to have an effect on next year's breeding

the 168 assessments of likelihood were made in haste. They deserve re-consideration in any later review of this scenario. Validity judgements that were recognized as especially uncertain or unlikely are mentioned in the following text.

Link 1 **A platform blowout off the Mackenzie Delta in summer, as described in this scenario, will cause crude oil to be present in parts of the southeastern Beaufort Sea and (if winds are northerly) on the outer coast of the Yukon and Mackenzie Delta. If a storm surge occurred during the spill, it could carry patches of oil-water emulsion as much as several kilometres inland onto low-lying tundra and ponds.**

This "scenario specific" link was assumed to be **valid.** It is unlikely that crude oil would reach the areas where most "terrestrial" geese and Tundra Swans concentrate. However, significant numbers of the birds in these groups could encounter oil if a storm surge occurred during the spill, and the small numbers of these species occurring near the shore might encounter oil even without a surge. Larger proportions of the local populations of the other six valued bird groups (those that are at least sometimes in marine waters) would be likely to encounter oil. The relative impacts on different bird groups would depend on wind direction, spill date, and other variables.

Link 2 **Presence of oil in the environment will result in reduction of traditional harvests of birds because of the possibility or perception that birds might be oiled or tainted.**

This link was considered **valid for ducks, geese and swans**, which are hunted. This link is **invalid for loons, shorebirds and alcids**, which are rarely or never hunted. The eider ducks are a special case. They are not hunted during the summer or early autumn in the western Canadian Arctic. However, they are hunted after they migrate into northern Alaska, and again in parts of the western Canadian Arctic during the spring. Thus, it is possible that there could be a perception of tainting of eiders at a distant location or time.

Links Based on Direct Oiling of Birds

Link 3 **Presence of oil in the environment will result in direct oiling of birds.**

This link is **valid** for all eight of the valued species and groups under consideration. Direct oiling would be less likely for the "terrestrial" species of waterfowl (Snow, Canada and White-fronted Geese; Tundra Swans) than for the other six valued groups, which occur in marine waters during at least part of the open water season.

Link 4 **Ingestion of oil by birds while preening oiled plumage will result in changes in their palatability and a reduced harvest of birds.**

This was considered to be a **valid link for the hunted species** (ducks, geese and swans). This link is **invalid for loons, shorebirds and alcids** because they are not hunted to a significant degree (if at all). As noted under Link 2, eider ducks are a special case, in that hunting and potential palatability problems occur at distant locations or times.

Birds preen their plumage when it is fouled. It is likely that some waterfowl would contact sufficient oil to foul parts of the plumage but not enough to be lethal. If such a bird were taken by a hunter, it would likely be judged to be unpalatable based either on its appearance or on its taste. As a result, hunters would probably reduce their harvesting effort in the area where the oil-contaminated bird was taken. Thus, Link 4 was considered **valid for waterfowl**. However, the number of birds likely to be affected under the present scenario would be highly variable, depending on date, wind direction and other factors. This would be a more important link if the wind blew oil to shore than if the oil remained well offshore. Also, it is not known how much oil must be ingested for the flesh to become noticeably tainted. Thus, the likelihood of occurrence of this link under this scenario was judged to be unknown for all hunted groups. (Note: The workshop recognized but did not further consider the harvest of waterfowl in southern areas.)

Link 5 **Direct oiling of birds' feathers will result in bird mortality and reduced bird numbers via loss of buoyancy and hypothermia.**

There is abundant evidence that this link is **valid** for any birds that are coated by a significant amount of oil. Some birds of all eight valued groups could be oiled and killed via this mechanism under the present scenario. Except in the event of a storm surge during the blowout, the proportions of regional populations that would be killed by oiling are likely to be lower for "terrestrial" geese and Tundra Swans than for the other groups. However, mortality of all groups would depend strongly on the particular circumstances of the spill, including date and wind conditions.

Link 6 **Direct oiling of birds' feathers will result in bird mortality and reduced bird numbers via ingestion of lethal doses of oil during preening.**

All eight of the valued bird groups are potentially subject to oiling under this scenario. However, this link is of **unknown** validity for all of these valued groups of birds. During previous field studies, it has not been possible to separate toxicity effects (this link) from buoyancy and hypothermia effects (Link 5). For further discussion, see Hypothesis C-8, Link 6.

Link 7 **Birds with non-lethal doses of oil on their feathers will transfer oil to their eggs, which will kill or deform embryos and thereby reduce hatching success.**

This link is **invalid**, or at least probably invalid, for all valued groups of birds under consideration. This scenario is set in summer, after most birds are finished incubating eggs. Oiled birds that survived until the next breeding season would have moulted their oiled plumage in the interim, so there would be no carry-over effect of this type in the next year. If the spill occurred as early as July, some birds whose first nests had failed might be renesting. However, late broods of waterbirds are unlikely to fledge even without an oil spill.

Link 8 **Birds with non-lethal doses of oil on their feathers will ingest non-lethal doses of oil during preening, which will affect their physiological condition.**

This link is **valid** for all valued groups of birds under consideration. Except in a storm-surge situation, contact with oil (and thus ingestion of oil during preening) is probably less likely for "terrestrial" geese and Tundra Swans than for the more marine groups.

Links Based on Spill Response Program and Related Disturbance

Link 9 **Presence of oil in the environment will trigger industry- and government-sponsored oil spill response plans.**

Link 10 **Oil spill cleanup activities involving crews and equipment in coastal and terrestrial areas will cause degradation of bird habitats.**

Link 9 is **valid**. Link 10 is **valid** for birds that depend on the shoreline, adjacent nearshore waters, and adjacent coastal lowlands seaward of the inland extent of storm surges. Of the valued groups of waterbirds considered here, the only ones for which Link 10 likely would be largely **invalid** are loons, eiders and alcids:

- Few loons nest seaward of the storm-tide line.
- The only eiders that might be affected would be the few that nest along the affected coast. (The vast majority of the eiders that occur in the area are migrants from breeding areas farther east. These migrants do not depend on coastal and terrestrial areas in the spill impact zone.)
- Of the two alcid species in the area, Thick-billed Murres do not occur in coastal or terrestrial areas of the spill impact zone. Black Guillemots nesting at Herschel Island fly out to marine waters to feed.

Link 11 **Oil spill response (spill cleanup and/or bird deterrence) will involve intensive activity, noise, and disturbance to feeding, resting, nesting, migrating, and/or brood-rearing birds.**

Link 12 **Activity, noise and disturbance associated with oil spill response activities will cause birds to be stressed and will result in non-lethal effects on their physiological condition.**

Link 11 is **potentially valid** for at least some species within all eight valued groups, depending on the circumstances of the spill.

Link 12 is **valid** for all eight of the valued groups, and for most of them it is likely to occur in at least some spill situations. The main exception would be eider ducks. Eiders fly west over the spill area in summer and autumn; exclusion from any one area as a result of disturbance is unlikely to have a significant physiological effect on eiders.

Thick-billed Murres swim west across the Beaufort Sea in autumn while migrating from their colony at Cape Parry toward western Alaskan waters. Some swimming murres might encounter cleanup or bird deterrent operations and be considerably stressed. However, a more immediate problem for any murres that approach cleanup operations would be the high likelihood of death from direct oiling (Link 5). Because murres are unable to fly during their autumn migration, they are extremely vulnerable to oiling at that time. Little is known about the location, width or variability of the autumn migration corridor of these murres, and this represents a significant gap in existing data on this species.

Link 13 **Activity, noise and disturbance associated with oil spill response activities will cause birds to be disturbed and displaced, and will result in a reduced harvest of birds.**

Link 13 is **valid for waterfowl that are hunted,** but not for loons, shorebirds or alcids. As noted under Links 2 and 4, eiders are not hunted as they travel west over the Canadian Beaufort Sea in summer, but are hunted elsewhere. Link 13, unlike Links 2 and 4, deals only with local effects. Because eiders are not hunted locally, Link 13 is **invalid for eiders.** For all other valued groups of waterfowl, the potential disturbance effect on harvest would be highly variable, depending on spill circumstances.

Links Based on Habitat Degradation and Oil Ingestion

Link 14 **Presence of spilled oil will lead to degradation of bird habitats (e.g. water surface, benthic communities, shorelines, adjacent terrestrial wetlands), including oil contamination of plant and animal foods of birds.**

Link 15 **Degradation of bird habitats through oiling, and contamination of plant and animal foods of birds through oiling, will result in ingestion of oil-contaminated foods by birds.**

Link 16 **Ingestion of oil-contaminated food by birds will have lethal effects that will reduce bird numbers.**

For each of the eight valued groups of birds under consideration, Link 14 is **valid**. Link 15 is **valid** for most groups, but its validity is **unknown** for eiders and murres. It is not known whether eiders consume much food while migrating through offshore waters in summer or fall. Even if they do, it is unlikely that their benthic food would be significantly contaminated. Thick-billed Murres swimming west through offshore waters no doubt feed, but their pelagic prey probably would not be significantly contaminated. (As noted above, murres engaged in a swimming migration through oil-contaminated areas would be far more likely to succumb to direct oiling.)

The validity of Link 16 is **unknown** because it is not known whether birds would eat enough contaminated food to obtain a lethal dose of crude oil. Some species of waterbirds can consume considerable oil without dying.

Link 17 **Ingestion of non-lethal amounts of oil-contaminated food by birds will result in changes in their palatability and a reduced harvest of birds.**

This link is **valid for the hunted waterfowl species**, but **invalid for the loons, shorebirds and alcids** (not hunted). As noted for Links 2 and 4, the situation for eiders is complicated by the fact that they are not hunted locally during summer and autumn, but are hunted at other seasons and locations. A reduced eider harvest attributable to oil-induced inpalatability is less likely for eiders than for other waterfowl, but it might occur in a distant hunting area.

Link 18 **Ingestion of non-lethal amounts of oil-contaminated food will affect birds' physiological condition, including growth and development of young-of-the-year.**

Link 19 **Non-lethal effects on the physiological condition of birds will cause declines in their reproductive output.**

Link 20 **Reproductive declines in birds will result in reduced bird numbers.**

Link 18 is **valid** for most valued bird groups under consideration. However, it's validity is **unknown** for eiders and murres, for reasons explained under Link 15.

Link 19 is **potentially valid** for all valued groups, in that all valued groups could be susceptible to oiling, and those not killed outright (Link 5) would ingest oil while preening the plumage (Link 8). In addition, most if not all groups could be subject to further reduction in physiological condition as a result of disturbance (Link 12) or consumption of oil-contaminated food (Link 18). However, the postulated spill is late in the breeding season or after breeding. If physiological effects began after breeding was completed, it is unknown whether reproductive output would be impaired during the following year. The murre is again a special case. Chicks are still dependent on their parents for food during the autumn swimming migration. An oil-related decline in physiological condition of the parent could make it incapable of rearing its chick.

Link 20, resulting in reduced bird numbers, is considered **potentially valid** for all valued bird groups under consideration, given the potential validity of Link 19. However, caveats similar to those discussed for Link 19 would apply here.

Link 21 Reduced bird numbers will result in reduced harvest of birds.

This link is considered **valid** for all valued waterfowl, but **invalid** for the groups that are not hunted (loons, shorebirds, alcids). However, the likelihood of a significant impact on local harvest is low for most of the hunted groups, for a variety of reasons.

CONCLUSIONS

Table 4-7 summarizes the workshop group's evaluation of the validity of the impact hypothesis for the offshore oil blowout scenario as applied to each of the valued groups of birds. These evaluations are summarized below.

Reduced Bird Numbers

It was concluded that the impact hypothesis was ***valid*** with respect to reduced numbers of all eight of the valued species or species-groups. In all eight cases, birds could be oiled to the degree that they would die from hypothermia and/or buoyancy problems (Links 1, 3 and 5). Other less direct chains of valid linkages could also lead to reduced numbers. In all cases, recovery of the population and its habitat is likely. However, the speed of recovery would depend greatly on the species and on the circumstances of the spill. Depending on the situation, recovery could occur in the short term, in the long term, or at an unknown rate. If the hypothesized spill occurred with the worst possible wind direction and at the worst possible date for each species, it is most likely that the effect on numbers of "terrestrial" geese and swans would persist for less than one generation, i.e. "**Insignificant** (Class 3)" by the criteria of Duval and Vonk (1991). However, the effect on numbers of marine species might in some cases persist for more than one generation, and thus be "**Significant** (Class 2)".

TABLE 4-5
VALIDITY OF HYPOTHESIS C-11

	Hypothesis Validity		Significance Class using the Duval and Vonk	(1991) method (ref. to Figures 4-13 and 4-14)
Bird Group	Reduced Numbers	Reduced Harvest	VEC	VSC
"Terrestrial" Geese	Valid	Valid	3-Insignificant	3-Insignificant
Tundra Swans	Valid	Valid	3-Insignificant	3-Insignificant
Loons	Valid	Invalid because not harvested	2-Significant	-
Brant	Valid	Valid	2-Significant	2-Significant
Eiders	Valid	Invalid locally Valid in distant areas	2-Significant 2-Significant	- 2-Significant
Other Ducks	Valid	Valid	2-Significant	2-Significant
Alcids	Valid	Invalid because not harvested	2-Significant	-
Shorebirds	Valid	Invalid because not harvested	2-Significant	-

Reduced Bird Harvest

It was concluded that the impact hypothesis was ***valid*** with respect to reduced harvest of the five valued species or groups that are harvested: "terrestrial" geese; Tundra Swans; Brant; eiders; and other ducks. The validity of the hypothesis for these groups is most obvious from the facts that

- members of each of these groups can be killed by oiling (Links 1, 3 and 5), and
- the resultant reduction in bird numbers could lead to a reduced harvest (Link 21).

However, other chains of valid linkages also lead to reduced harvest, e.g. as a result of the disturbance effects of the spill response program. Again, the severity of the effect on harvest would depend greatly on the species and spill circumstances, and could be "**Significant** (Class 2)", "**Insignificant** (Class 3)" or unknown according to the Duval and Vonk criteria.

The hypothesis was ***invalid*** with respect to reduced harvest of loons, shorebirds, and alcids, which are hunted rarely if at all.

RECOMMENDED RESEARCH AND MONITORING

An offshore spill is likely to affect far more birds than would either of the two types of river spill evaluated in Hypotheses C-8 and C-9. Hence, the most important research needs for birds relate either to the offshore spill or to generic questions relevant to any oil spill situation.

The following research priorities are identified by number for ease of reference. These numbers do not reflect any consensus about the relative priorities of the various recommendations. Of the pre-spill studies listed below, items (1), (2) and (4) are probably the most important short-term studies that could be done. Item (5), development of monitoring programs, is important but would be practical only if there were a long-term funding commitment. Item (3), post-spill studies, is a very high priority if a major spill occurs.

Generic Pre-Spill Research Relevant to All Scenarios

1. Literature review on aspects of oil uptake by birds: (a) To what degree do birds feed on, or avoid, oil-contaminated habitats (e.g. geese) or oil-contaminated prey (e.g. raptors)? (b) To what degree, and under what circumstances, is bird flesh tainted after oil ingestion? (c) Does oil ingested when birds preen oiled plumage or feed on oil-contaminated prey cause lethal physiological effects? In field conditions, are such effects likely to cause additional mortality beyond that which will occur due to the thermoregulatory and buoyancy problems associated with

external oiling? Research recommendations would be formulated based on the results of the literature review.

2. Conduct field tests of the effectiveness of selected bird scaring devices under Beaufort Sea conditions. A recent literature review and analysis (Koski *et al.* 1993) identifies (a) the most promising scaring techniques for various potential oil-spill situations in the Beaufort Sea, and (b) the techniques that hold promise but need specific field testing.

Generic Pre-Spill Research Relevant to All Scenarios

3. After any significant spill, the following types of field monitoring should be done where appropriate: (a) Apply systematic survey procedures to determine bird numbers before (if possible), during and after arrival of oil in those habitats that are used by many birds; estimate the numbers of birds affected, their short-term responses within the season, and long-term effects extending to subsequent years. (b) Monitor the effectiveness of bird scaring efforts. (c) Document the effects of the spill on hunting (i.e., are oiled or tainted birds taken, do hunters reduce their harvest or move to different areas?) **Note:** After an oil spill, it is common to apply mark/recovery methods to oiled carcasses in an attempt to estimate the proportion of dead birds that are found. This may be impractical after a spill in the Beaufort Sea because of the low population density.

Research Specifically Related to Hypothesis C-11

4. What are the stopover and turnover patterns of (a) Brant geese migrating along the Beaufort Sea coast and (b) eider ducks migrating offshore? Specifically, do significant proportions of the Canadian Beaufort populations stop in any one coastal or offshore area that might be oiled? When flocks of Brant are seen in a particular area for prolonged periods, are the same birds present throughout, or

is there rapid turnover such that the total numbers using the area far exceed the number present at any one time? (Note: This study would also be relevant to Hypothesis C-9.)

5. Develop effective monitoring programs for some of the valued bird species occurring in the Canadian Beaufort Sea, in addition to the loon monitoring program already in place (Dickson 1992). This would involve development and routine application of systematic field survey methods prior to any significant spill (e.g. Johnson and Gazey 1992).

6. The Thick-billed Murre colony at Cape Parry is the only murre colony in the Canadian western Arctic. These birds migrate west in late summer by swimming, not flying, and thus they may be especially susceptible to oil spills. There is little information about the location of their migration corridor, and about its degree of concentration in space and time. The latter will strongly affect the susceptibility of these murres to an oil spill. Because of the relatively small size of the Cape Parry colony, the migration of these birds would be very difficult to study directly. However, it could be instructive to examine existing aerial- and boat-survey data on spatial and temporal patterns of the swimming migration from the much larger colonies in the Canadian High Arctic.

