PRELIMINARY SUMMARY REPORT
FOR WORKSHOP II
BEAUFORT ENVIRONMENTAL MONITORING PROJECT

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Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

December 15, 1983

Dr. John Tener,
Chairman,
Beaufort Sea Environmental
Assessment Panel.

Your file Votre référence

Our file Notre référence
N-5510-B1

Beaufort Sea Environmental Monitoring Program

The following is an update to the statement made to the Panel in Inuvik, entitled "The Beaufort Environmental Monitoring Program - DIAND" (IN 28). The update consists of a summary of results from the second workshop of this program.

The very preliminary nature of the document must be emphasised. It was originally planned for the workshop to be held in early January 1984, and for there to be a detailed report, due March 1, 1984. However, the panel requested that as much information on the program as possible be made available to them. In order to achieve this, two steps were taken.

i) The second workshop was advanced to the first week of December.

ii) A summary report was prepared in order that the Panel could clearly foresee the objectives and probable content of the detailed March 1984 report and of the program as a whole.

The summary report was prepared in a little over a week and was received by me less than two days ago. It has not been seen by Environment Canada (who have helped finance the program) or by many of the workshop participants. There has therefore been no opportunity for comments or editing by participants or by either Department, and there will undoubtably be considerable discussion before production of the detailed March 1984 report. However, I believe that the summary will provide the panel both with an excellant preview of the contents of the March 1984 report, and with an accurate insight into DIAND's planned approach to effects monitoring in the Beaufort offshore.

Finally the restricted objectives of the BEMP activity should also be re-emphasised. It is not intended to provide recommendations for a definitive research program to address all the fundmental knowledge gaps which exist for the Beaufort environment. The costs to remedy this situation will be very high and the outcome may still fail to address

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the issues which finally emerge as those of regulatory and public concern. The objective of the BEMP initiative is to identify and implement those research and effects monitoring activities which are considered to be required for the responsible management of a phased approach to the development of Beaufort Sea hydrocarbons, through the administration of the relevant legislation administered by DIAND. This should not detract from a recognition of our fundamental knowledge gaps in the Beaufort. Every encouragement should be given to those agencies with research responsibilities to conduct programs which reflect their particular missions in that area.

Yours sincerely,

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INTRODUCTION

This document is intended to supplement a previous submission to the BEARP Panel titled "Presentation to the BEARP Panel: The Beaufort Environmental Monitoring Program" and submitted during the General Session hearings held at Inuvik in November, 1983. Descriptions of the program's objectives, methodology, simulation model structure, and project status as of October, 1983 are contained in this earlier submission. The following material briefly describes the events leading to the second workshop, the workshop itself and its principal products.

During October and November of this year, a series of technical meetings focusing on each of the model subsystems were held to:

(1) review and refine the submodels in light of new information and/or new participants;

(2) introduce new participants to the model and process; and

(3) develop a series of hypotheses relevant to the subsystem that related hydrocarbon development in the Beaufort region to one or more of the Valued Ecosystem Components (VEC's).

Prior to the workshop, the recommended refinements were made to the model and the impact hypotheses were reviewed and summarized in a common flowchart - linkage format. The second workshop was held in Victoria, B.C. during the period from November 28 to December 2, 1983. Participants included most individuals that attended the first workshop, as well as additional expertise that was considered important based on discussions held during the first workshop and subsequent technical meetings (a list of participants at the second workshop is provided in Appendix I).

The workshop was organized around a series of 21 hypotheses regarding potential impacts of hydrocarbon development in the Beaufort region. On the first day, each hypothesis was reviewed by the participants, and following this review, the necessary modifications, additions or deletions were undertaken. For the next three days, each hypothesis was critically evaluated by one of five working groups and a monitoring/research strategy proposed where the hypothesis was considered worth testing. These working groups were different from the modelling sub-groups and were restructured each day to include a cross-section of expertise relevant to all aspects of the hypothesis under discussion.

The agenda for each days discussions included the following five steps:

(1) clarification of the hypothesis to reach a concensus on its structure and wording;

(2) description of existing knowledge for all linkages in the hypothesis including:

- evidence for and against
- uncertainties associated with each link
- other potentially useful information
- description of model projections (if appropriate);

(3) conclusion regarding the hypothesis consisting of one of:

- extremely unlikely and not worth testing
- possible but too difficult to detect
- requires more information before a monitoring plan can be designed
- should be tested with a detailed monitoring plan;

(4) description of recommended monitoring and research programs to test the hypothesis; and

(5) documentation of the above by the designated recorder and selected working group participants.

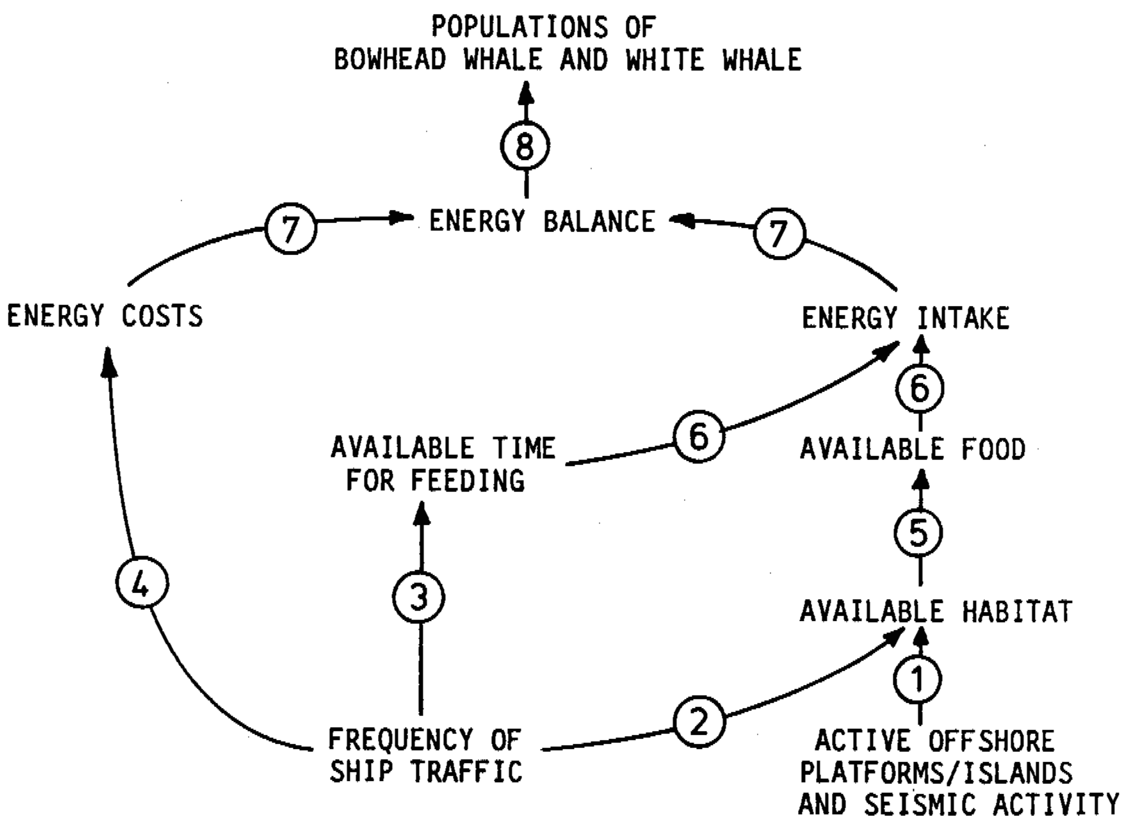
In addition to these "development to VEC" hypotheses, a working group was assembled to discuss various early warning monitoring strategies (e.g. "mussel watch", mixed function oxidase, etc.), which will be detailed in the final report. The final report will also include a discussion of ecosystem indicators (e.g., species diversity indices) and their potential value to the Beaufort Environmental Monitoring Program.

On the final day of the workshop the recorders presented brief summaries of subgroup discussions and conclusions regarding each impact hypothesis.

The documentation of this workshop is now being completed and the report is expected to be ready for distribution by 1 March 1984. Because the report is in an early stage of preparation, this summary must be regarded as preliminary and subject to change. Summaries of the 21 hypotheses examined during the second Beaufort Environmental Monitoring Project workshop are provided in the present report.

HYPOTHESIS NO. 1

Ship traffic, seismic programs and active offshore platforms and artificial islands will cause reductions in the western arctic population of bowhead whales.



LINKAGES

Link 1: Each active offshore structure will exclude bowhead whales from a zone surrounding the structure.

Although this is considered likely, the size of the zone is unknown.

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

It is likely that bowheads will be excluded from a zone approximately 1 to 2 km on each side of a passing ship, although the duration of this effect is not known. A more serious effect could occur if a large zone of exclusion resulted from the combination of industrial activities. There has been a steady decline in the use of the Beaufort industrial area by bowheads during the period from 1980 to 1983. However, it should be emphasized that these distribution patterns may be due to changes in food supply rather than the industrial activities.

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

This effect is substantiated by the available data.

Link 4: Each passage by a ship will increase the energetic costs to a whale due to its avoidance behaviour.

The limited existing data can be used to estimate the energetic cost of avoidance behaviour.

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

This relationship is considered correct, in that reductions in habitat will generally result in reductions in available food. However, the relationship is mediated by factors that concentrate zooplankton, thereby causing "patchiness" in the distribution of food resources.

Link 6: The level of available food and the time available for feeding determine the energy intake.

Available evidence indicates that bowhead whales must feed almost continuously to obtain their necessary energy requirements. Therefore, the ability of bowheads to recover from disturbances that decrease their feeding time or access to feeding areas may be limited.

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

This linkage is true by definition.

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

Bowhead whales are expected to do most, if not all, of their feeding during the arctic summer. Therefore, it is considered likely that their energy balance would be highly positive in summer and highly negative in winter.

CONCLUSION

It was concluded that this hypothesis is both valid and testable. However, the level of uncertainty is high, since most of the linkages are only supported by circumstantial evidence; direct quantitative data are lacking.

RESEARCH

1. Energy Balance

Important information regarding the relative summer and winter energy balance dynamics of bowheads can be gained from measurements taken on individuals harvested in Alaska.

2. Distribution of Bowhead Food Supply

An understanding of the factors affecting the distribution of zooplankton is necessary to properly interpret changes in bowhead distribution that have occurred during the past four years (as well as future changes). This research should commence with examination of existing data on the bowhead distribution in relation to large scale physical oceanographic features in the Canadian Beaufort Sea during the past 4 years. Subsequent field studies should address the spatial and temporal distribution of bowhead food organisms in relation to hydrometeorological phenomena with the objective of finding easily measured parameters that are indicative of large scale spatial distribution patterns of food organisms.

3. Bowhead Biology

The basic biology of the bowhead whale is very poorly documented. However, information required for the recommended monitoring programs would be collected in the studies described above. No other specific studies of bowhead biology are recommended.

4. Passive Acoustics

The feasibility of utilizing some innovative approaches to passively monitor the acoustic behaviour of bowheads in the presence of conspecifics should be examined.

MONITORING

1. Behavioural Responses of Bowheads

The distribution of bowhead whales in the southern Beaufort Sea and Amundsen Gulf should be determined annually (using aerial surveys) to document overall patterns and assess year-to-year variability. The short-term behavioural responses of individual bowheads to industrial activities and facilities should be further quantified using techniques similar to those developed during U.S. Minerals Management Service projects. In addition, potential age and sex segregation should be assessed over a number of years using aerial photography.

2. Reproductive Rates

Measurement of the reproductive success of bowhead whales is likely to be the most direct means of testing the present hypothesis. The methods for monitoring reproductive success are the same as those recommended for monitoring behavioural responses (i.e. aerial surveys and photography).

3. Ambient Noise Monitoring

The levels of ambient noise in the hydrocarbon development zone over a full year should be measured at 5 to 10 year intervals to determine the incremental level of increase with time. These data would be important in the interpretation of the results of the behavioural response and reproductive rate monitoring studies described previously.

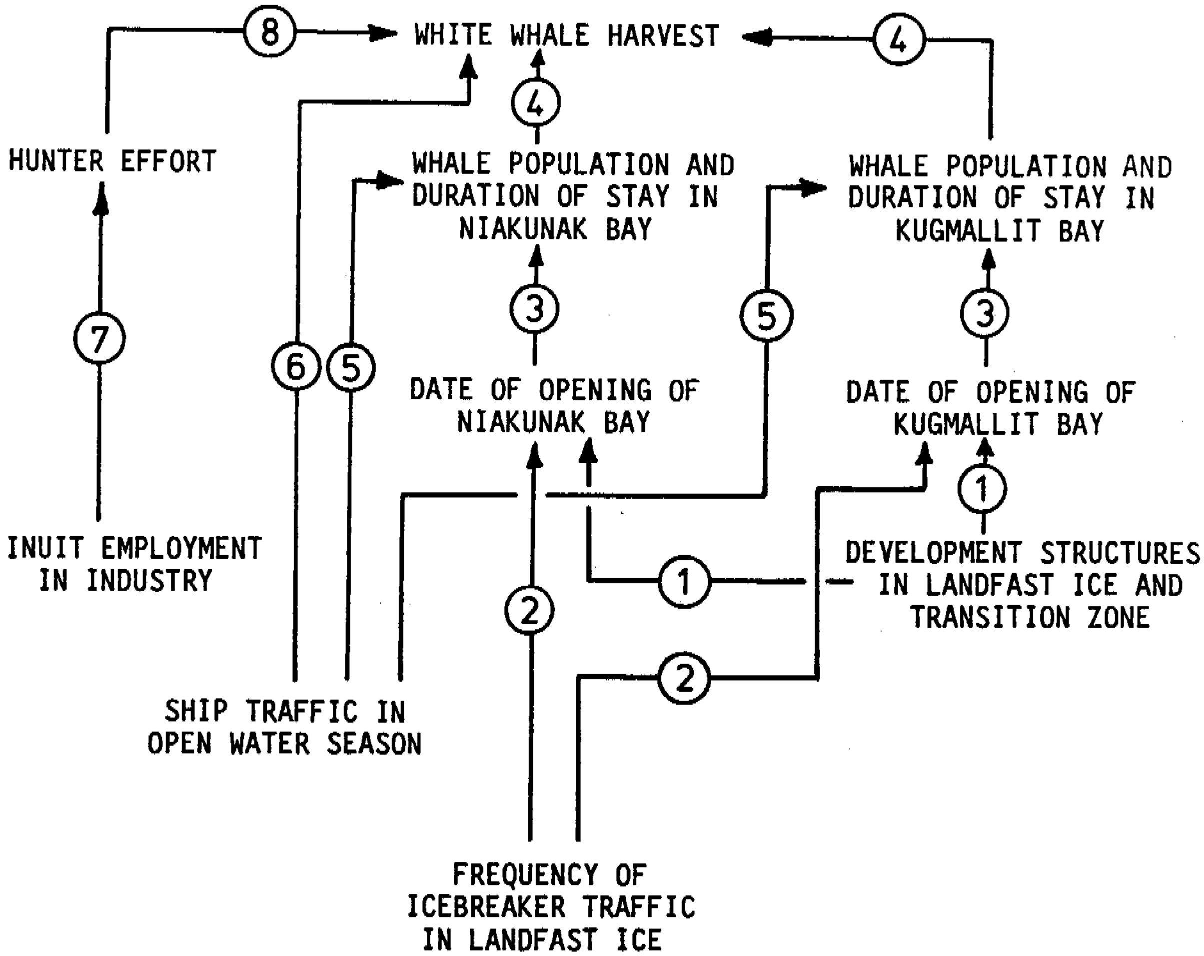
HYPOTHESIS NO. 2

A. Offshore structures will reduce the white whale harvest.

B. Frequent icebreaker traffic in landfast ice will increase the white whale harvest.

C. Open water ship traffic in the Mackenzie estuary will alter white whale distribution and lead to changes in harvest levels.

D. Inuit employment in industry will change the white whale harvest.



LINKAGES

Link 1: Artificial islands located offshore of the Mackenzie Delta will delay breakup of the landfast ice by extending the outer limit of landfast ice and/or by anchoring it.

Information on the ice regime and breakup collected from 1972 to date does not suggest that artificial islands have affected landfast ice breakup by either of these two mechanisms.

Link 2: Frequent icebreaker traffic in the landfast ice in spring will advance the breakup of the ice barriers across Kugmallit and Niakunak bays.

Existing industry proposals indicate that very low levels of icebreaker activity will occur in the Mackenzie estuary during June. This link is therefore considered very unlikely.

Link 3: The timing of breakup of the landfast ice determine the timing of entry, the numbers, and the duration of residence of white whales in Niakunak and Kugmallit bays.

The effect of artificially-induced delays in breakup on the use of the estuary by white whales cannot be determined with existing information. Available data support the hypothesis that first arrival in the estuary is a function of breakup timing. However, the numbers of animals and their length of stay in the estuary does not appear to be directly related to breakup timing. It is possible that delayed breakup could, in extreme cases, prevent the use of the estuary, since it is likely that there is a critical date after which the whales will not use the estuary.

Link 4: <u>The timing of entry, the numbers and the duration of residence of white whales in Kugmallit and Niakunak bays will influence the white whale harvest.</u>

Existing data on the harvest in Niakunak Bay cannot be used to evaluate this linkage. In Kugmallit Bay, harvest levels are positively correlated with both the numbers of whales present in the area and their date of arrival.

Links 5 and 6: <u>Ship traffic through Niakunak and Kugmallit bays will disturb white whales, thereby reducing the number of whales in the bays, and/or reducing the time spent in these areas.</u>

Ship traffic in Niakunak and Kugmallit bays will lead to local changes in the distribution of whales within these areas, and/or may directly interfere with hunting activities by frightening whales. It is clear from data collected in the Beaufort Sea and elsewhere that short-term changes in white whale distribution patterns can be induced by moving ships and barges. The potential for longer term changes is much less certain, and there is some evidence that white whales can become habituated to repeated disturbance by passing ships. In addition, there is no evidence to suggest that existing ship traffic levels along the southern and eastern shores of Kugmallit Bay have affected the whale distribution within the central and western parts of the bay.

Link 7: <u>Increased Inuit employment in industry will change hunter effort.</u>

This is likely to occur to some degree, although the mechanisms which could lead to changed hunter effort and its potential magnitude are both unknown.

Link 8: <u>Changes in hunter effort will lead to changes in the white whale harvest.</u>

This hypothesis is probably true, but again the direction and magnitude of change are unknown.

CONCLUSIONS

A. It is unlikely that offshore structures will influence landfast ice breakup and thereby affect white whale harvest.

B. It is unlikely that icebreaker traffic will advance the breakup of ice barriers across Niakunak and Kugmallit bays, thereby affecting the harvest of white whales.

C. Available information supports the hypothesis that ship traffic will affect white whale harvest, particularly within Niakunak Bay.