Note: Site-specific bird harvest data are needed for locations where they are not already being collected and where oil spills are possible. A harvest study is already being done in the Inuvialuit region. Additional harvest studies are likely to be done as part of land-claims settlements. Thus, this task is not considered to be part of BREAM, but the results would be valuable in support of BREAM objectives.

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4.4.8 BREAM HYPOTHESES C-17 AND C-18: Effects of an Island Platform Blowout (C-17) and Diesel Spill (C-18) in a River on Fish and Fish Harvest

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INTRODUCTION

Two hypotheses dealing with the effects of crude oil and diesel fuel on fish were examined at the workshop. The hypotheses covered a broad range of potential pathways or mechanisms by which a spill of oil into or onto water might affect the harvest of fish. Although the hypotheses were geographically distinct, and dealt with different species of fish under different hydrological settings, and the behaviour and environmental fate of the two very different types of oil was expected to have effects of differing importance to fish, it was found that the mechanisms by which oil might affect fish harvest were similar. Figure 4-22 describes the commonality between the oil-effects on fish harvest that was presented during the workshop closing plenary session. This is presented here by way of introduction and as a guide to the workshop evaluation of these two hypotheses. The notations in the shaded boxes refer to the Sub-Hypotheses that evaluates the linkages in that particular "path".

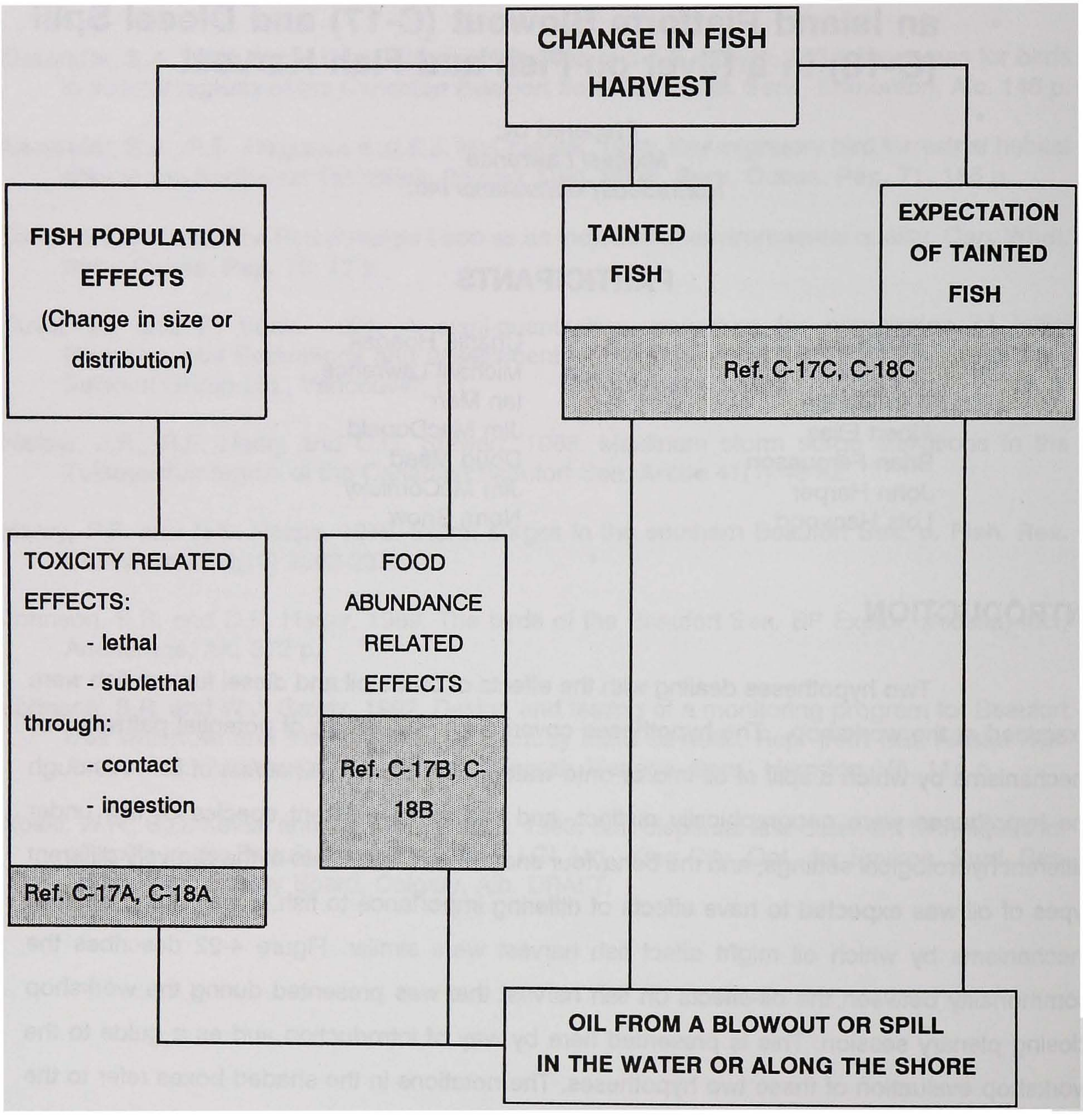

Figure 4-22: Pathways for Effects on Fish Harvest that may result from an Oil Spill or Blowout

The evaluation of the two hypotheses concerning oil, diesel fuel and fish, was performed by examining the various pathways of effects that were apparent in the hypothesis linkages. The original C-17 and C-18 hypotheses that were evaluated, were done so in their entirety. However, after the fact, and for purposes of a clearer understanding of the linkages involved and their importance, the hypotheses were broken out into sub-hypotheses, each sub-hypothesis reflecting a particular and more or less discrete mechanism for effect. Thus, sub-hypotheses C-17A and C-18A deal with changes in the abundance of food as a result of exposure of food organisms to oil. Sub-hypotheses C-17B and C-18B deal with the toxic effects (direct and indirect, lethal and sub-lethal) of oil on fish. And finally, sub-hypotheses C-17C and C-18C deal with the problem of tainting, real and anticipated.

When it came to the evaluation of significance, participants defined short-term and long-term ecosystem effects in relation to the generation time of the species involved; i.e. short-term was defined as less than a single generation, and long-term was defined as one generation time or longer. In the case of social effects, short-term was defined as less than the time required to affect one season's harvest. Long-term was anything greater than short-term.

Responses to the "Significance Questions" were also modified to reflect the wishes of participants. In regard to the VEC and VSC questions, the Yes and No were modified to Probable and Unlikely respectively. Also the rankings of significance were identified as Class 1, 2, 3 or 4 as per the flowchart, however the terms "significant" and "insignificant" were dropped. Particularly with regard to the social implications of the assessment, it was felt by the group that classifying even a short-term loss of harvest as "insignificant" made inappropriate implications." *As the BREAM Project Manager is not in agreement with the views of this group and it is important to use these terms for comparative purposes in evaluating research priorities related to all nine hypotheses examined at the workshop, both the class and descriptive category of impact significance are stated in this section.*

4.4.8.1 Offshore Platform Blowout - BREAM Hypothesis C-17

AN ISLAND PLATFORM BLOWOUT WILL AFFECT THE HARVEST OF FISH IN THE COASTAL AND DELTA AREA AS A RESULT OF THE TOXIC EFFECTS OF OIL (SUB-HYPOTHESIS C-17A) AND REDUCTION IN FOOD SUPPLY (SUB-HYPOTHESIS C-17B) ON THE SIZE OF FISH POPULATIONS AND TAINTING OF FISH (SUB-HYPOTHESIS C-17C)

INTRODUCTION

These sub-hypotheses deal with the effects of an island platform blowout on fish and fish harvest. In the case of an island platform blowout, a greater proportion of oil is expected to reach the nearshore and strand on shore, than would be the case with an offshore sub-sea blowout. The VEC populations considered in these sub-hypotheses include:

- Broad whitefish
- Lake whitefish
- Arctic cisco
- Least cisco
- Dolly varden
- Pacific herring

Other VEC populations were not considered, due to time constraints. Notably inconnu and burbot which inhabit the outer delta area and are locally important, were omitted from discussion and evaluation. The lake whitefish and broad whitefish evaluations may serve as a reasonable surrogate for both these species in terms of local distribution. However, any conclusions will need to be modified in light of the differences in diet; both burbot and inconnu are highly piscivorous feeders, and burbot have generally intimate contact with the bottom substrate.

Summer distribution of the VEC populations will affect their vulnerability to oil from an island platform blowout. Arctic cisco, Dolly varden and Pacific herring have the greatest tolerance for salinity, and thus may be expected to have the furthest offshore range. Dolly varden are restricted to the coastal waters near the Yukon coast and have not been reported along the northwest portion of the outer delta. Arctic cisco are distributed widely throughout the area, but may be expected to be most concentrated nearer to shore during the late summer, early fall period. Pacific herring are unlikely to be found in abundance during mid summer, but may be expected to congregate in the nearshore embayments on the east and west coasts of Richards Island with the approach of fall. Least cisco are similarly distributed to Arctic cisco, however, they are likely to be more abundant throughout the summer and nearer to shore than may be the case with Arctic cisco. The range of broad and lake whitefish is restricted for the most part to the fresher water areas of the plume, and appear to occur in relatively low abundance in central portions of the outer delta during mid-summer.

Feeding habits differ among the VEC species that were considered in the hypothesis evaluation, and affected the expected exposure of species to the various portions of oil once released into the environment. Broad whitefish and lake whitefish are predominantly shallow-water benthic feeders whose diet consists mainly of infaunal organisms. Arctic and least cisco feed predominantly on epibenthic and planktonic organisms. However, Arctic cisco appear to more frequently bottom feed than do least cisco. Dolly varden feed principally on fish and epibenthic invertebrates while in coastal waters (Bond and Erickson 1987). Pacific herring feed on a wide variety of planktonic organisms.

With the exception of Pacific herring, the valued fish species evaluated spawn in fresh water systems either within the coastal drainage (Dolly varden) or in the mainstem or tributary systems to the MacKenzie River.

Workshop participants worked with the oil spill scenario presented, namely a 12,900 BOPD blowout in summer that results in oil being stranded on shore along the Yukon coast, and along the shore of the western side of the MacKenzie River delta. An adjustment was made to the scenario, to include stranding of oil along the coast of Richards Island and its numerous embayments, when evaluating Pacific herring.

SUB-HYPOTHESIS BREAM C-17A

AN ISLAND PLATFORM BLOWOUT WILL AFFECT THE HARVEST OF FISH IN THE COASTAL AND DELTA AREA AS A RESULT OF THE TOXIC EFFECTS OF OIL ON THE SIZE OF FISH POPULATIONS

INTRODUCTION

This sub-hypothesls deals with the direct and indirect (food-linked) effects of an island platform blowout on fish and fish harvest.

Therehave been few reports of widespread effects of oil spills on adult fish. Eggs and larvae are about 10 times more sensitive than adult fish (Moore and Dwyer 1974). In the Beaufort Sea the spawning area of most valued fish species would not be affected by oil spilled offshore or in the nearshore coastal waters. Cross *et al.* (1993; cited in Lawrence and Davies 1993) describe a variety of sublethal effects that may occur where oil concentrations are not high enough to kill fish. Fish readily take up components of oil into their tissues from water, food organisms and sediment. Reported sub-lethal effects include changes or damage to a variety of organs; physiological changes such as altered respiration, changes in blood parameters and ion concentrations, and decreased energy reserves; and behavioural effects such as decreased ability to locate food or react to fright stimuli, disorientation and changes in schooling behaviour. Thereis also some concern that an oil spill might interfere with salmon (infer charr) homing, as the final stages of the homing migration are guided by olfactory cues (Brannon *et al.* 1986).

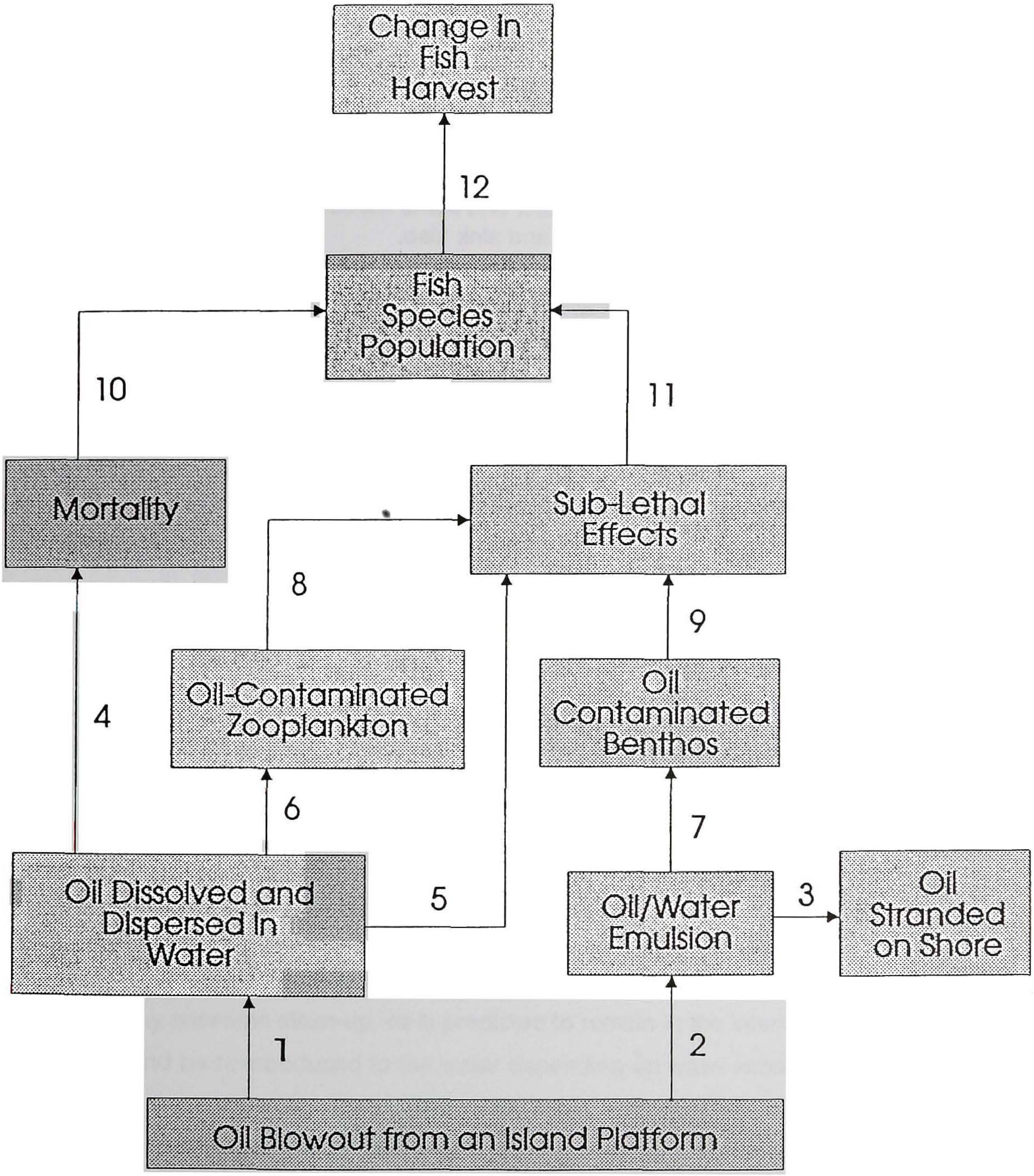

Figure 4-23: BREAM Hypothesis C-17A - Change in Harvest Due to Lethal and Sub-lethal Effects of Oil on Fish

Linkages for Sub-Hypothesis 17A

1. Oil from an island platform blowout will result in oil being "rained down" on the surface with some fraction of the oil being dissolved in water.

2. A portion of the oil will emulsify in the water and some will sink to the bottom; residue from countermeasures burning will disperse and sink also.

3. Oil emulsion will strand on the shoreline and will subsequently be re-introduced into the water column.

4. Oil dissolved in water will be in sufficient concentration to cause fish mortality.

5. Oil dissolved in water will have sub-lethal toxic effects on fish.

6. Zooplankton exposed to dissolved oil will become contaminated.

7. Benthic invertebrates exposed to oil/water emulsion that settles to the bottom, will become contaminated, either by contact or through ingestion.

8. Oil-contaminated zooplankton that are consumed by fish will affect development, growth and reproductive success.

9. Contact with, or consumption of, oil-contaminated benthos by fish will affect development, growth and reproductive success.

10. Fish mortality will result in a decrease in population size.

11. Change in development and behaviour leading to reductions in growth and spawning success, will result in a decrease in fish population size.

12. Reduction in the local availability of fish will cause a change in fish harvest levels or fish harvest patterns.

EVALUATION OF LINKAGES

Link 1: **Oil from an island platform blowout will result in oil being "rained down" on the surface with some fraction of the oil being dissolved in water.**

As described in the platform blowout scenario, the oil slick is initially 0.750 mm thick and 100 m wide. Of the 77,400 bbls of oil released over the 6 day blowout period, 4000 bbls (approx. 800,000 L) will be naturally dispersed into the water column. An estimated 1% of the dispersed oil is expected to dissolve in the water.