D. Changes in hunter effort and harvest levels resulting from increased Inuit employment by the petroleum industry are considered probable.

RESEARCH

A study of the factors that control the distribution of white whales within Niakunak and Kugmallit bays should be conducted. Initially, this study should focus on analysis of existing data. The necessity for more detailed field investigations could be evaluated after this analysis is complete.

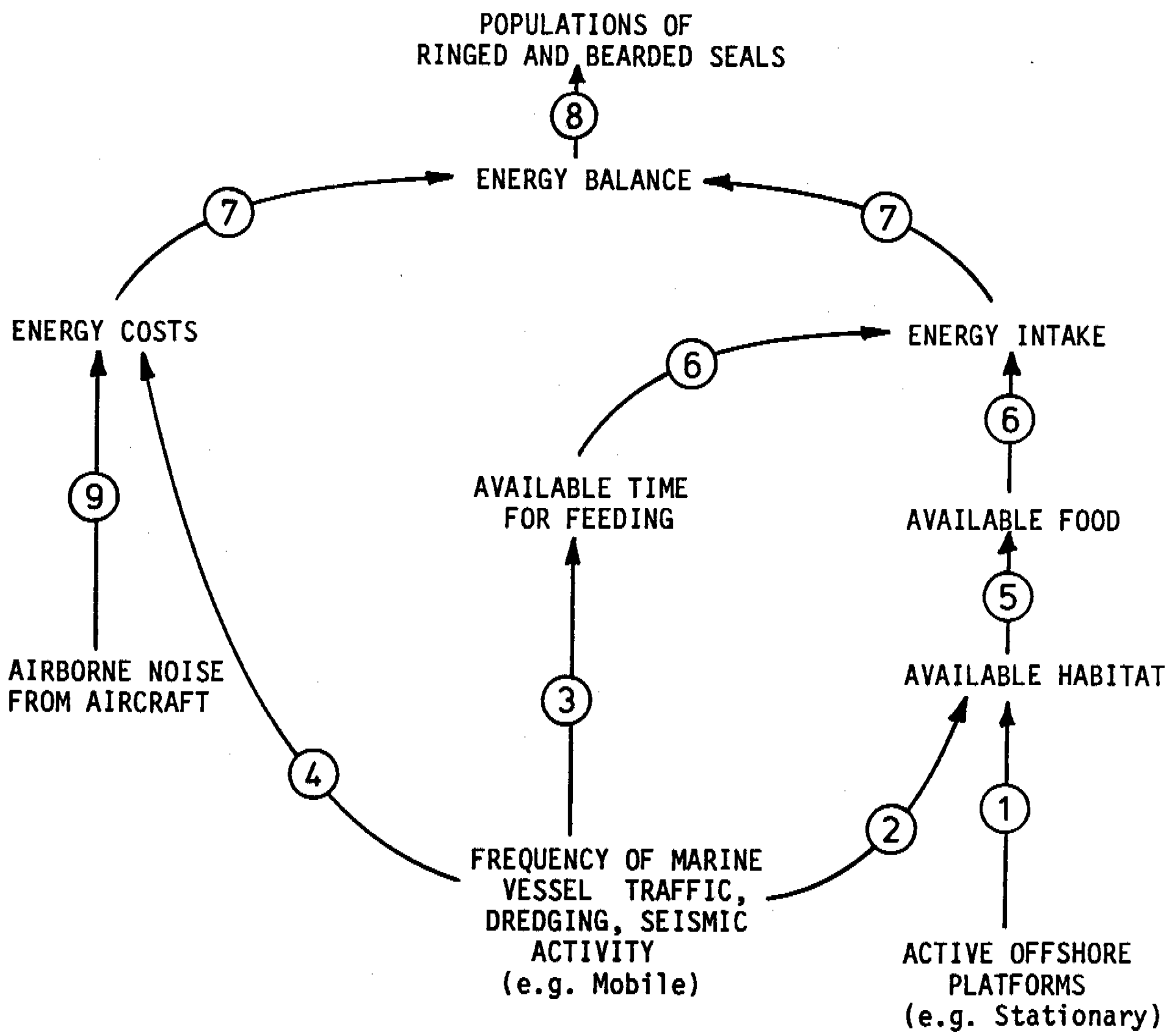
MONITORING

Annual monitoring of the regional extent, distribution and breakup of landfast ice using satellite imagery and aerial photography is recommended.

The existing industry-sponsored white whale monitoring program should be continued and revised. This program was recognized during the workshop for its accomplishment in providing the longest time series of data on any species of arctic marine mammal, which has allowed confident assessment of some aspects of the status of the Mackenzie stock of white whales.

HYPOTHESIS NO. 3

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



LINKAGES

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

There are no studies which have provided quantitative data on the effects of offshore oil and gas exploration and production structures on seals. However, industry personnel and ice observers stationed at offshore structures (and on vessels) in the Beaufort Sea frequently observe both ringed and bearded seals. The total numbers of seals recorded during the open water season has ranged from a few hundred to over 1000. It was agreed that although Link 1 is probably valid, the extent of the exclusion would probably be inconsequential and, in most instances, limited to the physical extent of the offshore structure/island.

Link 2: Marine vessel activities, dredging operations and seismic activity will exclude ringed and bearded seals from available habitat.

Link 3: Each passage of a marine vessel, seismic vessel or dredge will result in the loss of feeding time for ringed and bearded seals.

A. Marine Vessel Traffic (including "in transit" dredges)

Disturbances associated with marine vessel traffic will exclude ringed and bearded seals from available habitats and reduce feeding time, but for the following reasons this exclusion was expected to be inconsequential from a regional perspective:

(1) Ringed and bearded seals are observed regularly throughout the development zone;

(2) The zone of audibility (and therefore the zone of influence) would be limited in most instances;

(3) Icebreaking in the transition zone would probably increase the accessibility of feeding habitat for bearded seals during spring; and

(4) Icebreaking would largely occur within the transition zone. Movements of ringed seals (primarily subadults in this area) in response to vessel traffic would probably be inconsequential in terms of available feeding habitat and feeding time.

It was suggested that bearded seals, because of their preference for landward portions of the transition zone, may be affected to a greater extent than ringed seals by icebreaking and vessel traffic, although the effects were still expected to be regionally insignificant.

B. Dredging Operations

The removal and deposition of substrate during dredging operations will result in the exclusion of bearded seals from benthic feeding areas and loss of feeding time. However, the group agreed that this exclusion would probably be inconsequential (1) in terms of total available habitat and (2) in comparison to the amount of benthic habitat removed by natural processes such as ice scouring.

C. Seismic Activity

For the reasons described in the discussion of Marine Vessels and the fact that the majority of the seismic work planned for the Beaufort region has already been completed, the effects of exclusion of ringed and bearded seals from areas affected by offshore seismic activity and the concommitant reduction in feeding time are expected to be regionally inconsequential.

Link 4: Each pass of a marine vessel, seismic vessel and operating/in transit dredge will increase the energy costs of ringed and bearded seals since they will avoid ensonified corridors.

Although this link was considered valid, energy costs would be small and regionally insignificant since the extent and duration of exclusion would be small in terms of the regional populations. The group suggested that local effects could occur, particularly during the late winter and spring of "bad" ice years when the seals are in a negative energy balance situation.

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

This link was considered invalid for ringed seals, since they feed primarily on mobile prey items and are opportunistic feeders. However, bearded seals feed primarily on sessile food, and therefore exclusion from preferred foraging areas may result in exclusion from feeding areas. As a result, the link was considered valid with respect to bearded seals, although again, effects would probably be inconsequential in a regional sense.

Links 6 and 7: The level of available food and the time available for feeding determine energy intake. Energy intake and energy costs determine energy balance.

Both links are self-evident and valid.

Link 8: The energy balance of a marine animal determines its probability of survival and its capability to reproduce, thereby influencing its population dynamics.

This link was considered valid with respect to both ringed and bearded seals, although it was suggested that industry-induced changes in energetics would only be a local concern during periods of negative energy balance (March-June) in "bad" ice years.

Link 9: Mobile airborne noise associated with aircraft overflights will increase the energy costs of ringed and bearded seals during the June haul-out, and the energy costs of ringed seals during pupping and rearing (late March through May), since seals will dive in response to the noise source.

This link was considered valid for both ringed and bearded seals. It was estimated that 25 to 40 percent of hauled-out seals dive when overflown by an aircraft at an altitude of 300-500 m. The potential biological significance of repeated immersion during pupping or haul-out are not known, but could be locally significant because seals are in a negative energy balance condition during these periods. The workshop subgroup suggested that mitigative measures for reducing effects of overflights on birds could also be applied to flights over seal haul-out and pupping areas.

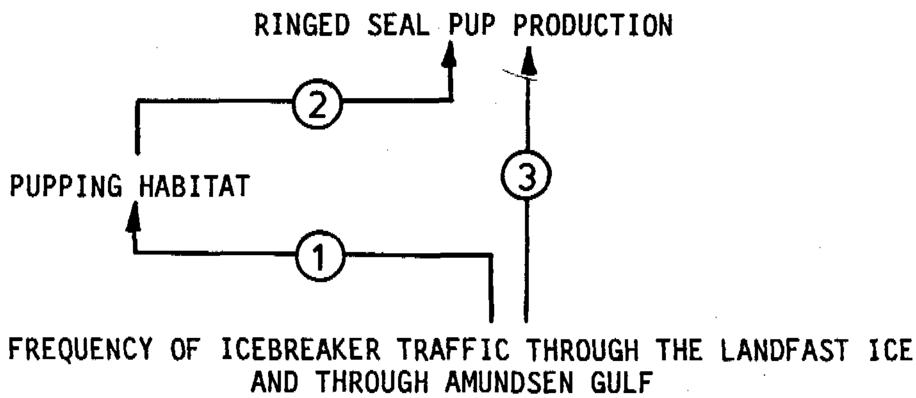
CONCLUSIONS

It was agreed that all links of the hypothesis could be valid, and that ringed and bearded seals could be affected through (1) habitat exclusion, (2) lost feeding time, (3) increased energy costs, (4) altered energy balance, and (5) reduced survival/reproductive capacity. However, the <u>extent</u> to which these effects could occur would be extremely limited and unlikely to be manifested in the regional populations.

It was concluded that the combined effects of marine vessel traffic, seismic activity, dredging, aircraft overflights and offshore platforms on ringed and bearded seal populations would be <u>unlikely (or at most possible) and therefore not worth testing (or too difficult to detect)</u>.

HYPOTHESIS NO. 4

Increased frequency of icebreaker traffic through landfast ice and through Amundsen Gulf will reduce ringed seal pup production.



LINKAGES

Link 1: Icebreaker traffic in March and April will decrease the amount of available pupping habitat in one of the following three ways:

A. Large scale destabilization of the ice regime.

Icebreaker activities in the Beaufort fast ice since 1979 have not resulted in apparent impacts on the ice regime. Existing and proposed corridors through landfast ice occur in areas of relatively low pupping density, which are not considered prime ringed seal habitat.

However, the northeast portion of Amundsen Gulf is important ringed seal habitat, and areas characterized by high pup concentration would be exposed to icebreaker traffic in this region. Although there is no direct evidence of large scale ship-induced alteration of the ice regime, numerous authors have considered various hypothetical scenarios using theoretical physical approaches and qualitive, subjective evaluations of observed conditions. The present group concluded that there is a finite possibility that icebreaker traffic could significantly alter the Amundsen Gulf ice cover, and this may have subsequent implications to ringed seal pup production in this area.

B. Small scale alterations of ice regime in the path of a ship.

The area of pupping habitat potentially affected by small scale alterations in the ice regime was calculated assuming a worst case scenario of a 2 km wide corridor where pupping would be excluded. The resultant total habitat exclusion in the offshore Beaufort Sea fast ice was 14.5×10^3 km^2, and this area was expected to be insignificant by the workshop subgroup in terms of regional seal population. On the other hand, the potential habitat losses associated with similar icebreaking corridors in northern Amundsen Gulf and southern Prince of Wales Strait was expected to have substantially greater regional significance.

C. Prevention of ice utilization by adult female seals near the ship track due to noise effects.

Limited studies of seal densities near active industrial facilities in the Beaufort Sea have not indicated adverse impacts of these facilities and activities on local populations. The workshop subgroup agreed that even assuming a worst case situation involving a 2-km wide corridor, there was limited concern related to effects of icebreaking on ice utilization by the regional population of ringed seals.

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

The preferred habitat for ringed seal pupping is characterized by specific ice and snow cover conditions and is also limited to a restricted range of water depths. The distribution of these habitats within the Beaufort region is non-random and can recur in the same general areas from year to year. However, there is no conclusive evidence to suggest that availability of pupping habitat is, or is not, a limiting factor to pup production.

Link 3: Increasing icebreaker traffic in April and May will result in mortality of ringed seal pups.

Although mortality of ringed seal adults or pups due to vessel traffic in ice covered waters has not been documented to date, some degree of mortality may be expected during the various transportation activities associated with Beaufort development. Nevertheless, even assuming the maximum tanker traffic which may occur at the "technologically feasible" hydrocarbon development level (1.2×10^6BOPD), impacts on the regional population of ringed seals are not expected to be a serious environmental concern.

CONCLUSIONS

Although small scale alterations of the ice regime in the path of a ship (Link 1B) and noise-related prevention of ice utilization by adult females near the ship track (Link 1C) were considered probable by workshop participants, these icebreaking-related effects on ringed seal pup production were not expected to be regionally significant or worthy of further investigation. In a similar manner, the regional impacts of pup mortality resulting from icebreaker traffic in April and May were expected to be insignificant at the population level. On the other hand, large-scale destabilization of the ice cover in Amundsen Gulf due to icebreaker activities (Link 1A) could be an area of greater environmental concern, although present evidence for this phenomenon occurring is largely circumstantial. The workshop subgroup recommended that further research regarding potential large-scale ice destabilization processes in Amundsen Gulf should be undertaken to determine the need for and most suitable design of any monitoring programs.

RESEARCH

Further analysis of existing ringed seal samples that were collected near Holman Island between 1971 and 1982 should be conducted. This research should reveal whether significant population variability has occurred (i.e., age-specific reproductive rates and mortality rates) which can then be related to years of unstable ice conditions in Amundsen Gulf (i.e. 1971 and 1978).

If analysis of the above data indicates that pup production is sensitive to variations in the ice regime, then further ice stability research may be warranted. This research could include modification and direction of existing theories of ice strength and structure, and investigation of two-dimensional ice strain involving use of NOAA, Landsat and SLAR imagery.

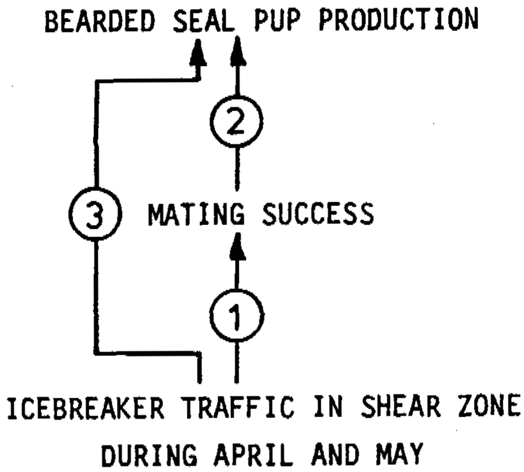
MONITORING

Uncertainties related to destabilization of the ice regime in Amundsen Gulf and potential impacts of this destabilization on ringed seal pup production may be adequate justification for the recommendation of a monitoring program. Monitoring could include routine aerial photography of icebreaker traffic in Amundsen Gulf which may than be analyzed (depending on the results of the previously described research) in conjunction with wind and larger scale ice movement data to provide further information on the probabilities and/or mechanisms of fast ice destabilization.

Concurrent experimentation could be designed to estimate the effects of tanker traffic on pup production in Amundsen Gulf, although this is considered logistically difficult at the present time and would only be practical with improvement of ringed seal air detection techniques. A thermo-graphic remote sensing device is presently being tested and may be well suited to detection of ringed seal birth lairs in ice-covered waters. Nevertheless, this type of a research/monitoring program would only be recommended after completion and detailed evaluation of the research suggested in the previous section.

HYPOTHESIS NO. 5

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



LINKAGES

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

Bearded seals (especially males) are highly vocal, particularly during the breeding season. The calls, which are audible for more than 40 km, are expected to attract female seals and may be involved in the exclusion of other males from underwater territories. It has been suggested that disturbance could reduce vocalization rates and therefore mating success, and this could subsequently be reflected in reduced pregnancy rates. There has been little research directed specifically at bearded seals, and there is essentially no evidence available at this time to support or reject this link.

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

This link is self-evident and valid. Pup production is typically estimated by recording age-specific pregnancy rates based on the presence of a large corpus albicans and a placental scar. The average pregnancy rate is 86 percent but varies from between 50 to 100 percent over age classes of 6 to 22. There is almost no data on the possible extent of natural variation in pregnancy rates between years or between areas. Low bearded seal densities make it difficult, in fact, to detect general distribution changes or population changes less than 20 percent.

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

The shear zone is both the preferred pupping habitat of bearded seals and will be the preferred corridor for some shipping activity associated with hydrocarbon development. Although there is some limited anecdotal evidence of mortality of other species of seals, there are no documented cases of mortality of seal pups or their mothers resulting from icebreaking activities. However, the workshop participants agreed that some degree of mortality would be expected, particularly in the case of seal pups during the vulnerable period which is limited to 2 or 3 days after birth. Calculations using an effective corridor width of 1 km, suggested that potential losses of the pups could range from 1 to 4 percent in preferred pupping areas, or 0.5 to 2 percent of the total pup production.

CONCLUSIONS

Although icebreaker traffic will probably result in direct mortality of bearded seals particularly pups (Link 3), such losses are not expected to be critical to the regional population. At the present time, the level of understanding regarding bearded seal vocalizations and their importance in determining mating success and pup production is inadequate to either accept or reject Link 1. An expanded information base on bearded seal vocalizations and behaviour in general would be useful for prediction and interpretation of the potential impacts of icebreaker traffic. However, given the limited understanding and inadequate methods of measuring reproductive success, it is considered unlikely that industry-related shifts in pup production or population stability would be detectable.

RESEARCH

The hypothesis that ship disturbance will lead to a reduction in bearded seal vocalization rates could be tested through a series of hydrophone recordings. It would be necessary to establish a baseline for vocalization rates in both a control area and an area which would be exposed to icebreaker traffic. Use of an array of hydrophones would allow location of individual seals through triangulation, and therefore determination of the effective area of disturbance.