Link 2: **A portion of the oil will emulsify in the water and some will sink to the bottom; residue from countermeasures burning will disperse and sink also.**

In addition to the oil becoming dispersed within the water column, the slick spreads, thins, evaporates and emulsifies as it drifts away from the spill site. It is predicted that 29,000 bbls of oil will form 116,000 bbls of oil/water emulsion, and that some portion of the emulsion will sink to the bottom as the oil weathers. Incineration of oil and oil/water emulsion will result in some amount of residue being released in the offshore area. The amount of residue involved will be dependent on the efficiency of incineration.

Link 3: **Oil emulsion will strand on the shoreline and will subsequently be re-introduced into the water column and the nearshore bottom substrate.**

The oil/water emulsion (mousse) is expected to be stranded on shore. In the absence of any shoreline clean-up, oil is predicted to remain in the intertidal zone for a number of seasons, and be re-introduced to the water depending on wave action and ice-scouring.

Link 4: **Oil dissolved in water will be in sufficient concentration to cause fish mortality.**

8,000 L of dissolved oil will create a zone with potentially lethal effects on juvenile fish within 2 km of the island platform. It was assumed that oil concentrations could exceed 1 ppm within this zone, and depending on duration of exposure, some young-of-the-year fish mortality could occur. The link is **valid** for least cisco and Arctic cisco, broad and lake whitefish and Pacific herring. It is **invalid** for Dolly varden, as their coastal range does not overlap with the lethal zone of dissolved/dispersed oil.

Link 5: Oil dissolved in water will have sub-lethal toxic effects on fish.

Dissolved oil in the 1 ppm range has been demonstrated in the laboratory to cause a reduction in growth on some species of fish, and to cause developmental aberrations in fish and fish eggs and larvae (Payne *et al.* 1988). Based on estimates of the zone of influence for sub-lethal effects (approximately 1 ppm dissolved component), the zone may extend for several kilometres landward from the platform. The link is **valid** for all VEC species.

Link 6: Zooplankton exposed to dissolved oil will become contaminated.

The link is **valid**. Crustacean zooplankton and ichthyoplankton are expected to accumulate hydrocarbon contaminants in much the same fashion as has been well documented for benthic invertebrates and is described in BREAM Hypothesis R-26 (BREAM Final Report 1992).

Link 7: Benthic invertebrates exposed to oil/water emulsion that settles to the bottom, will become contaminated, either by contact or through ingestion.

The link is **valid**. The accumulation of hydrocarbon contaminants by benthic invertebrates has been well documented and has been thoroughly evaluated in Link 6a of BREAM Hypothesis R-26 (BREAM Final Report 1992).

Links 8 & 9: Oil-contaminated zooplankton that are consumed by fish will affect development, growth and reproductive success.

Although the link is considered **valid** because food represents a major pathway for hydrocarbon uptake and accumulation, effects on growth and reproductive success were expected to be reduced because of the capacity of fish in this area to readily metabolize and depurate hydrocarbon contaminants. The background concentrations of hydrocarbons in sediments in this region (due to upstream hydrocarbon sources in the MacKenzie River system) are relatively high, and consequently enzyme systems in fish responsible for degradation/metabolism of hydrocarbons are expected to be more active. See Duval (ed. 1985) for a detailed discussion of this topic. These enzyme systems may not be well developed in larval and post-larval stages of coastal fish species, and so they may have an increased sensitivity to the effects of hydrocarbon exposure resulting from the ingestion of contaminated zooplankton (and direct contact, see Links 4 and 5).

Link 10: Fish mortality will result in a decrease in population size.

This link was evaluated for all VEC populations and was determined to be conceptually **valid**. However changes in population size are not expected to occur because of the very small proportion of populations that would be exposed for sufficient duration to lethal concentrations of the toxic fractions of oil. Some locally detectable effects may occur (eg. where conditions are right for oil to accumulate in a local embayment, where an abundance of larval and post/larval fish could be exposed to lethal concentrations for a number of days). However, natural mortality of fish larvae is very high, and even larval losses of 50% or more may have little effect on adult populations (Longhurst 1982).

Link 11: Change in development and behaviour leading to reductions in growth and spawning success, will result in a decrease in fish population size.

The link was evaluated for all VEC species and found to be **valid** for those species (Dolly varden and Pacific herring) whose spawning activity or early larval development may be affected by exposure to oil. The effect of short-term exposure of the non-spawning adult portion of coastal populations of broad whitefish, lake whitefish, least cisco, and Arctic cisco to low concentrations of dissolved oil, and to oil ingested with their food, was expected to have no population-level effect with an oil spill of this magnitude. Because it was thought that oil may be in coastal waters along the Yukon coast, and in some local embayments of Richards Island in sufficient concentration to interfere with the homing of Dolly varden to their spawning streams

(Yukon coast) or with early development of eggs and larvae of the next seasons herring spawn, the link was considered valid and of potential consequence to these two species.

Link 12: Reduction in the local availability of fish will cause a change in fish harvest levels or fish harvest patterns.

The link is **valid**, and could be of some consequence with respect to Dolly varden and local Pacific herring populations.

ASSESSMENT OF SIGNIFICANCE AND CONCLUSIONS

The overall sub-hypothesis was considered to be **valid**. The anticipated consequences of the toxicity-related oil spill effects to the VEC populations and the VSC they support, were assessed as described below.

Valued Ecosystem Component	Responses to Questions of Significance (ref. to Figure 4-13)			
	Question #1	Question #2	Question #3	Conclusion
Broad Whitefish	Unlikely	-	-	Class 4 - Insignificant Minimal sublethal effects of short duration and transitory nature
Lake Whitefish	Unlikely	-	-	Class 4 - Insignificant As above
Arctic Cisco	Unlikely	-	-	Class 4 - Insignificant As above
Least Cisco	Unlikely	-	-	Class 4 - Insignificant As above
Dolly Varden	Probable	Probable	Short-term	Class 3 - Insignificant Research recommended
Pacific Herring	Probable	Probable	Short-term	Class 3 - Insignificant Research recommended

Valued Social Component	Responses to Questions of Significance (ref. to Figure 4-14)			
	Question #1	Question #2	Question #3	Conclusion
Broad Whitefish	Unlikely	-	-	Class 4 - Insignificant Population size is not expected to be affected
Lake Whitefish	Unlikely	-	-	Class 4 - Insignificant As above
Arctic Cisco	Unlikely	-	-	Class 4 - Insignificant As above
Least Cisco	Unlikely	-	-	Class 4 - Insignificant As above
Dolly Varden	Probable	Probable	Short-term	Class 3 - Insignificant
Pacific Herring	Unlikely	-	-	Class 4 - Insignificant Area affected is not normally fished

RECOMMENDED RESEARCH AND MONITORING

The only research recommendation that was made in respect to this sub-hypothesis was the need for research into the effects of oil on the homing abilities of Dolly varden. The effects of oil on other aspects of fish behaviour, such as aggression, flight response, and reaction to a variety of stimuli, was also identified in the case of Dolly varden and Arctic charr.

Monitoring was recommended to document the condition of livers of harvested fish species. Adequate baseline information of this type for locally harvested fish is not presently in hand. In the event of an oil spill, or with accelerated oil production from the Norman Wells facility, there are no data available to document any change in the frequency or severity of "spotty liver" condition.

Continued archiving of tissue samples from harvested fish species was also recommended, along with the suggestion that some effort should be placed on examining the effects of long-term freezer storage on petroleum hydrocarbons that are present in fish tissues.

SUB-HYPOTHESIS BREAM C-17B

AN ISLAND PLATFORM BLOWOUT WILL AFFECT THE HARVEST OF FISH IN THE COASTAL AND DELTA AREA AS A RESULT OF A REDUCTION IN FOOD SUPPLY AFFECTING THE ABUNDANCE AND DISTRIBUTION OF FISH POPULATIONS

INTRODUCTION

This sub-hypothesis deals with the effects of an island platform blowout on invertebrate abundance and the subsequent effects on coastal fish population and abundance.

The toxic effects of oil spills on coastal marine benthic invertebrates and zooplankton have been the subject of numerous field and laboratory experiments, at both the organism and population level. Readers are directed to the BIOS Experiment in the Eastern Arctic as a notable example of recent research of relevance to this sub-hypothesis.

It appears that zooplankton are susceptible to significant sub-lethal damage if exposed to hydrocarbon concentrations in water greater than 0.05 - 0.3 ppm for periods as little as a few days (Wells 1985). Lethal effects could be expected if concentrations between 0.5 - 1.0 ppm persist. However concentrations above 0.5 ppm rarely last for more than a few hours or a day in the water column, even in the case of large spills (Wells 1985). Conover (1979) concluded that even for large spills, no lasting impact on zooplankton populations will occur due to the transient nature of their populations and their wide distribution.

Shallow water nearshore benthic environments are most susceptible to oil stranded on the shore and in the intertidal zone. Most effects are attributable to the water soluble fraction and bivalves and amphipods seem to be the most sensitive to the presence of oil. Long-term (several month) exposure to 3 ppm dissolved oil can result in bivalve mortality (Stekoll et al. 1980). Sub-lethal effects are usually short-lived in areas with adequate water transport. Confined embayments with poor water exchange could be problematic. Despite the sensitivity of invertebrates to oil, the BIOS Experiment was not able to demonstrate any reduction in benthic invertebrate population size after exposure to relatively heavy dosings of oil (J. Harper pers. comm.).

Linkages for Sub-Hypothesis 17B

1. Oil from an island platform blowout will result in oil being "rained down" on the surface with some fraction of the oil being dissolved in water.
2. A portion of the oil will emulsify in the water and some will sink to the bottom; residue from countermeasures burning will disperse and sink also.
3. Oil emulsion will strand on the shoreline and will subsequently be re-introduced into the water column.
4. Oil dissolved in the water will cause lethal and sub-lethal effects to zooplankton in the vicinity of the oil blowout.
5. Oil emulsion and solids on the bottom substrate will be toxic to bottom dwelling organisms.
6. Reductions in the abundance of zooplankton will reduce the availability of prey for water-column feeding fish.
7. Reductions in the abundance of bottom organisms will reduce the availability of prey for bottom feeders.
8. Reduction in prey items (food) will cause a reduction (or redistribution) of fish populations.
9. Reduction in the local availability of fish will cause a change in fish harvest patterns.

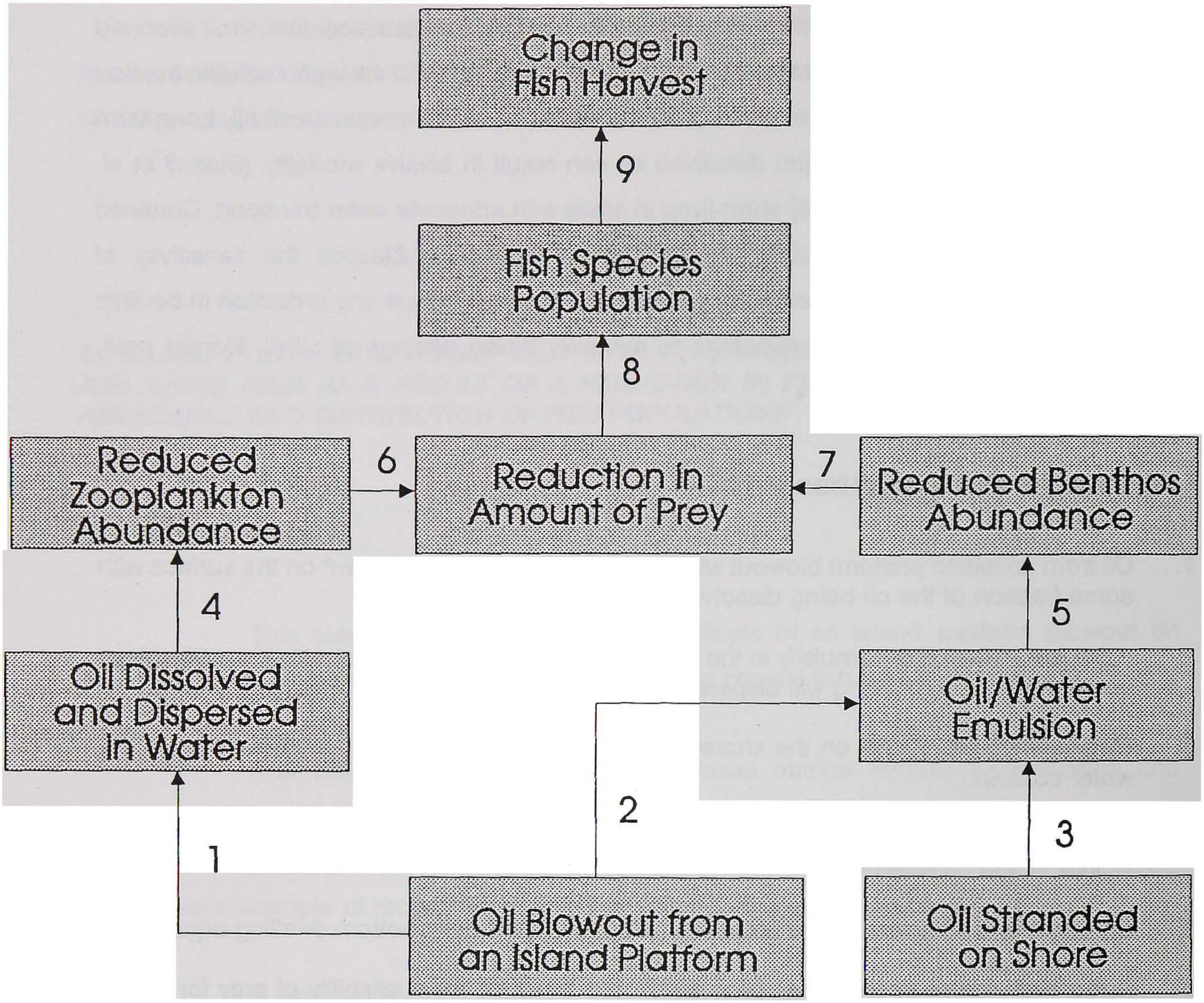

Figure 4-24: BREAM Hypothesis C-17B - Change in Harvest Due to Reduction in Prey Abundance from Oil Exposure

EVALUATION OF LINKAGES

Link 1: **Oil from an island platform blowout will result in oil being "rained down" on the surface with some fraction of the oil being dissolved in water.**

Link 2: **A portion of the oil will emulsify in the water and some will sink to the bottom; residue from countermeasures burning will disperse and sink also.**

Link 3: **Oil emulsion will strand on the shoreline and will subsequently be re-introduced into the water column and the nearshore bottom substrate.**

These linkages are **valid**. Refer to Sub-hypothesis C-A for discussion.

Link 4: **Oil dissolved in the water will cause lethal and sub-lethal effects to zooplankton in the vicinity of the oil blowout.**

Link 5: **Oil emulsion and solids on the bottom substrate will be toxic to bottom dwelling organisms.**

Both these links are **valid**. Sub-lethal and lethal effects of oil-in-water on zooplankton and benthic invertebrates have been demonstrated when organisms are exposed for days, weeks and months, to concentrations between the range of 0.05 - 3.0 ppm (See Introduction) depending on species and oil fractions present.

Link 6: **Reductions in the abundance of zooplankton will reduce the availability of prey for water-column feeding fish.**

Based on flow rates and the duration of the blowout, lethal and sub-lethal effects to zooplankton are expected to be restricted to within an area of 1 - 2 km^2. Consequently reductions in zooplankton abundance are anticipated to be small, patchy and localized. The VEC species potentially affected include Pacific herring, Arctic and least cisco and Dolly varden. Broad whitefish and lake whitefish are principally bottom feeders and so would be unaffected. This link is **valid**.

Link 7: **Reductions in the abundance of bottom organisms will reduce the availability of prey for bottom feeders.**

Evidence from the BIOS Experiment indicate that this link is **invalid**. No reduction in benthic invertebrate populations were detected.

Link 8: **Reduction in prey items (food) will cause a reduction (or redistribution) in fish populations.**

This link is **invalid** for the two bottom feeding species, broad whitefish and lake whitefish. The link is **tentatively valid** for water column feeders, but likely only in isolated circumstances, where a local population is dependant on feeding at locations where zooplankton recruitment may be curtailed by poor water circulation and exchange. This is potentially the case with some of the deep embayments on Richards Island, that become hydrologically isolated from the surrounding coastal waters in winter. Thus effects that persist beyond the open water season could affect the availability of zooplankton prey during the winter months. The link is considered **invalid** during the open water season, but **valid** for those species (Pacific herring, least cisco, Arctic cisco, least cisco) which overwinter in coastal embayments, should oil persist there.

Link 9: **Reduction in the local availability of fish will cause a change in fish harvest and harvest patterns.**

The link is **valid** for Pacific herring, Arctic cisco and least cisco. It is **invalid** for the two bottom feeders, broad and lake whitefish. Dolly varden which is transient along the coast, is expected to be unaffected by patchy, transient effects on zooplankton abundance. Consequently, the link is **invalid** for Dolly varden.

ASSESSMENT OF SIGNIFICANCE AND CONCLUSIONS

The overall sub-hypothesis was considered to be **invalid** for Dolly varden, broad whitefish and lake whitefish, and **valid** for Pacific herring, Arctic cisco and least cisco. The anticipated consequences of any oil-related loss in food supply to the VEC populations and the VSC they support, were assessed as described below.