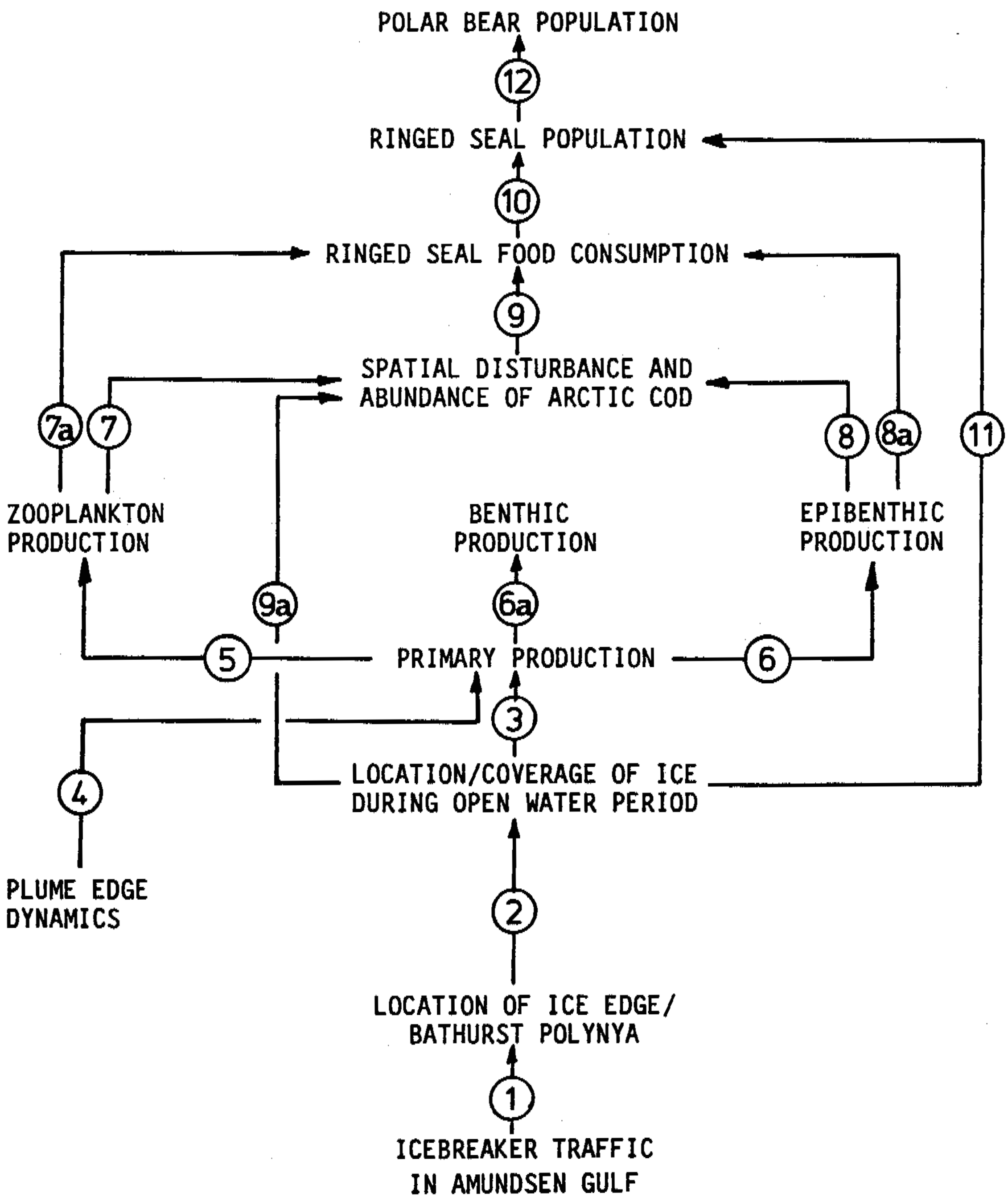
However, it should be emphasized that although no changes in vocalization rate could lead to rejection of the hypothesis, contrary results would not necessarily lead to acceptance of the hypothesis. The latter would require confirmation that changes in vocalization rates could then result in altered reproductive rates. The logistical difficulties associated with collection of an adequate sample size of adult female bearded seals are expected to be substantial. Furthermore, the sampling program itself could result in an impact on the population which is greater than that caused by icebreaker traffic. It was concluded that although a research program directed at bearded seal vocalizations could offer some relevant information, this research is not considered a high priority at the present time.

MONITORING

A monitoring program to determine the impacts of tanker traffic in the transition zone on bearded seal pup production was not considered justifiable or practical.

HYPOTHESIS NO. 6

Icebreaker traffic in Amundsen Gulf will affect the polar bear population.



LINKAGES

Links 1 and 2: Icebreaker traffic in Amundsen Gulf will move the stable ice edge to the east (and alter the Bathurst polynya) in winter and spring. This effect may in turn change the total amount of open water in the region.

The hypothesis that icebreaker traffic in Amundsen Gulf will move the stable ice edge to the east is considered possible, although improbable. This conclusion was reached on the basis of very limited available knowledge and untested physical process arguments. However, consequences of this occurrence could be great, although the amount of total open water in the general area is unlikely to be changed significantly.

Link 3: The coverage and location of ice in the "open" water period determines the level of primary productivity.

Primary production in open water areas is likely to be greater than in adjacent ice covered areas due to increased temperature and light penetration. This effect would probably occur early in the season (late May or early June) if the water column was relatively stable and the water residence time of sufficient duration. However, vertical transport of nutrient-rich deep water and subsequent stimulation of primary production could be inhibited by movement of the open water to a shallow water area.

Link 4: Primary production is enhanced (perhaps in patches) near the plume edge.

This linkage is expected to be operative near the seaward edge of the Mackenzie River plume; however, its inclusion in the present hypothesis is probably not appropriate since the Mackenzie plume seldom if ever occurs as far east as the Bathurst polynya.

Links 5, 6 and 6a: The level of primary productivity determines the level of secondary productivity in zooplankton, epibenthos and benthos.

Primary production is generally believed to largely determine the abundance and species composition of zooplankton and epibenthos, and eventually the benthos (infauna). An important concern in attempting to define the present flow chart is related to possible changes in the partitioning of primary production among these three communities. For example, growth and development of many species of zooplankton are timed to coincide with certain seasonal aspects of primary production. If the timing of primary production is altered, zooplankton species capable of taking advantage of the increased production may not be present, and much of the increased algal biomass resulting from increased production could sink and be subsequently incorporated into the benthos. This could greatly reduce energy flow to higher trophic levels.

Links 7, 8 and 9a: Distribution and production of zooplankton and epibenthos and the location of ice determine the production and distribution of Arctic cod.

The relationships among Arctic cod, their food resources and features of the physical environment have not been examined in the Canadian Beaufort Sea. Evidence from other areas suggests that the diet of Arctic cod is largely zooplankton and epibenthos, including various epontic invertebrates. Shelter provided by ice may have considerable importance in determining their distribution, while the presence of ice may also influence the dominant food source since some large invertebrates that are consumed by Arctic cod are associated with the epontic community. Increases in zooplankton may not necessarily be beneficial to Arctic cod since some of the major predators (i.e., chaetognaths, jelly fish, ctenophores) of juvenile cod are members of the zooplankton community.

Links 7a, 8a and 9: Spatial and temporal patterns in the abundance and distribution of Arctic cod, epibenthos and zooplankton determine ringed seal food consumption.

Data from other regions indicate that arctic cod, epibenthic invertebrates and large zooplankters constitute the bulk of the diet of ringed seals. The proportion of each type of food in their diet may vary with season, general location of the population and specific locations of the individual. Although studies have not been conducted there is no reason to believe that the diet of ringed seal would be substantially different in Amundsen Gulf.

Link 10: Quality and quantity of food determine ringed seal survival and mortality.

Evidence for this linkage is primarily from (1) general knowledge of other animal species and (2) specific data on the varying qualities of foods ingested by ringed seals. There is also a limited amount of information on seals which link the amount of fat reserves to reproductive rates. Simultaneous consideration of food quality and effort required to capture a given biomass suggests that ringed seal prey could be ranked in the following order of descending importance: Arctic cod, epibenthos and zooplankton. The workshop subgroup agreed that reduced food will result in increased mortality of seals, especially in subadults.

Link 11: Location and type of ice are important in determining ringed seal distribution.

Ringed seals are dependent on the ice cover for haul-out, moulting, pupping and breathing holes, as well as the provision of habitat for prey species. Therefore, the type and distribution of ice are expected to be important determinants of ringed seal distribution. Correlations between ice characteristics and pupping densities have been observed. However, subtle differences may also be of considerable importance, and not all seal-ice relationships are known. For example, ringed seals may have difficulty maintaining breathing holes in heavily compacted ice, such as that extensively covering the Beaufort Sea in 1974.

Link 12: Numbers of polar bear are determined by numbers of ringed seals.

Ringed seals are the primary prey of polar bears. Consequently, when the ringed seal population in the Beaufort Sea suddenly decreased by about 50 percent from 1974 to 1975, the reduced availability of prey (especially seal pups and subadults) was reflected in reduced polar bear numbers in 1975 and 1976. Reproduction and survival in the bear population did not appear to return to normal until 1977 to 1979, in conjunction with recovery of the ringed seal population.

CONCLUSION

Present knowledge does not allow a firm conclusion to be made regarding whether or not polar bear and ringed seal populations could be affected by icebreaker traffic in Amundsen Gulf. The members of the workshop subgroup suggested that such effects were highly improbable, although certainly possible. The group also emphasized that major uncertainties exist in many linkages, particularly those between icebreakers, ice, lower trophic levels and Arctic cod populations.