Valued Ecosystem Component	Responses to Questions of Significance (ref. to Figure 4-13)			
	Question #1	Question #2	Question #3	Conclusion
Arctic cisco	Unlikely	-	-	Class 4 - Insignificant
Lake Whitefish	Unlikely	-	-	Class 4 - Insignificant
Pacific Herring	Probable	Probable	Short-term	Class 3 - Insignificant

Valued Social Component	Responses to Questions of Significance (ref. to Figure 4-14)			
	Question #1	Question #2	Question #3	Conclusion
Arctic cisco	Unlikely	-	-	Class 4 - Insignificant Effects will be localized to areas not normally fished, and will not affect harvest in areas where they are fished
Lake Whitefish	Unlikely	-	-	Class 4 - Insignificant As above
Pacific Herring	Unlikely	-	-	Class 4 - Insignificant As above

RECOMMENDED RESEARCH AND MONITORING

No requirements or recommendations for research and monitoring were made in regard to this sub-hypothesis.

SUB-HYPOTHESIS BREAM C-17C

AN ISLAND PLATFORM BLOWOUT WILL AFFECT THE HARVEST OF FISH IN THE COASTAL AND DELTA AREA AS A RESULT OF TAINTING OF FISH AND A CONCERN FOR TAINTING.

INTRODUCTION

This sub-hypothesis deals with a change in harvest of fish species due to tainting caused by an island platform blowout. It also examines the possibility that just an awareness of a blow out will affect fish harvest because of a concern or perception of taint.

Hydrocarbons can accumulate in the tissues of fish at concentrations below those which are lethal or lead to pathological changes. They may still be a concern because they (or their degradation products) can cause tainting. A number of compounds present in petroleum are believed to be responsible for creating an oily flavour in fish. While many researchers have reported many specific compounds that have been shown to cause a taint, few have described the threshold concentrations of these compounds. However, it is apparent that tainting may result from very low environmental concentrations of petroleum (e.g, 0.01 - 0.02 ppm hydrocarbons in sediment; Sidhu *et al.* 1972).

Tainting may occur as a result of absorption through the skin, however, the more usual modes of uptake are through respiration (via gill tissue) and/or ingestion (Connell 1974 in Tidmarsh *et al.* 1986). If ambient concentrations are low, days or weeks may be required to acquire a taint, but if concentrations are high, tainting may require only a day or so. The taint can be eliminated through depuration in a clean environment. This process can take weeks or months to complete (Tidmarsh 1986).

The acquisition of taint is also strongly influenced by the lipid (fatty) content of the tissue involved. Species and tissues with a high lipid content will be more susceptible to taint. Consequently, species such as Dolly varden and whitefish that have a high fat content, are more likely to acquire and retain a taint than species like pike or pickerel. Liver tissue is more susceptible than muscle tissue to accumulating taint-producing hydrocarbons. Seasonal effects are also likely, as the fat content of fish is often season dependent.

Fear of tainting arising from an oil pollution incident can be as serious a problem as an actual tainting event. Tainting is as much (or more) an economic problem than either an environmental or public health concern, and is as much a perceptual problem as a concern based on science-supported reality. Fortunately, unlike exposure to carcinogens, the presence of tainted produce is readily detectable by humans, so the risk to health is reduced (Tidmarsh 1986).

Reviews of case histories of tainting in fish (Tidmarsh *et al.* 1986), indicate that the risk of tainting is higher in coastal waters than in offshore areas. Rapid dispersion in the offshore areas reduces the risk of exposure to concentrations of dissolved or particulate matter that would cause a taint. A comprehensive discussion of tainting can be found in the BREAM R-26 evaluation (BREAM Final Report 1992).

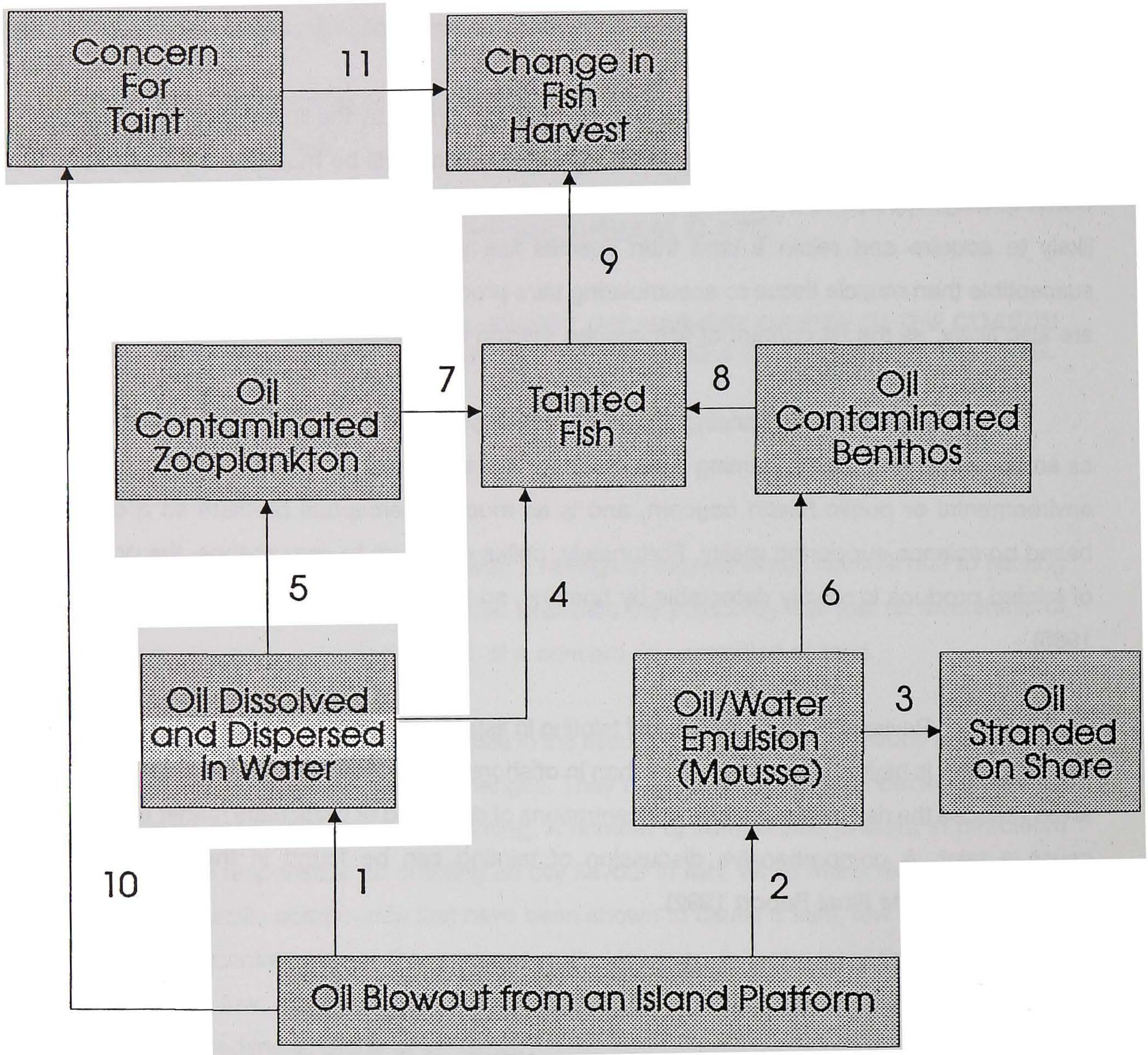

Figure 4-25: BREAM Hypothesis C-17C - Change in Harvest Due to Tainting or Concern for Taint in Fish

Linkages for Sub-Hypothesis 17C

1. Oil from an island platform blowout will result in oil being "rained down" on the surface with some fraction of the oil being dissolved in water.

2. A portion of the oil will emulsify in the water and some will sink to the bottom; residue from countermeasures burning will disperse and sink also.

3. Oil emulsion will strand on the shoreline and will subsequently be re-introduced into the water column.

4. Oil dissolved in water will cause a taint in fish that are in contact with that water.

5. Zooplankton will uptake oil that is dissolved in the water column and will ingest small droplets of dispersed oil.

6. Benthic invertebrates and the bottom substrate will be coated in oil/water emulsion that sinks to the bottom.

7.,8. Ingestion of oil-contaminated prey or contact with oiled bottom-substrates will cause a taint in fish.

9. The presence of tainted fish will cause a change in harvest rate and/or pattern.

10. The knowledge of an oil blowout will cause concerns that fish will be tainted and unfit for consumption.

11. A concern and expectation of taint will result in a change in harvest rate and/or pattern.

EVALUATION OF LINKAGES

Link 1: **Oil from an island platform blowout will result in oil being "rained down" on the surface with some fraction of the oil being dissolved in water.**

Link 2: **A portion of the oil will emulsify in the water and some will sink to the bottom; residue from countermeasures burning will disperse and sink also.**

Link 3: **Oil emulsion will strand on the shoreline and will subsequently be re-introduced into the water column.**

These linkages are **valid**. Refer to Sub-hypothesis C-A for discussion.

Link 4: Oil dissolved in water will cause a taint in fish that are in contact with that water.

This link is **valid** for all VEC species. The likelihood of exposure to levels that will cause a taint is greater for those species that may remain in the immediate vicinity of higher concentrations of taint producing oil fractions. These instances are likely to occur if oil becomes entrapped in coastal embayments of Richards Island. Absorption of dissolved oil in water, through the gills is one of the main processes causing a taint.

Link 5: Zooplankton will uptake oil that is dissolved in the water column and will ingest small droplets of dispersed oil.

The link is **valid**. See evaluation of Link 6, BREAM Sub-hypothesis C17-A.

Link 6: Benthic invertebrates and the bottom substrate will be coated in oil/water emulsion that sinks to the bottom.

The link is **valid**. The area potentially affected extends from Richards Island in the East to the Yukon coast. It is unlikely that stranded oil would persist for any length of time along the Yukon coast because of its exposure to wave action and currents. Oil on the bottom in the littoral/sub-tidal zone would be swept away or buried in sediments. Oil may persist for a longer period of time were it to enter the sheltered embayments of Richards Island.

Links 7, 8: Ingestion of oil-contaminated prey or contact with oiled bottom-substrates will cause a taint in fish.

Ingestion and respiration are the major pathways for acquiring a taint. Oil will be in sufficient concentration to cause a taint, within an area that extends into the range of all VEC populations. There is potential, either through ingestion of invertebrates that have accumulated hydrocarbons, or through absorption through the gills, that broad whitefish, lake whitefish, Arctic and least cisco, Pacific herring and dolly varden could accumulate sufficient oil to cause a taint. The link is **valid**.

Link 9: **The presence of tainted fish will cause a change in harvest rate and/or pattern.**

Case studies have clearly demonstrated the effect of the presence of a taint on the acceptability of fish (Tidmarsh *et al.* 1986). The presence of tainted fish in catches or in catches from a particular area has potential to curtail the fishery voluntarily or through regulation, and could result in increased effort in another area to make up for the local loss of harvest. Where a taint or other affect on palatability (texture) is not pervasive, it could also result in increased local effort to catch more fish, only a portion of which may be acceptable. Accordingly, this link is considered **valid**.

Link 10: **The knowledge of an oil blowout will cause concerns that fish will be tainted and unfit for consumption.**

The link is **valid**. There is sufficient evidence that an oil spill can cause tainting, that the concern is valid and justifiable.

Link 11: **A concern and expectation of taint will result in a change in harvest rate and/or pattern.**

The link is **valid**. Numerous instances have been reported where a fishery has been closed voluntarily as a result of warnings of possible exposure of gear and/or catch to oil. It has rarely been necessary to legally "close" a fishery because a stock has knowingly become tainted (Tidmarsh *et al.* 1986).

ASSESSMENT OF SIGNIFICANCE AND CONCLUSIONS

The overall sub-hypothesis was considered to be **valid** for the Valued Social Components. The anticipated consequences of the taint-related oil spill effects to the Valued Ecosystem Component populations is **invalid** as the concern is focused on the harvest aspect of the resources, not the ecological consequences (see Sub-hypothesis C17-A for discussion and evaluation of this aspect).

Valued Social Component	Responses to Questions of Significance (ref. to Figure 4-14)			
	Question #1	Question #2	Question #3	Conclusion
Broad Whitefish	Probable	No	Long-term	Class 2 - Significant Concern for taint is likely to persist in the absence of actual risk to these coastal migrants; localized areas may contribute to taint into the next year
Lake Whitefish	Probable	No	Long-term	Class 2 - Significant As above
Arctic Cisco	Probable	No	Long-term	Class 2 - Significant As above
Least Cisco	Probable	No	Long-term	Class 2 - Significant As above
Dolly Varden	Probable	No	Long-term	Class 2 - Significant As Above
Pacific Herring	Probable	No	Long-term	Class 2 - Significant More of a government concern than local because of location of effects; Pacific herring are not a target species in area where effects are likely

RECOMMENDED RESEARCH AND MONITORING

Research was recommended to determine hydrocarbon depuration rates of more local fish species, and to develop a better understanding of the effect of suspended particulates on the acquisition of taint.

4.4.8.2 Diesel Fuel Spill from Barge - BREAM Hypothesis C-18

A DIESEL FUEL SPILL FROM A BARGE ON EAST CHANNEL IN SUMMER WILL AFFECT THE HARVEST OF FISH IN THE COASTAL AND DELTA AREA AS A RESULT OF THE TOXIC EFFECTS OF OIL (SUB-HYPOTHESIS C-18A) AND REDUCTION IN FOOD SUPPLY (SUB-HYPOTHESIS C-18B) ON THE SIZE OF FISH POPULATIONS AND AS A RESULT OF TAINTING OF FISH (SUB-HYPOTHESIS C-18C)

INTRODUCTION

These sub-hypotheses deal with the effects on fish harvest of a diesel fuel spill in East Channel. The effects that result from this scenario differ from the crude oil blowout (Hypothesis C-17) with respect to a lesser potential for oiling of bottom substrates due to the light nature of the oil, and a greater potential for dissolved and dispersed oil to exist within the water column. The scenario and hypothesis were developed as a result of concerns expressed by northerners that participated in the Community-based Concerns Working Group meeting held in February 1992. The VEC populations considered in these sub-hypotheses include:

- Broad whitefish
- Northern pike
- Burbot
- Inconnu

It was expected that broad whitefish would serve as a reasonable surrogate for lake whitefish, Arctic cisco and least cisco, all species having similar distribution within the zone of influence of the oil spill during summer. Summer distribution of the VEC populations will affect their vulnerability to a diesel fuel spill in summer. The range of Dolly varden and Pacific herring does not extend into the zone of influence of the spill. The seasonal distribution and life histories of inconnu, broad whitefish, and lake whitefish put non-spawning adults in contact with oil from this spill, as well the potential for juveniles to come in contact with oil exists. The spawning segment of these populations are most likely upstream of the spill area by the time the spill occurs (soon after ice-out). Northern pike and burbot occur within the spill area throughout the summer. Young-of-the-year pike and burbot may be exposed to oil that invades tributary stream mouths.

Feeding habits differ among the VEC species that were considered in the hypothesis evaluation, and affected the expected exposure of species to the various portions of oil once released into the environment. Broad whitefish and lake whitefish are predominantly shallow-water benthic feeders whose diet consists mainly of infaunal organisms. Inconnu, burbot and northern pike are all highly pisciverous.

All the VEC populations evaluated, spawn in the mainstem MacKenzie River (broad whitefish, inconnu and burbot) or in tributary streams (northern pike). Broad whitefish and inconnu spawn in fall upstream of the spill site, and the young emerge in spring and are transported downstream with the spring flood. They are present in nearshore coastal waters by mid-July (Lawrence *et al.* 1984). Burbot spawn in mid-late winter, however the distribution of young-of-the-year is not well understood. Pike spawn in spring in the shallows of small tributaries. Young emerge shortly after and usually remain in their natal streams for some time. They often reside in the mouths of tributaries, feeding on drifting invertebrates and small fish.

Workshop participants worked with the oil spill scenario presented, namely a 2,300 bbls spill of diesel into the river in summer. Mid-August was established as the time of the spill incident, and the surface current was estimated to be 0.65 m/s as a opposed to 0.5 m/s described in the original scenario. As a result, it was thought that spilled oil would be more likely to affect the shores of Hendrickson Island, or one or other coastline of Kugmallit Bay.

SUB-HYPOTHESIS BREAM C-18A

A BARGE SPILL OF DIESEL WILL AFFECT THE HARVEST OF FISH IN THE COASTAL AND DELTA AREA AS A RESULT OF THE TOXIC EFFECTS OF DIESEL OIL ON FISH POPULATIONS

INTRODUCTION

This sub-hypothesis deals with the direct and indirect (food-linked) toxic effects of a diesel fuel spill on fish and fish harvest. The major difference between the potential effects of this spill and the island platform blowout scenario relates to the increased soluble component of the oil, the lesser potential for oiling of bottom substrates because of the lightness of the oil, and the relatively greater transport potential of a small amount of oil, due to the river current. Sediment mediated transport could also be of more significance than was the case with the island platform. In general, there would appear to be more potential for exposure to acutely toxic levels of dissolved oil (0.5 - 1 ppm) for at least some period of exposure, and generally less potential for effects to be felt through the food chain. This latter expectation is a result of the much reduced diet dependency of the riverine fish for zooplankton, and the reduced potential for oiling of the bottom. The general effects of oil on fish have been summarized in the preceding BREAM Sub-hypothesis C-17A.