RESEARCH

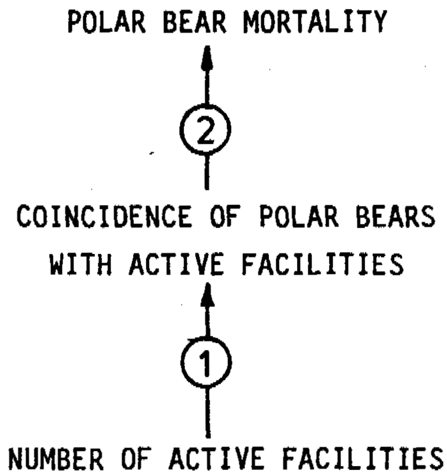
Although the hypothesis is considered improbable, the effects of such a scenario, were it to occur, could be highly significant in terms of the regional populations of ringed seals and polar bears. For this reason, a study is recommended to further examine the hypothesis that polar bear populations will be affected by icebreaking activities in Amundsen Gulf. Specifically, data on ice cover and seal populations should be examined for the years between 1971 and 1983 to determine if correlations can be found between ringed seal population parameters and annual ice conditions in Amundsen Gulf. Years of extremely unstable ice cover in the Gulf (i.e. 1971, 1978) could be reflected in factors such as ringed seal reproductive rates, cohort success, etc.

MONITORING

Monitoring programs to test the hypothesis that icebreaker traffic in Amundsen Gulf will affect the polar bear population is not recommended at the present time, pending detailed evaluation of the results of research described above. Such monitoring programs would likely concentrate on the top and bottom links of the hypothesis. This would involve obtaining pertinent data on ice distribution before, during and after icebreaker traffic, as well as concurrent information on population parameters (e.g. cohort strength, condition, diet) of ringed seals and/or polar bears.

HYPOTHESIS NO. 7

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



LINKAGES

Link 1: There is considerable evidence that polar bears (particularly subadult males) are attracted to both occupied and unoccupied human facilities. Bears that receive positive reinforcement (e.g., garbage at such sites) will return to or remain at these locations. Produced water discharges may also create areas of open water or thin ice around offshore production platforms which may attract seals and therefore bears.

Although many polar bears have been reported near active offshore facilities, limitations in experimental design have hampered establishment of a direct cause and effect relationship between the location of active sites and the distribution of polar bears.

Link 2: <u>Polar bears attracted to offshore structures will have to be controlled, resulting in occasional bear mortality.</u>

Several polar bears attracted to both onshore and offshore active sites in the Beaufort Sea have been destroyed as nuisance animals. In two instances, the bears were shot after they attacked and killed humans. Similar encounters with bears have been reported in Churchill, Manitoba and elsewhere in the Canadian Arctic.

Inuit hunters, hired as "polar bear monitors", are responsible for deterring polar bears at offshore sites. The number of animals actually killed following failure of deterrent attempts is limited, although it is difficult to estimate the exact number because the circumstances surrounding such kills may not be reported and the animal can be included as part of the community quota. There is also some risk that unintended injury or mortality of polar bears may result from hits with misplaced riot gun rubber projectiles used by bear monitors at industrial facilities.

Inuit monitors will probably continue to harvest bears in the vicinity of offshore sites under the existing quota system, thereby reducing the frequency of polar bears becoming problem animals. There is also evidence (from Churchill) that polar bears (particularly adults) which are in good condition and feeding successfully on seals do not find human facilities sufficiently attractive to override their natural caution.

In the future, the size and design of offshore structures may preclude polar bear access to areas where they could become dangerous to humans.

CONCLUSIONS

The hypothesis that polar bears will be attracted to active sites, particularly in the offshore areas, has already been accepted by both industry and government and was substantiated by the present workshop discussion group. However, the corollary that bears which are attracted and become problems must be destroyed has not been unanamously accepted.

In response to the safety hazard associated with polar bear encounters, both monitoring and research programs have been designed and are presently in progress. Records of the number of bears seen near active sites (industry) and records of the number and location of bears killed in the Beaufort area (government) should continue to be maintained. Continuing research on methods of detecting and deterring polar bears should also be supported.

MONITORING

The existing polar bear monitoring and deterrent programs should be supported and improved. In addition, the workshop subgroup suggested that changes in data recording and in the communication of information between government and industry should be implemented. Such changes would include a more detailed, systematic recording of monitoring data, and improved training of polar bear monitors and supervisory staff at industry facilities. It was also recommended that monitoring and deterrent records should be summarized annually and reviewed once every 3 to 5 years to re-evaluate the present hypothesis.

HYPOTHESIS NO. 8

> Offshore hydrocarbon development activities will reduce the harvest of polar bears.

HARVEST OF POLAR BEARS

↑ (2)

LOCATION OF POLAR BEARS

↑ (1)

OFFSHORE DEVELOPMENT ACTIVITIES

LINKAGES

Link 1: Offshore hydrocarbon development may cause polar bears to move away from areas of disturbance or create an access barrier to hunters.

Observations in Churchill and other northern communities indicate that bears, especially adult males, will avoid areas of disturbance. Adult males likely avoid these areas because they are more efficient than either females or subadults in obtaining prey in remote prime feeding habitats. There is also evidence that hunting sensitizes bears to disturbance, and the noise of nearby industrial activity or approaching hunters may cause individuals to flee towards open water. In addition, the presence of artificial islands could 1) extend the range of the land fast ice; and/or 2) create rubble fields around the islands. Either of these phenomena could cause bears to permanently relocate in areas which are less accessible to hunters.

Contrary evidence regarding the avoidance of sites of human activity by bears is the well documented problem with nuisance bears around some industrial facilities and northern communities, although these bears tend to be the younger age classes.

Link 2: Fewer bears will be available for harvest if 1) there is a shift in polar bear distribution from fast ice to active ice areas, or 2) if hunters are in some way prevented from reaching the edge of the fast ice.

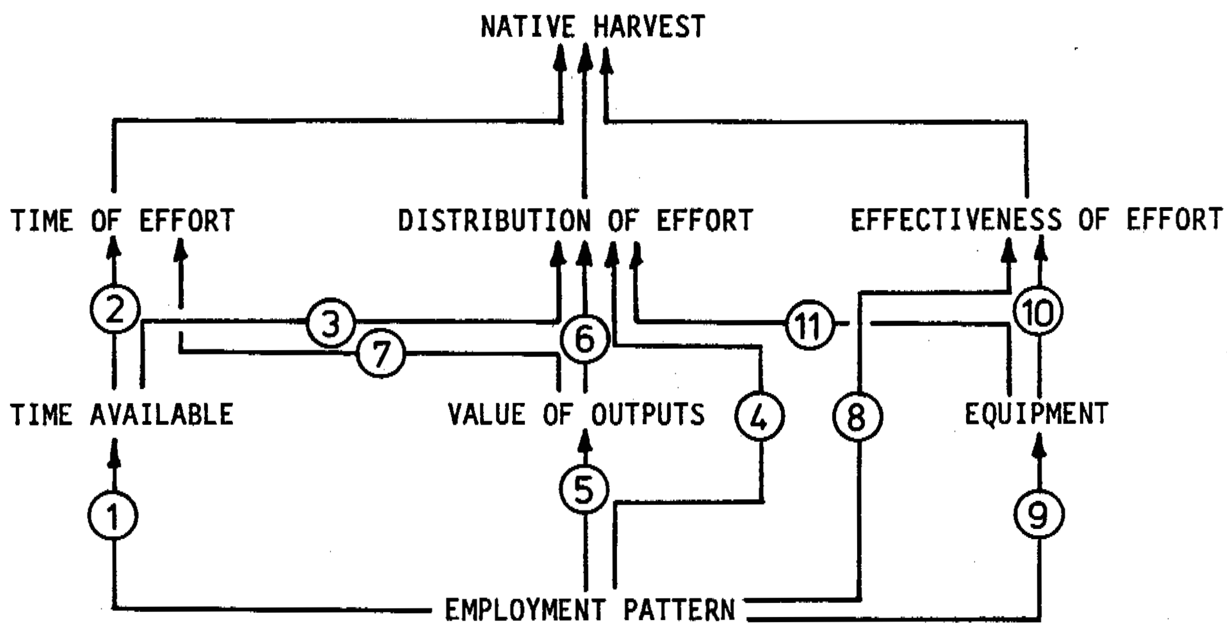
Extension of the outer limit of the fast ice by industry facilities in offshore areas is expected to be a relatively remote possibility. However, even if limited extension of the landfast ice edge did occur, the high demand for polar bear hunting licences would, except in the most extreme situation, make reduced access a non issue. In the case of icebreaking tanker traffic, vessel movements would be generally perpendicular to the ice edge and therefore, would have little impact on polar bear distribution or hunter access.

CONCLUSIONS

The workshop subgroup concluded that the reduced harvest of polar bears as a result of industrial activities was extemely unlikely. However, it was stated that the existing monitoring program on hunter kill, in conjunction with a more precise specification of industrial activities, ice movement and distribution of ice types (available from current air photos), would facilitate ongoing differentiation between industry-related and natural environmental effects.

HYPOTHESIS NO. 9

Increased native employment in industry will reduce marine bird and mammal harvests.



LINKAGES

Links 1 and 2: The time available to natives for hunting will be affected by employment in the wage economy and will be reflected in the total hunting effort.

Job obligations may limit the total amount of time available for hunting particularly the participation in extended hunting trips. Conversely, many of the anticipated job opportunities in industry will involve work schedules that include extended periods of work (i.e. 2 to 3 weeks) alternating with relatively long periods of time off. Also, in recognition of the cultural significance of hunting to native communities, industry has often developed work schedules around hunting seasons. These factors could effectively increase the time available for recreational hunting.