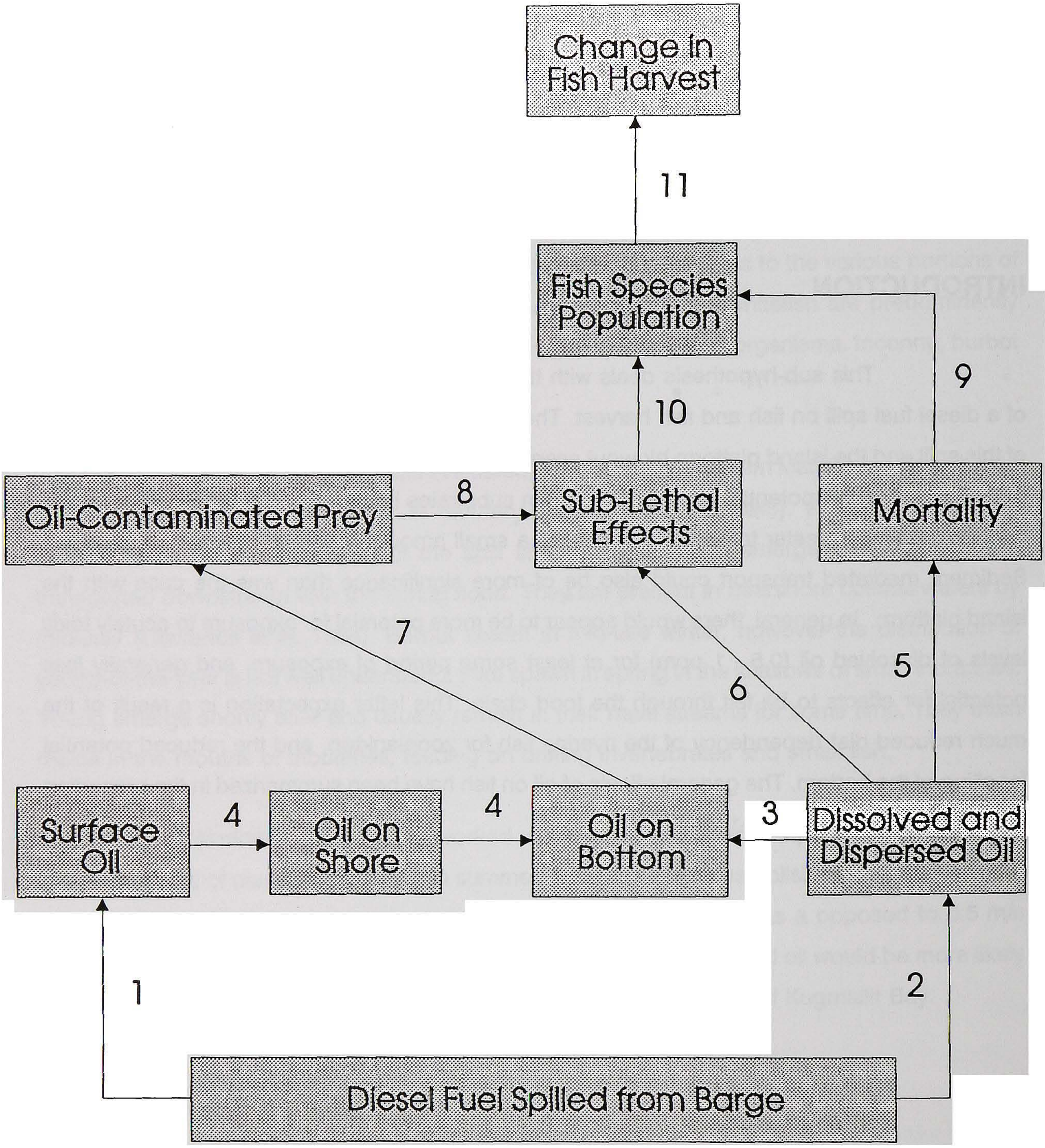

Figure 4-26: BREAM Hypothesis C-18A - Change in Harvest Due to Lethal and Sub-Lethal Effects of Diesel Oil on Fish

Linkages for Sub-Hypothesis 18A

1. Oil spilled in the water will result in oil spreading on the water surface and volatile components of the oil will evaporate.

2. A portion of the oil will dissolve and some will be dispersed in the river water column and be transported downstream.

3. A portion of the diesel oil will be adsorbed to particulates in the water column and sink to the bottom at some downstream location. Residue from any countermeasure burning will disperse and sink also.

4. Some surface oil will sporadically strand on the shoreline and may subsequently be re-introduced into the water, most of which will sink to the bottom.

5. Oil dissolved in water will be in sufficient concentration to cause fish mortality.

6. Oil dissolved in water will have sub-lethal toxic effects on fish, affecting spawning migration behaviour and/or growth and development.

7. Benthic invertebrates exposed to oil/water emulsion that settles to the bottom, will become contaminated, either by contact or through ingestion.

8. Contact with, or consumption of, oil-contaminated benthos by fish will affect development, growth and reproductive success.

9. Fish mortality will result in a decrease in population size.

10. Change in development and behaviour leading to reductions in growth and spawning success, will result in a decrease in fish population size.

11. Reduction in the local availability of fish will cause a change in fish harvest levels or fish harvest patterns.

EVALUATION OF LINKAGES

Link 1: Oil spilled in the water will result in oil spreading on the water surface and volatile components of the oil will evaporate.

The link is **valid**. As described in the oil spill scenario, 0.16 km^2 of water surface will be covered by oil.; 90% in the form of a thin sheen, and 10% as thick oil lenses. The slick spreads to a maximum size of 1.2 km^2, of which 0.14 km^2 is thicker portions. The slicker portions of the slick thin as time passes, so that after 2 days it has spread approximately 113 km (0.65/50 x 87) downstream and is 0.35 mm thick. By the time the slick has dissipated downstream, 500 bbl of the 2300 bbl spill are predicted to have evaporated.

Link 2: **A portion of the oil will dissolve and some will be dispersed in the river water column and be transported downstream.**

Peak dispersed oil concentrations at the beginning of the spill are 5 ppm and extend to a depth of 3 m under the entire spill. Average oil concentrations decline from 5 ppm at the spill site, to about 0.2 ppm by the time the surface slick dissipates. The exposure time for organisms at any fixed point along the river will increase with distance from the spill site, according to the formula presented in the oil spill scenario. Sedentary organisms nearest to the spill will be exposed to higher concentrations (5 ppm) for shorter duration. For example 2 hours after the spill, benthic infauna in water less than 3 m deep, are expected to be exposed to 5 ppm dissolved oil for 0.75 hrs. However, 100 hours after the spill, benthic fauna near Kugmallit Bay would be exposed to 0.2 ppm oil for 38 hours as the cloud of oil-contaminated water swept past.

Link 3: **A portion of the diesel oil will be adsorbed to particulates in the water column and sink to the bottom at some downstream location. Residue from any countermeasure burning will disperse and sink also.**

An unknown proportion of dissolved oil is expected to be adsorbed to clay and silt particulates in the water column, and be transported downstream to eventually be deposited as bottom sediment. The rate, efficiency and factors affecting oil adsorption are not well understood. The MacKenzie River has a high concentration of suspended particulates, and so the adsorption effect on oil fate is likely to be of some consequence. The link is **valid** but of unknown significance to the fate of oil in this environment.

Link 4: **Some surface oil will sporadically strand on the shoreline and may subsequently be re-introduced into the water, most of which will sink to the bottom.**

The oil spill scenario assumes that both shores of the river will be sporadically oiled along the 105 km stretch of river affected. The possibility exists that oil may strand on the shores of Hendrickson Island in Kugamallit Bay. A total of 500 bbls are stated to be stranded. As water levels increase and decrease in response to storms etc., some portion of the stranded oil will be re-introduced to the wetted portion of the channel. Because the oil is weathered and mixed with water, it is expected to remain in contact with the bottom, as opposed to floating near the surface.

Link 5: **Oil dissolved in water will be in sufficient concentration to cause fish mortality.**

Concentration of oil in water are in the lethal range, however, the time of exposure is insufficient to cause mortality. Adult fish are unlikely to be affected given their relative insensitivity to oil, and the potential for avoidance. Young-of-the year (Y-O-Y) are more susceptible to lethal effects, however, at the time of the spill (mid-August) there are few Y-O-Y in the mainstem Mackenzie R. By this time broad whitefish and inconnu Y-O-Y are in nearshore coastal water, and northern pike and burbot fry are more likely to be found in creek mouths. The link is **invalid** for broad whitefish and inconnu exposed to very low concentrations predicted in coastal areas, and **valid** for northern pike and burbot fry in those circumstances where oil enters and persists in creek mouths.

Link 6: **Oil dissolved in water will have sub-lethal toxic effects on fish, affecting spawning migration behaviour and/or growth and development.**

The link is **valid** to some degree for all VEC species. See discussion and evaluation in Link 5, Sub-hypothesis C-A. The spawning segment of the broad whitefish and inconnu populations are unlikely to be affected however as they are generally upstream of the spill area by this time of year. Local populations of pike and burbot as well as sub-adult and non-spawning coregonids may also be affected.

Link 7: **Benthic invertebrates exposed to oil/water emulsion that settles to the bottom, will become contaminated, either by contact or through ingestion.**

The linkage is less important than in the case of a crude oil spill because of the "light" nature of diesel oil. Only those invertebrates exposed to the oil transported to the bottom adsorbed to particulate matter are likely to be affected. In any event the link was considered to be **valid** as discussed in Link 7, Sub-hypothesis C-A.

Link 8: **Contact with, or consumption of, oil-contaminated benthos by fish will affect development, growth and reproductive success.**

The link is **invalid** for northern pike, burbot and inconnu. These species are not benthic feeders. The link is **valid** for broad whitefish in locales where oil may accumulate in sediments. Areas exposed to higher currents neither support the benthic organisms (small bivalves) fed on by broad whitefish, nor are they likely locations for accumulation of oil.

Link 9: **Fish mortality will result in a decrease in population size.**

Only northern pike and burbot were considered. (Link 5 was invalid for broadwhitefish and inconnu). The link was considered **valid**, however the short duration of effect, the age class of the fish affected (fry) and the ease of recruitment from unaffected populations lead to an inconsequential nature of effect.

Link 10: **Change in development and behaviour leading to reductions in growth and spawning success, will result in a decrease in fish population size.**

The link is **valid** for all VEC species. Effects are not expected to be food-linked (See Link 8). The lack of exposure of spawning segments of the broad whitefish and inconnu populations to oil, render the effects inconsequential to the population. The localized nature of effects on burbot and pike lead to similar conclusions of population effects.

Link 11: Reduction in the local availability of fish will cause a change in fish harvest levels or fish harvest patterns.

It is anticipated that effects due to toxic effects of oil on populations will be inconsequential and unmeasurable for all VEC populations.

ASSESSMENT OF SIGNIFICANCE AND CONCLUSIONS

The overall sub-hypothesis was considered to be **valid** but unrelated to direct mortality (Links 5 and 9) or ingestion of oiled prey (Links 8 and 10). Zooplankton were not considered in the food chain effects because of the low dependency of these species on zooplankton, and also because of the low abundance of zooplankton in the river. The anticipated consequences of the direct toxicity-related diesel fuel spill effects to the VEC populations and the VSC they support, were assessed and summarized as described below.

Valued Ecosystem Component	Responses to Questions of Significance (ref. to Figure 4-13)			
	Question #1	Question #2	Question #3	Conclusion
Broad Whitefish	Unlikely	-	-	Class 4 - Insignificant Effects are unlikely to be measurable; research is recommended with respect to oil-sediment deposition
Inconnu	Unlikely	-	-	Class 4 - Insignificant As above
Burbot	Probable	Yes	Short-term	Class 3 - Insignificant Minimal sub-lethal effects of short duration and localized nature
Northern Pike	Probable	Yes	Short-term	Class 3 - Insignificant As above

Valued Social Component	Responses to Questions of Significance (ref. to Figure 4-14)			
	Question #1	Question #2	Question #3	Conclusion
Broad Whitefish	Unlikely	-	-	Class 4 - Insignificant
Inconnu	Unlikely	-	-	Class 4 - Insignificant
Burbot	Unlikely	-	-	Class 4 - Insignificant Minor and short-term reductions in local population size of pike and burbot are not expected to affect harvest
Northern Pike	Unlikely	-	-	Class 4 - Insignificant As above

RECOMMENDED RESEARCH AND MONITORING

A major information gap identified through the evaluation of this hypothesis relates to rate and efficiency that oil is adsorbed to particulates in the water column. At present, little is known regarding oil/particle interactions. The working group, therefore, recommended that research be undertaken to develop a better understanding of the role of suspended sediments on the fate of oil in the MacKenzie River environment.

SUB-HYPOTHESIS BREAM C-18B

A BARGE SPILL OF DIESEL WILL AFFECT THE HARVEST OF FISH IN THE COASTAL AND DELTA AREA AS A RESULT OF A REDUCTION IN FOOD SUPPLY AFFECTING THE ABUNDANCE AND DISTRIBUTION OF FISH POPULATIONS

INTRODUCTION

This sub-hypothesis deals with the effects of a diesel oil spill on benthic invertebrate abundance and the subsequent effects on riverine and coastal fish populations and abundance.

The major difference between the potential effects of this spill and the island platform blowout scenario relates to the focus on benthic invertebrates. Zooplankton are not important to the diet of the fish species involved in this scenario, and are not abundant in the environment affected by the spill. Consequently, this sub-hypothesis deals only with effects on benthic (bottom-dwelling) invertebrates. Furthermore, the lesser potential for oiling of bottom substrates because of the lightness of the oil, and the relatively greater transport potential of a smaller amount of oil, due to the river current, reduce potential for effects on bottom invertebrate abundance. There is generally less potential for effects to be felt through the food chain as a result of the much reduced diet dependency of the riverine fish for zooplankton, and the reduced potential for oiling of the bottom. The general effects of oil on food supply have been summarized in the preceding BREAM Sub-hypothesis C-17B.

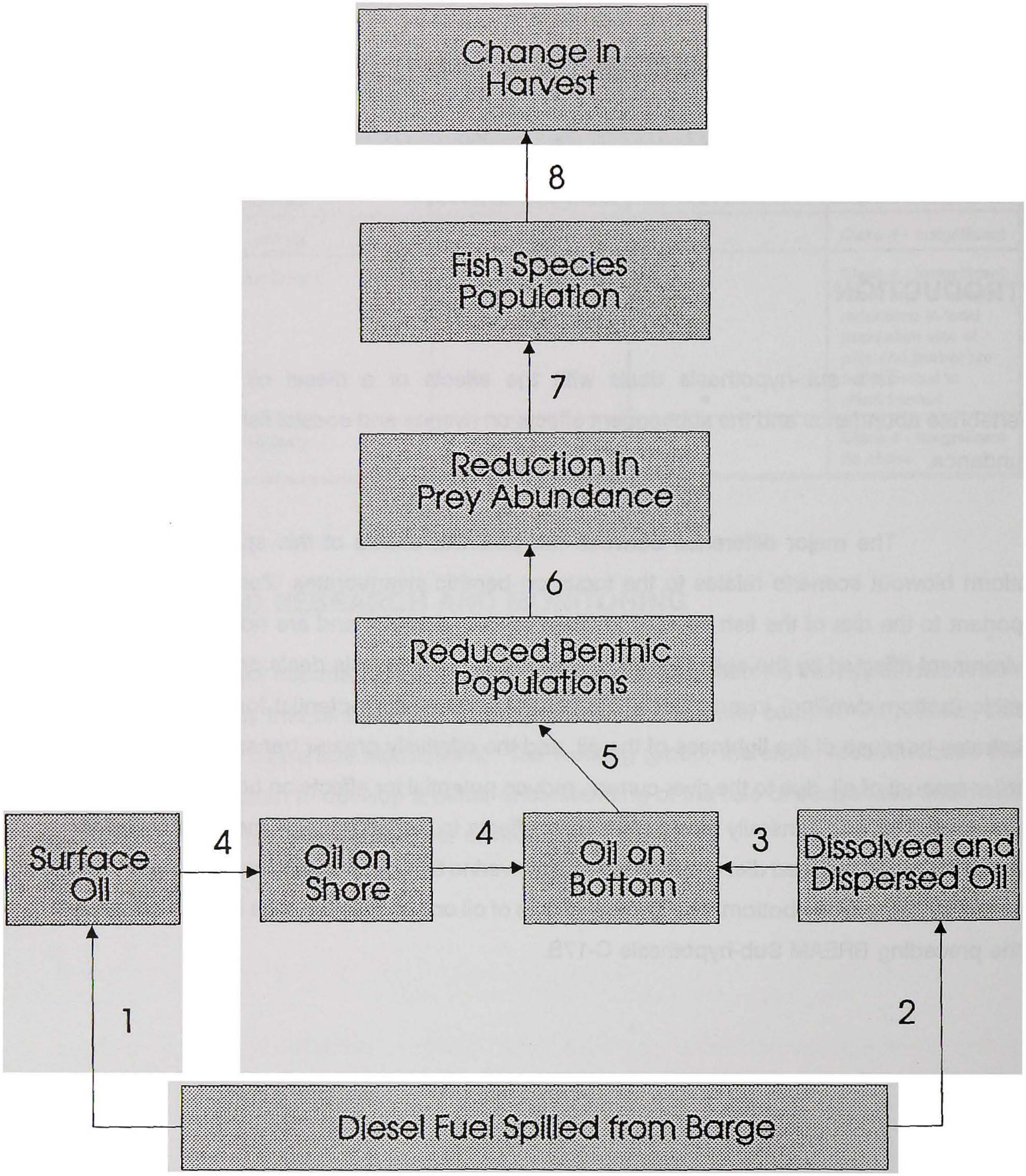

Figure 4-27: BREAM Hypothesis C-18B - Change in Fish Harvest Due to Reductions in Benthic Invertebrates following a Diesel Oil

Linkages for Sub-Hypothesis 18B

1. Oil spilled in the water will result in oil spreading on the water surface and volatile components of the oil will evaporate.

2. A portion of the oil will dissolve and some will be dispersed in the river water column and be transported downstream.