Link 3: Due to limitations in time available for hunting, hunting activities will be restricted to the immediate vicinity of communities participating extensively in the wage economy.

If natives employed by industry have only limited opportunities for hunting (e.g. weekends), then they are not likely to spend a great deal of time travelling to distant hunting grounds. As a result, the hunting pressure may become even more concentrated around the communities than is currently the case, resulting in very localized but intensive hunting effort.

Link 4: Wage employment will directly change the distribution of hunters and hunting effort.

Hunting effort directed at any species can be measured in terms of the distribution of hunting activity relative to the location of communities. It will determine the concentration or diffusion of hunting pressure on any animal population. As major centres generally experience a shift in the type of hunting pressure, recreational hunting is expected to become more prominent and to be concentrated near communities. As wage earners move towards jobs, altering the size of communities, this may also change the spatial distribution of hunting effort.

Link 5: Availability of wage employment changes the relative rewards or value of outputs to hunters from hunting.

Rewards which are considered important in the present context are: cash through saleable game products; food for hunters, their families and community; clothing; recreation; and the status associated with hunting success. It was concluded that general wage employment would reduce the value of most of these rewards, with the exception of recreational pursuits and the food value of certain species.

Links 6 and 7: Changed values of returns from hunting will change the total effort (time) and the distribution of effort.

Hunters distribute their efforts to maximize returns, and if the relative value of their rewards changes, this is expected to be reflected in their effort. It was concluded that the recreational value of hunting will be maintained, while other values will probably decrease, thus causing a shift to species which are either numerous or concentrated and therefore accessible with less effort. This may be partially offset by the specialization of a few individuals that hunt less accessible species extensively in order to trade or sell their harvest to wage earners. This trend could effectively balance the decline in total hunting effort.

Link 8: Cash employment will reduce hunters' effectiveness or level of skill.

There could be a decrease in hunting skill due to a lower hunting frequency and experience and/or a decrease in the survival element of hunting pursuits.

Link 9: Cash employment changes the quality of equipment used by hunters.

An early outlet for expenditure of wages will be capital goods associated with hunting activities, including skidoos, ATV's and outboard motors which will all result in better access to hunting areas. Over long periods of time, however, this high level of expenditure on hunting equipment is expected to decline.

Links 10 and 11: Better equipment will increase hunter effectiveness and will modify the distribution of effort.

Better equipped hunters are expected to be able to hunt more effectively, although catch per unit effort would probably be improved only marginally. However, better transportation equipment will allow improved travel, thereby offsetting the potential for concentration of hunters near communities. In a similar manner, better equipment may also result in an increase in hunting pressure by increasing the ease and safety of hunting, as well as the redistribution of hunting effort to more productive sites.

CONCLUSIONS

The present harvest scheme provides a framework to systematically consider potential changes in harvest as a function of changing employment patterns. Application of this framework to particular species led to the following tentative conclusions: (1) increased native employment in industry may cause a reduction in ringed seal harvest, an increase in marine bird harvest, and little forseeable change in white whale harvest; (2) changes in harvest rate and subsequent population changes are not only of potential concern in areas of industrial development, nor are they solely attributable to employment changes; and (3) harvest may be monitored most effectively through acceptance and modification of existing native and government programs.

RESEARCH/MONITORING

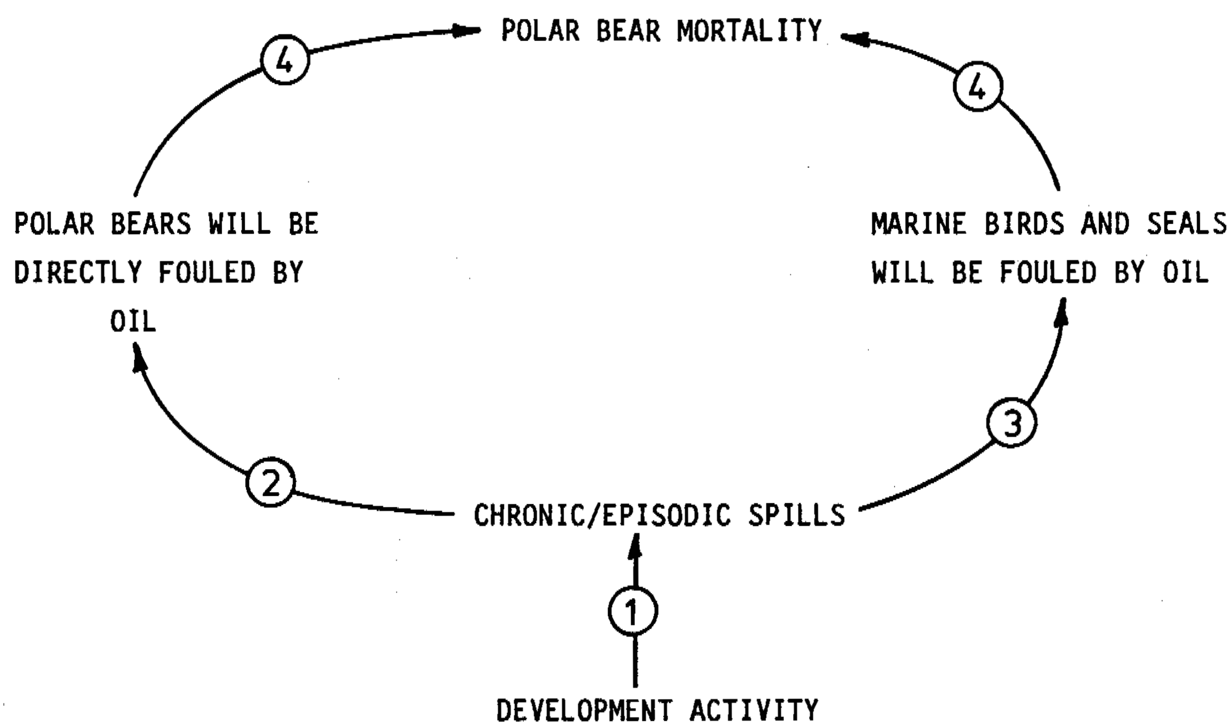
No completely new monitoring programs are recommended at this time until the following is assured:

1. Continuation of the current practice of recording pelt sales (ringed seals) by each village (possibly in greater detail);

2. An initial program to analyse data obtained in past and existing surveys in the Keewatin, Baffin and elsewhere in conjunction with native groups and the GNWT. A similar or improved program could be designed for the Beaufort region depending on the results of this analysis. The program would ideally include a socio-economic component to detect not only direct changes in harvest, but also structural changes in hunting values and effort.

HYPOTHESIS NO. 10

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



LINKAGES

<u>Link 1: Development activities will result in chronic/episodic spills of petroleum hydrocarbons.</u>

Oil spill case histories from elsewhere in the world can be used to provide estimates of spill probabilities and volumes in the Beaufort development region. Although it is recognized that there has been a decrease in spills with (1) increased awareness, (2) more thorough training programs, and (3) improved technology, the frequency and total volume of chronic oil spills will likely increase with the level of development in the Beaufort region, However, the relationship between spill frequency/volume and level of development in the region remains unknown.

Link 2: Chronic/episodic spills will result in the direct fouling of polar bears.

Polar bears have been observed swimming at various times of the year, often considerable distances from shore. Offshore industrial facilities have been constructed in or near the preferred habitats of bears, and individuals are often attracted to such sites. Contact with oil at these offshore facilities is considered possible, while polar bears may also be exposed to oil stranded in shoreline areas when travelling onto and off summer retreats. However, there is no experimental evidence or empirical observations on the behaviour of free ranging bears to the presence of an oil slick.

Link 3: Chronic/episodic oil spills will result in the direct fouling of marine birds or seals.

For oil to have detrimental effects on polar bears, individuals must either directly contact oil (Link 2) or consume prey (birds or seals) which has become contaminated with oil. There is extensive evidence of contamination and mortality of birds following contact with even small quantities of oil. In some instances, bird mortality as a result of oil fouling will occur in the Canadian Beaufort (see Hypothesis No. 11). There is limited information on the behaviour of marine mammals during free-ranging contact with oil and the consequences of such oil contact. Ringed seals and other species of seals have been observed in the wild fouled with oil, but the link between oil contact and mortality has not been unequivocably demonstrated.

Polar bears could encounter contaminated bird or seal carcasses, particularly along leads in the spring and on shorelines near summer retreats.

Link 4: Mortality of bears will occur if oil is contacted.

Fouling of the fur with oil can cause changes in insultation and compensatory changes in metabolic rate and/or body temperatures. However, the toxicity of oil to polar bears following ingestion through grooming of oil-contaminated fur is expected to be an area of greater concern. Although available information indicates that oiling of polar bears can be fatal, the amount of oil necessary to cause death is unknown.