3. A portion of the diesel oil will be adsorbed to particulates in the water column and sink to the bottom at some downstream location. Residue from any countermeasure burning will disperse and sink also.

4. Some surface oil will sporadically strand on the shoreline and may subsequently be re-introduced into the water, most of which will sink to the bottom.

5. Oil on the bottom will cause a reduction in benthic invertebrates, either by smothering, or as a result of oil toxicity.

6. Reduced populations of benthic invertebrates will result in a reduction in prey for bottom-feeding fish species.

7. Reduction in prey for bottom-feeding fish species will result in a reduction in growth or a change in the distribution of fish populations.

8. Reduction in the local availability of fish will cause a change in fish harvest patterns.

EVALUATION OF LINKAGES

Link 1: **Oil spilled in the water will result in oil spreading on the water surface and volatile components of the oil will evaporate.**

Link 2: **A portion of the oil will dissolve and some will be dispersed in the river water column and be transported downstream.**

Link 3: **A portion of the diesel oil will be adsorbed to particulates in the water column and sink to the bottom at some downstream location. Residue from any countermeasure burning will disperse and sink also.**

Link 4: **Some surface oil will sporadically strand on the shoreline and may subsequently be re-introduced into the water, most of which will sink to the bottom.**

These linkages are **valid**. Refer to Sub-hypothesis C-18A for discussion.

Link 5: **Oil on the bottom will cause a reduction in benthic invertebrates, either by smothering, or as a result of oil toxicity.**

The link is **invalid**. There is no evidence that the amounts of oil involved would reduce benthic invertebrate abundance. See Link 7 Sub-hypothesis C17-B for discussion. There was also reference made at the workshop to evidence that oiling of this nature may even enhance benthic invertebrate production (Reference to work by Brunskill and Snow in the 1970's).

Link 6: **Reduced populations of benthic invertebrates will result in a reduction in prey for bottom-feeding fish species.**

Link 7: **Reduction in prey for bottom-feeding fish species will result in a reduction in growth or a change in the distribution of fish populations.**

Link 8: **Reduction in the local availability of fish will cause a change in fish harvest patterns.**

The remaining links were not considered because of the **invalid** status of Link 5.

ASSESSMENT OF SIGNIFICANCE AND CONCLUSIONS

The sub-hypothesis was considered to be **invalid**. Zooplankton were not considered because of the low dependency of these species on zooplankton, and also because of the low abundance of zooplankton in the river. Consequently an assessment of significance was not performed for this sub-hypothesis.

RECOMMENDED RESEARCH AND MONITORING

No research needs were identified with respect to this hypothesis.

SUB-HYPOTHESIS BREAM C-18C

A BARGE SPILL OF DIESEL WILL AFFECT THE HARVEST OF FISH IN THE COASTAL AND DELTA AREA AS A RESULT OF TAINTING OF FISH AND A CONCERN FOR TAINTING

INTRODUCTION

This sub-hypothesis deals with a change in harvest of fish species due to tainting caused by a spill of diesel fuel from a barge on the East channel in summer. It also examines the possibility that just an awareness of such a spill will affect harvest because of a concern or perception of taint.

Tainting as a result of exposure to hydrocarbons was also discussed and evaluated in relation to an island blowout (See Sub-Hypothesis C-17C). As was pointed out in that discussion, tainting may occur as a result of absorption through the skin, however, the more usual modes of uptake are through respiration (via gill tissue) and/or ingestion. If ambient concentrations are low, days or weeks may be required to acquire a taint, but if concentrations are high, tainting may require only a day or so. The taint can be eliminated through depuration in a clean environment. This process can take weeks or months to complete.

Also, reviews of case histories of tainting indicate that the risk of tainting is higher in coastal waters than in offshore areas where rapid dispersion reduces the risk of exposure to concentrations of dissolved or particulate matter that would cause a taint.

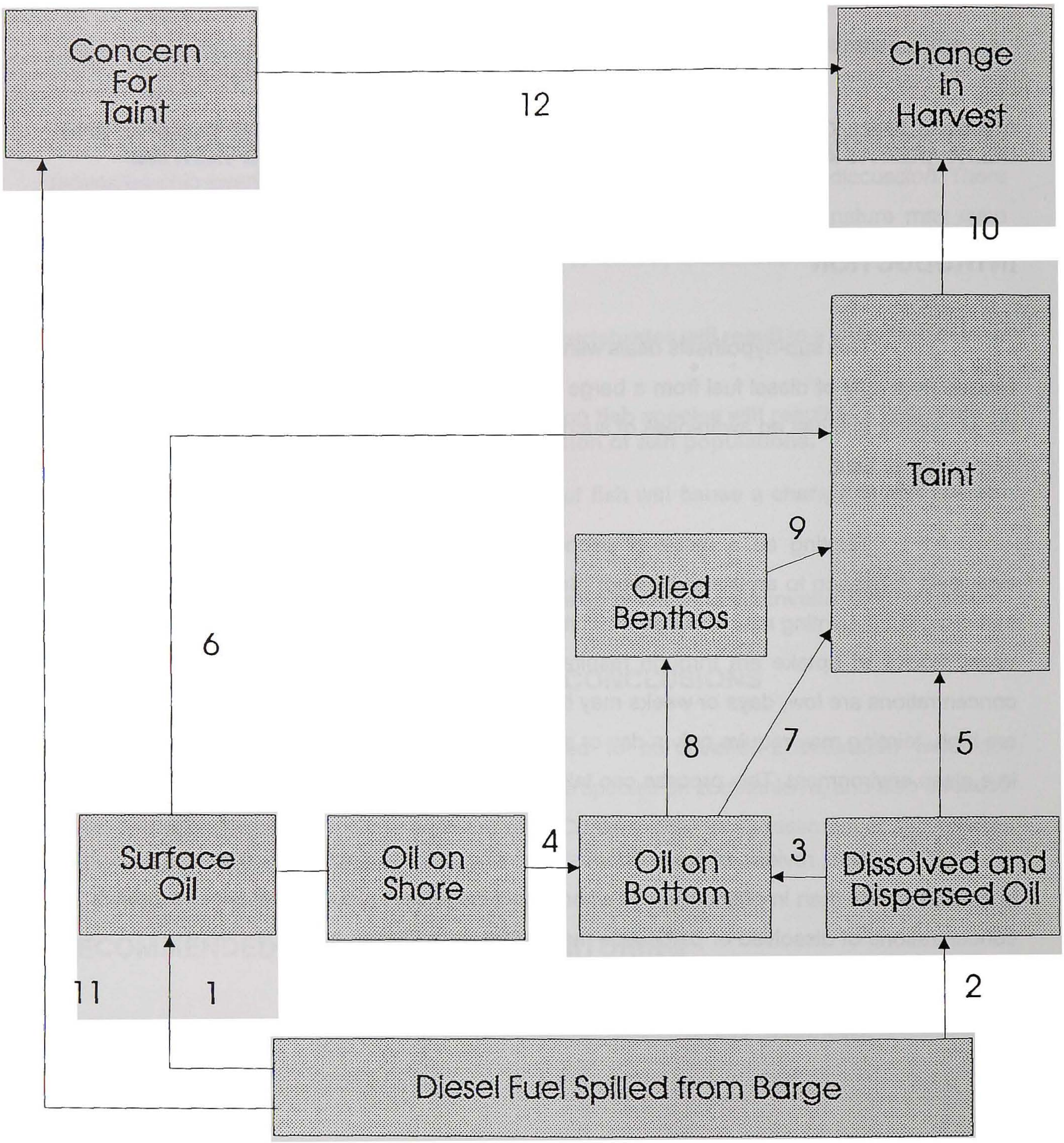

Figure 4-28: BREAM Hypothesis C-18C - Change in Fish Harvest Due to Tainting following a Diesel Oil Spill

Linkages for Sub-Hypothesis 18C

1. Oil spilled in the water will result in oil spreading on the water surface and volatile components of the oil will evaporate.
2. A portion of the oil will dissolve and some will be dispersed in the river water column and be transported downstream.
3. A portion of the diesel oil will be adsorbed to particulates in the water column and sink to the bottom at some downstream location. Residue from any countermeasure burning will disperse and sink also.
4. Some surface oil will sporadically strand on the shoreline and may subsequently be re-introduced into the water, most of which will sink to the bottom.
5. Oil dissolved in water will cause a taint in fish that are in contact with that water.
6. Fish that come into contact with surface oil will become tainted.
7. Fish that come into contact with, or ingest oil on the bottom, will become tainted.
8. Benthic invertebrates will uptake oil and become contaminated.
9. Ingestion of oil-contaminated bottom prey will cause a taint in fish.
10. The presence of tainted fish will cause a change in harvest rate and/or pattern.
11. The knowledge of an oil spill on the MacKenzie River will cause concerns that fish will be tainted and be unfit for consumption.
12. A concern for, or an expectation of taint, will result in a change in harvest rate and/or pattern.

EVALUATION OF LINKAGES

Link 1: **Oil spilled in the water will result in oil spreading on the water surface and volatile components of the oil will evaporate.**

Link 2: **A portion of the oil will dissolve and some will be dispersed in the river water column and be transported downstream.**

Link 3: **A portion of the diesel oil will be adsorbed to particulates in the water column and sink to the bottom at some downstream location. Residue from any countermeasure burning will disperse and sink also.**

Link 4: **Some surface oil will sporadically strand on the shoreline and may subsequently be re-introduced into the water, most of which will sink to the bottom.**

The linkages are **valid**. Refer to Sub-hypothesis C-18A for discussion.

Link 5: **Oil dissolved in water will cause a taint in fish that are in contact with that water.**

This link is **valid** for all the VEC populations. The likelihood of taint will be influenced by the length of time that fish are exposed, by the fat content of the fish, and by the concentration of dissolved oil in water. Broad whitefish and inconnu are the most susceptible to uptake due to the fatty nature of their muscle tissue, however, they are migratory, and unlikely to suffer prolonged exposure to significant exposure. Burbot might be expected to endure longer exposure, and their livers may become tainted because of the high fat content of this organ. Northern pike are the least fat of any of the VECs evaluated, and would be expected to be exposed similar to burbot.

Link 6: **Fish that come into contact with surface oil will become tainted.**

The link is conceptually valid. However, none of the species evaluated are surface feeders, and so the linkage is **invalid** in this circumstance.

Link 7: **Fish that come into contact with, or ingest oil on the bottom, will become tainted.**

This link is **valid** for broad whitefish because of their bottom-feeding nature. It is likely that were some amount of oil on the bottom, it could be ingested by broad whitefish. The degree to which oil would become incorporated into sediments is unknown and is a recommended area of research (See Sub-hypothesis C-18A). The link is also **valid** for burbot, which, although piscivorous, spend much of their time resting on bottom sediments. This is not a prominent pathway for taint however (See discussion in Sub-hypothesis C-17C). The link is **invalid** for northern pike or inconnu, both of which are piscivorous fish seldom in contact with bottom sediments.

Link 8: Benthic invertebrates will uptake oil and become contaminated.

The link is **valid**. Refer to discussion in Sub-hypothesis C-17C.

Link 9: Ingestion of oil-contaminated bottom prey will cause a taint in fish.

The link is **valid** for broad whitefish that consume large amounts of benthic infauna such as small clams and snails. Validity for northern pike, inconnu and burbot was also suggested based on the acquisition of taint from feeding on forage fish that have accumulated diesel oil (or its metabolites) either from feeding on contaminated benthos, or from direct contact with dissolved oil. Aspects of taint bioaccumulation was suggested as a potential area of research.

Link 10: The presence of tainted fish will cause a change in harvest rate and/or pattern.

The link was considered **valid** for all VEC species. Link 9, Sub-hypothesis C-17C discusses the validity of a similar link.

Link 11: The knowledge of an oil spill on the MacKenzie River will cause concerns that fish will be tainted and be unfit for consumption.

The link is **valid**. See Link 10, Sub-hypothesis C-17C.

Link 12: **A concern for, or an expectation of taint, will result in a change in harvest rate and/or pattern.**

The link is **valid**. See Link 11, Sub-hypothesis C-17C.

ASSESSMENT OF SIGNIFICANCE AND CONCLUSIONS

The overall sub-hypothesis was considered to be **valid** for the Valued Social Components. The anticipated consequences of the taint-related oil spill effects to the Valued Ecosystem Component populations is **invalid** as the concern is focused on the harvest aspect of the resources, not the ecological consequences (see Sub-hypothesis C-18A for discussion and evaluation of this aspect.

Valued Social Component	Responses to Questions of Significance (ref. to Figure 4-14)			
	Question #1	Question #2	Question #3	Conclusion
Broad Whitefish	Probable	No	Long-term	Class 2 - Significant Concern for taint is likely to persist (Link 12) in the absence of actual risks (Links 5 and 9) to these species; concern may persist into the next year.
Inconnu	Probable	No	Long-term	Class 2 - Significant As above
Burbot	Probable	No	Long-term	Class 2 - Significant As above
Northern Pike	Probable	No	Long-term	Class 2 -Significant As above

RECOMMENDED RESEARCH AND MONITORING

Research was recommended to determine hydrocarbon depuration rates of more local fish species, and to develop a better understanding of the effect of suspended particulates on the acquisition of taint, and on bioaccumulation aspects of taint.

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5. FUTURE ACTIVITIES OF BREAM

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This final report section discusses briefly the views of the BREAM project sponsors (Indian and Northern Affairs Canada, Environment Canada, and the Department of Fisheries and Oceans) in terms of the future directions of the program. As funding for BREAM under NOGAP is only assured for one more year (1993/1994) and in the absence of any near-term oil and gas development proposals for the Beaufort Sea region, it must be assumed that next year will mark the end of the BEMP/ MEMP/BREAM series of programs that have spanned more than a decade. This should be taken into consideration during the final design of the 1993/1994 BREAM program.

At present, it is envisioned that BREAM will have three quite distinct objectives in 1993/1994. These are given below and described in subsequent sections.

1. **SYNTHESIS** - One of the primary objectives of the last year of BREAM should be to provide a synthesis of the highlights and accomplishments of each year of BEMP, MEMP and BREAM over the period from 1983 to 1994.

2. **ASSESSMENT** - BREAM project sponsors should consider whether any further work should be carried out during the last year of BREAM regarding the development of an assessment methodology for future Beaufort Sea/Mackenzie Delta hydrocarbon projects. This should take into account the review of the Duval and Vonk procedure that was contracted by the Environmental Impact Review Board.

3. **COMMUNITY-BASED CONCERNS** - There are a number of outstanding issues that have been raised in the past two years by members of the Community-based

Concerns Technical Working Group; BREAM should attempt to address as many of these as possible in its final year.

5.1 Synthesis of Past Activities

Many people still believe that production of oil and/or gas reserves will occur from the Beaufort Sea/Mackenzie Delta region at some time in the 21st century when the demand for these resources will almost certainly justify the relatively expensive production and transportation costs. When this occurs, it will be extremely useful to have a document available that examines all of the efforts of BEMP, MEMP and BREAM over the past decade. These projects have been very successful in meeting most of their stated objectives and in providing the vehicle for cooperative evaluation, by government, industry, and northern communities, of research and monitoring priorities related to hydrocarbon development in the region. It will be important not to lose sight of the successes of BEMP, MEMP and BREAM, and a retrospective analysis and review of the projects in 1993/1994 will help ensure that future resource managers and decision-makers in both industry and government have some legacy of the efforts of hundreds of individuals involved in, or affected by northern development in some way since the first BEMP project was initiated in 1983 (see Appendix F).

The recommended synthesis and objective evaluation of past activities of these projects should examine a number of aspects of BEMP, MEMP and BREAM including (but not necessarily restricted to):

- Changes in the development scenario since 1983 and those aspects of development which appear to be most probable by virtue of their longevity in the long-term planning documents prepared by oil and pipeline industry engineers and planners since the early 1970s.

- The original suite of environmental issues associated with hydrocarbon development in this region at the time of the 1982 Beaufort Sea/Mackenzie Delta

Hydrocarbon Development EIS prepared by Dome, Esso and Gulf, and how these concerns have been alleviated and focused by BREAM and its predecessors.

- A review of the research and monitoring recommendations that have resulted from these programs, including an analysis of those recommendations that were acted upon, and the value of these studies in terms of addressing the original concern as articulated through some impact hypothesis evaluated in one of our many workshops.

- A clear statement of those issues (environmental, social and economic) inherited by BEMP, MEMP and BREAM, or arising during the course of our work in the past 10 years, that have not yet been resolved for one reason or another. This information will be extremely valuable to any agencies or organizations involved in future assessments of the implications of hydrocarbon development in the western Arctic.

5.2 Environmental Assessment

When BREAM was initiated in 1991, its sponsors wanted environmental assessment to become much more of an integral part of the process than had been the case with its predecessors BEMP and MEMP. Assessment goals became part of its overall objectives and the name of the new project was selected to incorporate the word "assessment" to reinforce this goal. However, it is fair to say that BREAM has only been a partial success in this area for at least two reasons.

- The Duval and Vonk procedure uses the terms "significant", "insignificant" and "unknown" to categorize the severity of potential impacts rather than terms used in earlier Beaufort assessments such as "major", "moderate", "minor" and "negligible". Because of the legal implications of the use of these words in a post-Rafferty assessment environment, there has been a reluctance among some

BREAM participants to use these terms. BREAM participants were concerned that these terms might be taken out of context and applied to a future environmental assessment of hydrocarbon activity.

- The Environmental Impact Review Board (EIRB) funded a review of the Duval and Vonk (1991) procedure to determine its suitability for use in public reviews conducted by the Board. Unfortunately, this evaluation was not undertaken in time to be considered in discussions of a BREAM assessment methodology.

The review of the Duval and Vonk procedure has subsequently led to recommendations for a guideline approach to environmental assessment for future EIRB reviews. In light of this and possible acceptance of this approach by the EIRB, the BREAM project sponsors should consider whether further work in development of an assessment methodology is necessary during the final year of BREAM.

5.3 Community-based Concerns

There have now been two meetings of the Community-based Concerns Technical Working Group and a large number of recommendations for further action have been made in this report (Section 3) and in last year's BREAM report (INAC 1992). Clearly, the strongest recommendation is the call for a program to investigate social and economic concerns of northerners related to hydrocarbon development. Neither the BREAM program sponsors or anyone involved in the management of this project disagree that this is an important need that will have to be satisfied prior to further hydrocarbon development in the region. However, there are a several reasons why this initiative should not be pursued in BREAM next year.

- NOGAP is not the appropriate funding source for a project that is to address social and economic concerns related to oil and gas development.

- The BREAM framework and tools used for this project are likely to be inappropriate to adequately address these concerns as they have been designed to evaluate ecological questions.

- It will take more than one year to begin to adequately treat the host of social and economic questions that would accompany hydrocarbon development in the western Arctic. It would likely be a grave injustice to attempt to start this important process in a project which is in its last year.

Other recommendations of this Working Group may be far more appropriate to tackle during BREAM in 1993/1994. One of the most important of these will be to provide a synthesis of the community-based concerns identified during the past in various land-use planning processes. This synthesis would be a valuable document that could be passed on to whatever agency eventually initiates a project to help resolve the larger issue described above. As part of this synthesis, it will be important to identify, in the case of ecological concerns, which issues have been fully or partially addressed by BEMP/MEMP/BREAM and which issues remain outstanding.

APPENDIX A

LIST OF PARTICIPANTS
PROJECT INITIATION MEETING

November 27, 1992
Richmond, B.C.

LIST OF PARTICIPANTS
PROJECT INITIATION MEETING

November 27, 1992
Richmond, B.C.

NAME	AFFILIATION
Martin Bergmann	Department of Fisheries and Oceans
Dave Bernard	ESSA Environmental and Social Systems Analysts Ltd.
Ian Buist	SL Ross Environmental Research Limited
Wayne Duval	Axys Environmental Consulting Ltd.
Richard Hoos	Trans Canada Pipelines Ltd.
Laura Johnston	Environment Canada
Anne Snider	Indian and Northern Affairs Canada
Patricia Vonk	Axys Environmental Consulting Ltd.

APPENDIX B

LIST OF PARTICIPANTS
COMMUNITY-BASED CONCERNS WORKING GROUP MEETING

January 12, 1993
Yellowknife, N.W.T.

PARTICIPANT LIST
COMMUNITY-BASED CONCERNS WORKING GROUP MEETING

January 12, 1993
Yellowknife, N.W.T.

NAME	AFFILIATION
Joe Benoit	Gwich'in Tribal Council
Dave Bernard	ESSA Environmental and Social Systems Analysts Ltd.
Johnny Charlie	Porcupine Caribou Management Board
Brian Fergusson	Department of Fisheries and Oceans
Jeff Green	Delta Environmental Management Group Ltd.
Bruce Hanbidge	Wildlife Management Advisory Council (NWT)
Brian Herbert	Indian and Northern Affairs Canada
Charlie Hoagak	Inuvialuit Game Council
Richard Hoos	Trans Canada Pipelines Ltd.
Laura Johnston	Environment Canada
Steve Kotchea	Fort Liard Band
Douglas Matthews	GNWT - Energy, Mines and Petroleum Resources
Jillian McKee	Deh Cho Regional Council
John Nagy	GNWT - Renewable Resources
Frank Pope	Sahtu Regional Council
Anne Snider	Indian and Northern Affairs Canada

APPENDIX C

LIST OF PARTICIPANTS
CATASTROPHIC OIL SPILL WORKING GROUP PLANNING MEETING

January 14, 1993
Richmond, B.C.

LIST OF PARTICIPANTS
CATASTROPHIC OIL SPILL WORKING GROUP PLANNING MEETING

January 14, 1993
Delta Pacific Hotel, Richmond, B.C.

NAME	AFFILIATION
Dave Bernard	ESSA Environmental and Social Systems Analysts Ltd.
Ian Buist	SL Ross Environmental Research Limited
Rolph Davis	LGL Environmental Research Associates Ltd.
Lynne Dickson	Environment Canada, Canadian Wildlife Service
Wayne Duval	Axys Environmental Consulting Ltd.
Jeff Green	Delta Environmental Management Group Ltd.
John Harper	Coastal and Ocean Resources Ltd.
Richard Hoos	Trans Canada Pipelines Ltd.
Steve Johnson	LGL Environmental Research Associates Ltd.
Michael Lawrence	North/South Consultants Inc.
Anne Snider	Indian and Northern Affairs Canada
Dave Thomas	Axys Environmental Consulting Ltd.
Patricia Vonk	Axys Environmental Consulting Ltd.

APPENDIX D

LIST OF PARTICIPANTS
CATASTROPHIC OIL SPILL WORKSHOP

February 22-25, 1993
Inuvik, N.W.T.

LIST OF PARTICIPANTS
CATASTROPHIC OIL SPILL WORKSHOP

February 22-25, 1993
Inuvik, N.W.T.

NAME	AFFILIATION
Joe Benoit	Gwich'in Tribal Council
Dave Bernard	ESSA Environmental and Social Systems Analysts Ltd.
Richard Binder	Inuvialuit Game Council
Stephen Charlie	Environment Canada
Sue Cosens	Department of Fisheries and Oceans
Rolph Davis	LGL Environmental Research Associates Ltd.
Lynne Dickson	Environment Canada, Canadian Wildlife Service
Wayne Duval	Axys Environmental Consulting Ltd.
Albert Elias	Environmental Impact Review Board
Brian Fergusson	Department of Fisheries and Oceans
Jan Gayle	Shell Canada Ltd.
Jeff Green	Delta Environmental Management Group Ltd.
Bruce Hanbidge	Wildlife Management Advisory Council (NWT)
John Harper	Coastal and Ocean Resources Ltd.
Lois Harwood	Department of Fisheries and Oceans
John Hayes	Interprovincial Pipelines Ltd.
Charlie Hoagak	Inuvialuit Game Council
Laura Johnston	Environment Canada
Steve Kotchea	Fort Liard Band
Michael Lawrence	North/South Consultants Inc.
Dick Levagood	Shell Canada Ltd.
Ian Marr	Canadian Coast Guard
Jim McComisky	National Energy Board

LIST OF PARTICIPANTS (Continued)
CATASTROPHIC OIL SPILL WORKSHOP

February 22-25, 1993
Inuvik, B.C.

NAME	AFFILIATION
George McCormick	Indian and Northern Affairs Canada
Jim McDonald	Shell Canada Ltd.
Doug Mead	Shell Canada Ltd.
John Nagy	Government of the Northwest Territories
Marshall Netherwood	Environmental Impact Review Board
Leo Norwegian	Deh Cho Regional Council
John Richardson	LGL Environmental Research Associates Ltd.
Anne Snider	Indian and Northern Affairs Canada
Norm Snow	Joint Secretariat
Murray Swyripa	Indian and Northern Affairs Canada
Dave Thomas	Axys Environmental Consulting Ltd.
Willem Van De Pypekamp	Shell Canada Ltd.
Patricia Vonk	Axys Environmental Consulting Ltd.
Bob Webb	Webb Environmental Services

APPENDIX E

1992/1993 PROGRAM UPDATES

Update #3, December 1992

BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

The purpose of this update is to advise you of the activities which are underway for the third year (1992/1993) of the Beaufort Region Environmental Assessment and Monitoring Program (BREAM). Work was initiated in November 1992 with a project meeting involving representatives from the client agencies (Indian and Northern Affairs Canada, Environment Canada, and Fisheries and Oceans Canada), an industry representative, and members of the study team. Between December 1992 and March 1993, a number of activities are planned for the Community-based Concerns Working Group and the Catastrophic Oil Spill Working Group, which were established as part of the 1991/1992 BREAM program. This will involve two technical meetings of the Working Groups, as well as an interdisciplinary workshop focusing on issues related to catastrophic oil spills and associated cleanup response activities.

During the 1991/1992 BREAM program, the Community-based Concerns Working Group held their first meeting. Representatives from northern communities identified a number of ecological concerns and issues that they believe should be considered in environmental assessments of future hydrocarbon developments in the Beaufort Sea/Mackenzie Delta and Valley region. Central to all these issues was harvestable food resources and the overall quality of the northern environment. While many of the issues (such as fish quality, increased ambient noise and traffic, and cumulative effects of industrial developments) are now reflected in existing BREAM hypotheses related to routine aspects of development, there may be additional community-based environmental concerns that need to be addressed through BREAM. A technical meeting of the Working Group is scheduled for early January 1993 in Yellowknife to define these additional concerns and ensure that all community-based ecological concerns brought forward are adequately incorporated into the process. Members of the Working Group will also refine the conceptual model developed last year for accessing and incorporating traditional and local knowledge into the BREAM program.

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. To date, BREAM and its predecessors (BEMP and MEMP) have focused solely on issues related to routine aspects of hydrocarbon development. Concerns related to the effects of catastrophic oil spills and cleanup on resources and resource use have now been addressed through spill scenarios (involving well blowouts, onshore pipeline ruptures, barge spills and refined fuel spills on winter roads) and associated impact hypotheses, which were developed by the Catastrophic Oil Spill Working Group last year. BREAM is now in a position to deal with this topic through an interdisciplinary workshop approach. For this reason, the primary emphasis of this year's activities will be placed on catastrophic oil spills.

In preparation for a workshop this year, a technical meeting of the Catastrophic Oil Spill Working Group will be held in January 1993 to: (1) refine the oil spill impact hypotheses that will be evaluated in the workshop; (2) modify these hypotheses to include any community-based environmental concerns that are identified during the technical meeting of the Community-based Concerns Working Group scheduled for January 1993 and have yet to be reflected in the existing linkages; and (3) prepare any documents that will be required at the workshop.

A 3-day workshop is scheduled for mid February in Inuvik, N.W.T. to evaluate nine of the 18 impact hypotheses that have been developed around the spill scenarios. As in past years of the program, a number of individuals from government, industry and northern communities will be invited to participate in this workshop. Its primary objectives will be to review the hypotheses in terms of the adequacy of existing information, conduct a preliminary assessment of each hypothesis, and identify future research and monitoring requirements.

A final report for this year's BREAM program will be prepared by late March 1993. This will include the results of the technical meeting of the Community-based Concerns Working Group and any background material prepared by this group, work undertaken by the Catastrophic Oil Spill Working Group, and results of the workshop including any research and monitoring programs recommended by workshop participants.

If you have any comments or questions regarding BREAM, please contact one of the following individuals.

Anne Snider
NOGAP Coordinator
Indian and Northern Affairs Canada
Hull, Quebec
(819)997-0046

Wayne Duval
Project Manager
Axys Environmental Consulting Ltd.
Vancouver, B.C.
(604)687-3385

BREAM Update #4 - March 1993

BEAUFORT REGION ENVIRONMENTAL ASSESSMENT AND MONITORING PROGRAM

Since Update #3 was issued in December 1992, there have been several significant accomplishments of the 1992/1993 Beaufort Region Environmental Assessment and Monitoring (BREAM) program. The primary emphasis of BREAM this year was on catastrophic oil spills and their potential impact on harvestable resources and the habitat of important fish and wildlife resources. A planning meeting and technical meetings of the Catastrophic Oil Spill and Community-based Concerns Working Groups were held earlier this year, and were followed by a 3-day interdisciplinary workshop to identify research and monitoring needs associated with major oil spills and cleanup/response activities in the Beaufort Sea, Mackenzie Delta and Valley regions.

The 1992/1993 BREAM program began with a planning meeting in Richmond, B.C. during November 1992. During this meeting, nine impact hypotheses were selected for review at this year's interdisciplinary workshop from a larger number formulated by the study team last year. These hypotheses were expected to address those issues of greatest scientific and community concern in the event of an oil spill. To followup on this review and prepare for the workshop on oil spills, a technical meeting of the Catastrophic Oil Spill Working Group was held in January 1993. The group was charged with the responsibility of: (1) modifying the spill scenarios (i.e., timing and location), where necessary, to best represent a worst case for each hypothesis; (2) refining the list of VECs[1] and VSCs[2] for each hypothesis; and (3) altering the hypothesis structure and wording to reflect suggestions made by the Community-based Concerns Working Group. This review led to the selection of nine impact hypotheses involving four different oil spill scenarios, which consider the potential direct and indirect (i.e. spill response activities) impacts of:

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

[1]*VEC - Valued Ecosystem Component*
[2]*VSC - Valued Social Component*

While the primary focus of BREAM in 1992/1993 was on catastrophic oil spills, it was also essential to continue and advance the progress of the Community-based Concerns Working Group. A one-day technical meeting of the Group was held in Yellowknife in January, 1993 to: (1) identify ecological concerns of northerners specifically related to large oil spills and their cleanup: (2) continue examining a process for identifying community-based ecological concerns and incorporating local and traditional knowledge into BREAM; (3) review the BREAM impact hypotheses related to routine aspects of hydrocarbon development to evaluate if previously-identified concerns have been adequately addressed; and (4) identify and refine community-based concerns not addressed by either the catastrophic oil spill hypotheses or hypotheses related to routine aspects of development. The single most important issue identified at the meeting was that social and economic concerns related to northern oil and gas development are not currently being addressed by BREAM or any other program. Participants recommended that a process to address socio-economic concerns of northern residents be established and that this program be integrated with and complement the BREAM process rather than exist as a separate parallel process.

The Community-based Concerns Working Group identified a number of outstanding tasks that should be completed by the Group and/or the program sponsors. In addition to some minor changes to the existing impact hypotheses, the group recommended that a review of recent land-use planning documents be undertaken to identify oil and gas-related issues that have not been identified previously through the BREAM process.

The most challenging work of BREAM this year involved the interdisciplinary workshop. It focussed on a number of complex issues specifically related to the effects of large oil spills and their cleanup on resources and resource use, and culminated in the identification of research and monitoring priorities related to spills in the Beaufort and Mackenzie regions. The workshop was held in Inuvik, N.W.T. on February 21 - 25, 1993 and was attended by 37 individuals from government, industry, and northern communities and organizations.

Despite the fact that this is the first year in which BREAM or its predecessors BEMP and MEMP have addressed the issue of oil spills, participants identified few research needs related to assessing the potential risks to and effects of large oil spills on fish and wildlife resources. Most of the recommendations involved post-spill research and monitoring programs to assist in the assessment of impact and recovery/restoration of resources and resource uses after potential spills. Some of the research and monitoring priorities identified during the workshop were as follows.

Marine Mammals and Fish

- *Post-spill sampling program for beluga to determine the effects of oil on the skin and internal organs; additional collection and archiving of pre-spill tissue samples may be required to ensure adequate baseline data.*

- *Post-spill monitoring of beluga and bowhead whale behaviour to determine their responses to oil and cleanup activities.*

- *Research to determine the effects of oil on homing abilities of spawning charr.*

- *Research to determine the relationships between oil and fine particulates and subsequent bioavailability of oil and tainting of fish tissue.*

- *Research to determine the rates that local fish species may depurate petroleum hydrocarbons.*

- *Monitoring to document liver condition for harvested fish species, and continued archiving of tissue samples.*

Birds

- *Pre-spill monitoring programs for some of the valued bird species occurring in the southeastern Beaufort Sea, in addition to the loon monitoring program already initiated by Canadian Wildlife Service.*

- *Monitoring program to determine the stopover and turnover patterns of brant migrating along the Beaufort Sea, and eider ducks migrating offshore.*

- *Determine the susceptibility of the Cape Parry thick-billed murre colony to oil spills by examining existing aerial- and boat-survey data on the temporal and spatial patterns of larger colonies in the Canadian High Arctic.*

- *In the event of a large oil spill, a number of field monitoring programs should be initiated, including: (1) systematic surveys to determine changes in the abundance of birds; (2) monitoring to determine the effectiveness of scare efforts; and (3) documentation of the effects of the spill and response on hunting activities and success.*

- *Field tests of the effectiveness of selected bird scaring devices under Beaufort Sea conditions.*

Terrestrial and Semi-Aquatic Mammals

- *A literature review of existing information regarding the chronic and acute effects of oil on terrestrial and semi-aquatic mammals, in particular grizzly bear, muskrat, mink and moose. The subgroup recommended opportunistic research be conducted if major information gaps in the database exist.*

The Final 1992/1993 BREAM report is currently being prepared and will be available for distribution by early to mid July, 1993. This report will include the results of each of the Technical Working Group meetings, and the interdisciplinary workshop.

If you have any questions 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.

APPENDIX F

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

Page 1

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Able, Alice	Dene Nation					■			
Adams, Stewart	Ma. Delta Reg. Council			■		■			
Alexander, Stewart	Canadian Wildlife Service					■			
Allard, Jim	Great Bear DIZ			■		■			
Allison, Lorraine	Salix Enterprises			■					
Andre, Dan	Gwitch'in Tribal Council							■	
Andrew, Tom	University of Alberta					■			
Andriashek, Dennis	Canadian Wildlife Service	■							
Antoniuk, Terry	**Gulf Canada Resources**			■	■	■	■		
Aviugana, Alex	**Inuvialuit Game Council**			■	■	■		■	
Babaluk, John	DFO							■	
Bailey, John	Inuvialuit Game Council							■	■
Balanoff, Wayne	INAC					■			
Bannon, Peter	INAC				■				
Barchard, Wayne	Environment Canada	■							
Barry, Tom	Canadian Wildlife Service	■							
Bastedo, Jamie	GNWT					■			
Beckstead, Gary	HBT Agra Ltd.							■	
Bell, Bob	FJMC						■		
Benoit, Joe	Gwitch'in Tribal Council								■
Bergmann, Martin	DFO						■	■	■
Bernard, Dave	**ESSA Ltd.**				■		■	■	■
Birchard, Evan	Esso Resources Ltd.	■					■	■	
Birdsall, Alan	LGL Ltd.	■	■	■					
Blasco, Steve	EMR	■							
Bond, Bill	DFO	■	■			■			
Boothroyd, Peter	Canadian Wildlife Service					■			

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM
Page 2

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Borstad, Gary	G.A. Borstad Assoc. Ltd.		■	■					
Bradstreet, Michael	LGL Ltd.			■	■				
Braham, Howard	NOAA (USA)		■						
Brakel, Bill	**Environment Canada**	■	■	■	■	■	■		
Bromley, Bob	GNWT					■			
Bruchett, Doug	Petro-Canada			■					
Buchanan, Bob	LGL Ltd.						■		
Budgell, Paul	DFO		■		■				
Buist, Ian	SL Ross Env. Res. Ltd.							■	■
Bunch, Jim	DFO	■							
Carpenter, Andy	Inuvialuit Game Council		■						
Chang-Kue, Ken	DFO					■		■	
Charlie, Johnny	Porcupine Car. Mgt. Bd.							■	■
Charlie, Stephen	Environment Canada								■
Clarkson, Peter	GNWT					■			
Connacher, Barry	Barcon Ltd.					■			
Cook, Greg	INAC					■			
Cosens, Sue	DFO				■			■	■
Cowles, Cleve	Min. Man. Serv. (USA)			■					
Cretney, Walter	DFO				■				
Cubbage, James	Cascadia Research (USA)				■				
Cullen, Andrew	INAC		■	■					
Danielewicz, Ben	Dome Petroleum Ltd.	■	■						
Davies, Stuart	North/South Consult. Inc.				■			■	
Davis, Rolph	**LGL Ltd.**	■	■	■	■		■	■	■
de Lange Boom, Bodo	Seakem Oceanog. Ltd.				■				
de March, Larry	DFO						■	■	

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

Page 3

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Decker, Bob	GNWT					■			
DeLancey, Debbie	GNWT			■		■			
Devenis, Peter	Gulf Canada Res. Inc.				■		■		
Dickson, Lynne	**Canadian Wildlife Serv.**			■		■	■	■	■
Doran, Lee	Polar Gas			■					
Dowler, Don	FJMC								■
Dunbar, Max	McGill University	■	■						
Duval, Wayne	**Axys Envir. Consult. Ltd.**	■	■	■	■	■	■	■	■
Edwards, George	Beaufort DIZ		■						
Elias, Albert	**Inuvialuit Game Council**		■	■		■			■
Englehart, Rainer	COGLA				■				
English, Karl	LGL Ltd.	■							
Erickson, Paul	Seakem Oceanog. Ltd.						■		
Everitt, Robert	ESSA Ltd	■		■		■			
Fabijan, Michael	FJMC					■			
Federko, Len	Gulf Canada Res. Inc.				■				
Fergusson, Brian	DFO							■	■
Finley, Kerry	LGL Ltd.		■						
Fissell, David	**Arctic Sciences Ltd.**	■	■	■	■		■	■	
Fleck, Susan	GNWT			■		■			
Ford, John	ESL Envir. Sciences Ltd.				■				
Frost, Jennet	GNWT					■			
Fuller, Stephan	Cordillera Resources Ltd.	■							
Gallaway, Benny	LGL Ltd. (USA)	■							
Gayle, Jan	Shell Canada Ltd.								■
Geiselman, Joy	Min. Manag. Serv. (USA)	■							
Gell, Alan	Independent			■		■			
George, John	North Slope Bor. (USA)		■	■					

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

Page 4

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Gillam, Andy	CBR International Inc.				■				
Gilman, Vic	DFO					■			
Glaholt, Randal	GNWT				■	■			
Graf, Ron	GNWT			■		■			
Grant-Francis, Dyan	GNWT					■			
Green, Roger	Univ. Western Ontario				■				
Green, Nelson	Inuvialuit Game Council			■					
Green, Jeff	Delta Group Ltd.						■	■	■
Griffith, William	LGL Ltd.	■	■	■					
Guimont, Francois	INAC	■							
Hagen, Larry	GNWT					■			
Hall, Russ	GNWT					■			
Haller, Albert	INAC	■							
Hanbidge, Bruce	WMAC							■	■
Harper, John	**Coast. & Ocn. Res. Ltd.**	■	■				■	■	■
Harwood, Lois	**DFO**	■	■		■	■		■	■
Hawkes, Michael	YTG	■							
Hawkings, Jim	Canadian Wildlife Service					■			
Hayes, John	Interprov. Pipelines Ltd.								■
Heard, Doug	GNWT					■			
Herbert, Brian	INAC							■	
Hill, Philip	DFO	■							
Hoagak, Charlie	Inuvialuit Game Council							■	■
Hoeffs, Manfred	YTG						■		
Hoos, Richard	Trans Can. Pipelines Ltd.							■	■
Hubert, Ben	Boreal Ecol. Serv. Ltd.					■			
Hunt, John	Petro-Canada			■					

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

Page 5

NAME	AFFILIATION	83	84	85	86	87	90	91	92
Hurst, Ricki	**INAC**	■	■	■	■	■	■	■	
Jackson, Wilfred	Sahtu Regional Council							■	
Jakimchuk, Ron	Renewable Res. Ltd.					■			
Jandali, Tarek	ESL Envir. Sciences Ltd.	■							
Jessup, Harvey	YTG			■		■			
Johnson, Stephen	**LGL Ltd.**	■				■	■	■	■
Johnston, Laura	Environment Canada								■
Jones, Michael	ESSA Ltd.			■					
Josephson, Rick	DFO		■	■					
Kennedy, Gay	GNWT					■			
Kerr, Gordon	Environment Canada							■	
Kimmerly, Peter	Gulf Canada Res. Ltd.				■				
Kingsley, Michael	DFO	■	■			■			
Klein, Dave	University of Alaska (USA)							■	
Koshinsky, Gordon	DFO						■		
Kotchea, Steve	Fort Liard Band								■
Kristofferson, Allen	DFO					■			
Krutko, David	Mack. Delta Regn. Coun.			■		■		■	
Langford, Bob	Government of B.C.	■							
Langtry, Ted	INAC	■							
Laraque, Helena	GNWT							■	
Latour, Paul	GNWT							■	
Lawrence, Michael	**North/South Cons. Inc.**		■			■	■	■	■
Levagood, Dick	Shell Canada Ltd.								■
Little, Lois	Lutra Associates Ltd.					■		■	
Lloyd, Kevin	GNWT					■			
Lockhart, Lyle	DFO							■	

DIRECTORY OF INDIVIDUALS HISTORICALLY INVOLVED IN BEMP, MEMP AND BREAM

Page 6

NAME	AFFILIATION	83	84	85	86	87	90	91	92
MacDonald, Jim	Shell Canada Ltd.								■
Mackas, Dave	**DFO**	■	■	■	■				
Mackenzie-Grieve, George	Environment Canada					■			
Mageau, Camille	INAC		■		■				
Mansfield, Arthur	DFO	■							
Marko, John	Arctic Sciences Ltd.	■	■						
Marmorek, David	ESSA Ltd.	■	■						
Marr, Ian	Canadian Coast Guard								■
Martens, Harvey	HBT Agra Ltd.						■	■	
Matthews, Steve	GNWT			■		■		■	
Matthews, Doug	GNWT						■		■
Matthews, Lorne	GNWT							■	
McCallum, John	Dene Nation					■			
McCart, Peter	Aquatic Environments Ltd.			■					
McComiskey, Jim	National Energy Board	■	■						■
McCormick, Kevin	Canadian Wildlife Service					■			
McCormick, George	INAC						■		■
McCue, Cara	GNWT							■	
McDonald, Rob	DFO		■						
McDonald, John	ESL Env. Sciences Ltd.	■		■		■			
McFarland, Fred	INAC		■	■					
McInnes, Kay	INAC					■		■	
McKee, Jillian	Deh Cho Regional Coun.								■
McKinnon, George	DFO					■			
McLaren, Peter	LGL Ltd.			■					
McLaren, Margaret	LGL Ltd.			■					
McNamee, Peter	**ESSA Ltd.**	■	■	■	■			■	

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NAME	AFFILIATION	83	84	85	86	87	90	91	92
Mead, Doug	Shell Canada Ltd							■	■
Meisner, Doug	ESSA Ltd.							■	
Melling, Humphrey	DFO	■	■	■					
Mendo, Maurice	Great Bear DIZ			■		■			
Metikosh, Serge	INAC	■							
Miles, Mike	M. Miles Assoc. Ltd.			■		■			
Mills, Hal	INAC					■			
Moen, John	INAC			■					
Moll, David	INAC					■			
Montague, Jerome	Min. Manag. Serv. (USA)				■				
Moore, Steve	GNWT					■			
Moore, Anita	Boreal Institute					■			
Morrison, Robert	Gulf Canada Res. Inc.	■							
Mossop, Dave	YTG		■	■		■			
Muir, Langley	COGLA	■	■						
Murray, Carol	ESSA Ltd.							■	
Myers, Heather	GNWT		■	■				■	
Nagy, John	GNWT							■	■
Nasogaluak, Sheila	Beaufort/Mackenzie DIZ							■	
Nerini, Mary	Nat. Mar. Mam. Lb. (USA)				■	■			
Nixon, Wendy	Canadian Wildlife Service			■					
Norton, Pamela	PN Research Projects		■	■					
Norwegian, Leo	Deh Cho Regional Coun.								■
Nyder, Sheldon	GNWT					■			
O'Brien, Chris	Dene Nation			■					
Owens, Rob	Foothills Pipelines Ltd.						■	■	
Packman, Glen	Environment Canada				■				

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NAME	AFFILIATION	83	84	85	86	87	90	91	92
Payne, Jerry	DFO		■						
Pessah, Ed	**Dome Petroleum Ltd.**	■	■	■	■	■			
Pick, Archie	Interprov. Pipelines Ltd.			■					
Pierrot, Jim	Great Bear DIZ			■		■			
Poole, Kim	GNWT					■			
Pope, Frank	Sahtu Regional Council			■				■	■
Potter, Steve	SL Ross Env. Res. Ltd.							■	
Reist, Jim	DFO					■			
Robinson, Don	ESSA Ltd.							■	
Richardson, John	LGL Ltd.			■	■				■
Russell, Don	Canadian Wildlife Service							■	
Rose, Mike	ESSA Ltd.							■	
Schell, Don	**Univ. of Alaska (USA)**	■	■	■				■	
Schweinsburg, Ray	GNWT	■	■						
Scullion, John	INAC		■						
Searing, Gary	LGL Ltd.					■			
Sekerak, Aaron	**LGL Ltd.**	■	■	■		■			
Sergy, Gary	Environment Canada						■		
Shank, Chris	GNWT					■			
Sikstrom, Cal	Esso Resources Ltd.			■					
Simpson, Bob	Mack. Delta Reg. Coun.			■					
Smiley, Brian	**DFO**	■	■				■	■	
Smith, Tom	DFO		■						
Snider, Anne	INAC							■	■
Snow, Norm	Joint Secretariat							■	■
Sonntag, Nicholas	ESSA Ltd.	■	■	■					
Sopuck, L.	Renewable Res. Ltd.					■			

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NAME	AFFILIATION	83	84	85	86	87	90	91	92
Spearing, Ted	Chevron Can. Res. Ltd.						■		
Stein, Jeff	DFO			■					
Stenhouse, Gordon	GNWT					■			
Stephen, Bob	Lutra Associates Ltd.					■	■	■	
Stewart, Donna	INAC					■			
Stone, David	**INAC**	■	■	■	■				
Strong, Tom	DFO		■	■		■			
Sutherland, Glen	ESSA Ltd.			■					
Sutherland, Dave	Environment Canada			■					
Swyripa, Murray	INAC								■
Taylor, Mitch	GNWT					■			
Taylor, Ken	Polar Gas Ltd.					■			
Thomas, David	**Axys Env. Consult. Ltd.**	■	■	■	■	■	■	■	■
Thomson, Denis	LGL Ltd.	■	■						
Tricoteux, Lorne	INAC					■			
Usher, Peter	P.J. Usher Consult. Ltd.			■		■			
Van de Pypekamp, Willem	Shell Canada Ltd.								■
Vonk, Patricia	**Axys Env. Consult. Ltd.**		■		■		■	■	■
Ward, John	**Amoco Can. Pet. Ltd.**		■	■	■		■	■	
Wagner, Gary	EIRB							■	
Webb, Tim	ESSA Ltd.	■	■						
Webb, Bob	Webb Environ. Serv. Ltd.								■
Wiebe, John	Environment Canada	■							
Wilson, Robert	DFO		■						
Wilson, Brian	Environment Canada	■	■						
Wolfe, Robert	Alask Fish & Game (USA)			■					
Wolfe, Douglas	NOAA (USA)	■							

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NAME	AFFILIATION	83	84	85	86	87	90	91	92
Wolki, Fred	Inuvialuit Game Council				■				
Wong,Brian	DFO					■			
Younkin, Walt	HBT Agra			■			■		

Compiled by Wayne Duval, Axys Environmental Consulting Ltd., Vers. Date: 93-06-10

NOTES

1. This directory includes meeting and workshop participants, study team members and persons supplying information to the study team.
2. While an attempt has been made to include everyone that has contributed to these projects in the directory, there is no guarantee that the list is complete. I apologize to anyone I may have missed.
3. Several individuals have had more than one affiliation during the course of these projects - only their affiliation during the last year that they were involved in one of the projects is indicated.
4. Persons having participated in these projects for 4 years or more are designated as "veterans" and indicated in bold face type.

APPENDIX G

PROPOSAL: THE SHORE-ZONE AS A VALUED SOCIAL COMPONENT

John Harper
Coastal and Ocean Resources Ltd.

THE SHORE-ZONE AS A VALUED SOCIAL COMPONENT (VSC)

Justification for VSC

The shore-zone is considered a VSC in the context of an oil spill as the shore zone is important human-use "habitat". In the Beaufort Sea and Mackenzie River the shore zone is a focus for summer subsistence activities and has a growing importance in the ecotourism industry. Previous spills have demonstrated that a substantial portion of cleanup efforts focus on the shore zone independent of the environmental impact associated with stranded oil. The reason is that people, who are intensive users of the shore-zone in the arctic, don't like oil in the areas they use.

Links

Link 1 Some oil spilled (all scenarios) will reach the shore. The volume and oil character will depend on original spill source and distance of the source from the shore. Stranding will likely produce (a) surface oil and (b) subsurface oil, that penetrates into the beach.

Link 2 Because the shore tends to be a focus for subsistence and tourism activities during the open-water season, there is a strong potential for these activities to come into contact with oil on the shore (e.g., boats, net, walking/hiking, camping, cleaning).

Link 3 Oil stranded on the shore will be cleaned up to reduce environmental and human-use impacts.

Link 4 Cleanup activities will result in (a) cleanup personnel, (b) cleanup equipment and (c) aircraft and support vessel noise. Cleanup activities may result in restrictions in the use of the shore-zone.

Link 5 Cleanup activities may change the habitat (e.g., tire tracks left on the beach, burning of log debris) that may result in a less desirable human-use habitat.

Link 6 Fouling of boats, nets or camping gear or even the nearby presence of oil will result in decreased use of the shore zone.

Link 7 People, equipment and noise (and possibly use restrictions) will result in decreased use of the coastal zone.

Link 8 Alteration of the habitat from the *status quo* will result in decreased use (Note: the alternative is also possible in some cases, i.e. habitat improvement).

Link 9 Perceptions, either "informed" or "uninformed" are likely to result in decreased shore-zone use. This is true for both traditional and tourist use.

Link 10 In terms of traditional use, the decreased use of the coastal zone is likely to result in either a decreased harvest of species normally hunted from shore-zone camps or alternatively an altered harvest, where hunting activities are relocated to unoiled areas.

Assessment of Linkages

All links are valid and have been demonstrated during the *EXXON Valdez* and other spill incidents. The significance is likely to vary between spill scenarios as follows:

Offshore Blowout - it is unlikely that all the shoreline oiled in this scenario would be recovered in the first year so that the decreased use is judged significant, Class 2

Barge Spill - a barge spill of diesel would cause sporadic oiling of the river banks but would be unlikely to persist for more than one year. As such the impact is judged to be Class 3.

Pipeline spill - given the relatively small volumes of oil that would be stranded along the shore, cleanup could probably be accomplished within one open-water season. If the spill took place in late fall, cleanup might be required in the following open-water season but still would only disrupt one season's activities, i.e. a Class 3 significance.

Research or Monitoring

The links have been sufficiently well documented that there is no required research to establish their validity.

A monitoring program that provides good documentation on both traditional and tourist use of the coastal resource activities would be useful. In the event of a spill, this information would (a) establish a basis for compensation or (b) serve as a framework for assessing tradeoffs among cleanup alternatives (e.g., one year of intensive cleanup vs several years of low intensity of cleanup; heavy equipment vs manual cleanup). Much of the information for this could be collected through game councils and through tour operators.