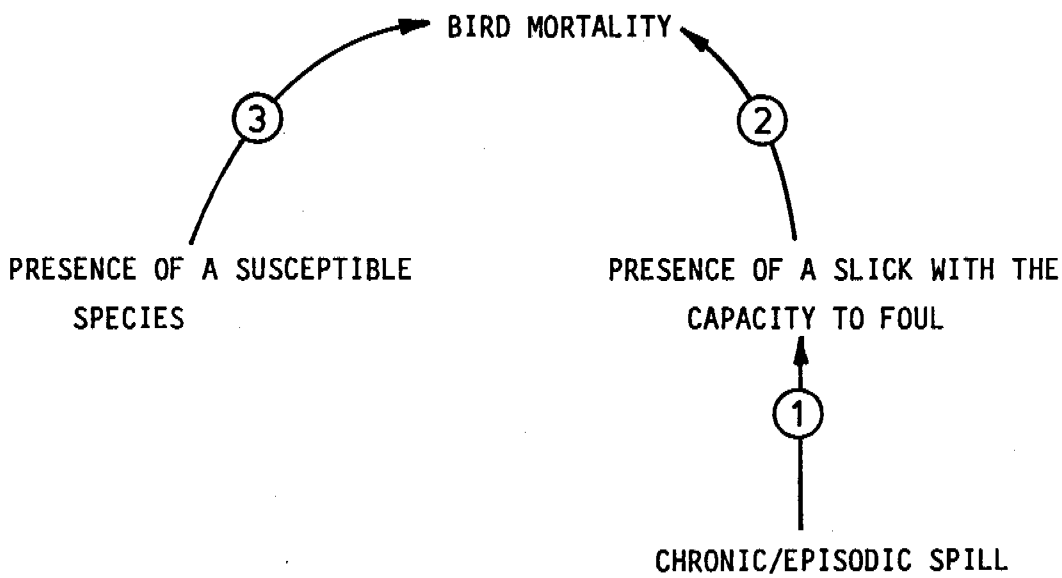
Consumption of oil through processes other than grooming such as the consumption of oil-contaminated prey are areas of potential impact which have not been tested empirically. However, anecdotal evidence indicates that polar bears will consume oil and oil products. The workshop subgroup agreed that polar bear mortality will result following exposure to a critical but unquantified amount of oil either through fouling of fur or ingestion.

CONCLUSIONS

The hypothesis is expected to be valid, although the number of polar bears affected by chronic oil spills will be small and probably not significant at the population level. The most significant information gaps relate to the behavioural response of polar bears to oil covered waters and to oil contaminated prey. The group recommended support and improvement of existing programs including: (1) polar bear monitoring at existing industry facilities; (2) polar bear detection and deterrents; and (3) contingency planning in the event of oil/polar bear contact. No specific new research or monitoring programs are necessary.

HYPOTHESIS NO. 11

Chronic (episodic) oil spills resulting from normal petroleum development activities within and adjacent to the marine environment will cause localized bird mortality.



LINKAGES

Data on the frequency and sizes of oil spills associated with nearshore and offshore petroleum development activities are available and can be extrapolated to the Beaufort development region. In some cases, spills will result in formation of an oil slick that will have the capacity to foul birds. However, the conditions that will result in such slicks have not been documented.

Many species of birds are highly susceptible to oil spills. Under some circumstances, relatively small spills can cause extensive bird mortality.

Large concentrations of susceptible bird species do occur at proposed shorebase development sites in the Beaufort region.

CONCLUSION

There is sufficient information to accept the hypothesis that chronic/episodic oil spills will cause localized bird mortality under some circumstances.

MONITORING

The objective of a monitoring program to address this hypothesis should be to estimate the number of birds of each species killed annually by contact with oil. However, accurate estimation of bird mortality by direct observation is not considered feasible. Nevertheless, an index of bird mortality should be obtained by direct and regular observation of bird abundance, distribution and mortality at shore bases and offshore islands. This regular observation program should be conducted by trained on-site observers and supplemented by more intensive efforts to estimate bird mortality at sites of all chronic (episodic) spills.

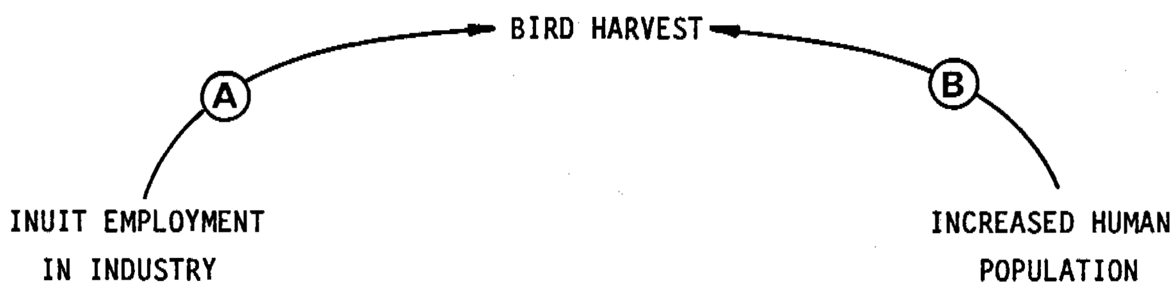
RESEARCH

Accurate estimation of bird mortality, by extrapolation of bird mortality indices from the trained observer counts and on-site studies at spills, will require statistically reliable data that can only be obtained through an extensive laboratory and experimental oil spill research program. Predicted Beaufort hydrocarbon development levels do not justify this approach. Rather, the management philosophy should be to closely scrutinize the results of the monitoring program and to emphasize mitigative actions (i.e. actions to reduce the spill frequency and volume, and to enable rapid clean up).

HYPOTHESIS NO. 12

A. Increased Inuit employment in industry will alter the harvest of birds.

B. A consequence of the increased human population in the Beaufort Sea region will be increased recreational hunting of waterfowl.



LINKAGES

<u>Hypothesis 12A</u>: The framework developed in Hypothesis 12 is appropriate to address the effects of Inuit employment in industry on bird harvest. To summarize, it is probable that as a result of increased Inuit employment in industry (1) the bird harvest will increase, (2) the value of birds as a recreational resource will increase, (3) ability to reach hunting areas will improve, and (4) the availability of hunting equipment (e.g. shells) will increase.

<u>Hypothesis 12B</u>: The projected increase in human population working for or in support of the petroleum industry is from 3,000 to 16,000 people. There is strong evidence that non-natives moving into (or through) the region have a strong desire to hunt birds, primarily geese. On the other hand, future land claims settlements may influence the accessibility of hunting areas to non-native immigrants, thereby reducing the bird harvest.

CONCLUSIONS

Hypothesis 12A: The hypothesis is valid and a monitoring program is recommended.

Hypothesis 12B: The hypothesis is valid and a monitoring program is recommended.

RESEARCH

Prior to design of monitoring programs, results from past harvest surveys in the Northwest Territories should be analyzed to allow the experience gained elsewhere to be applied to the design of a Beaufort region harvest survey.

MONITORING

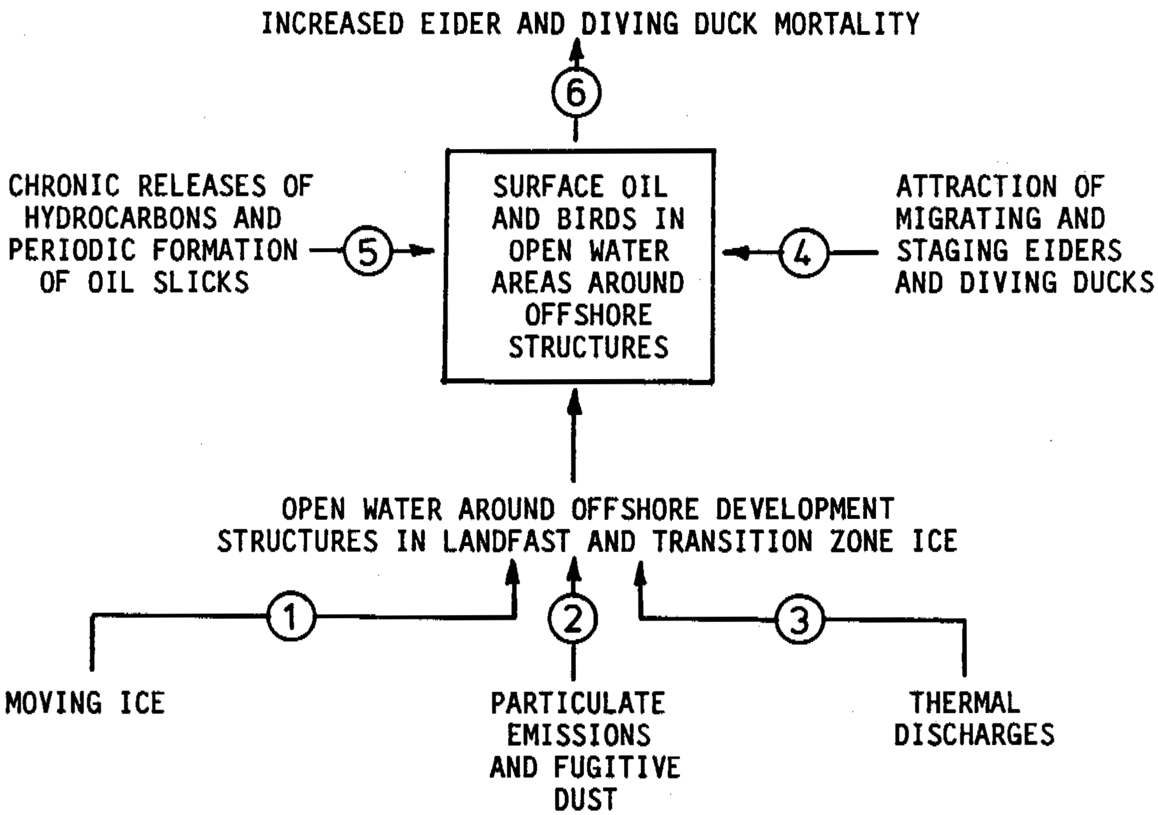
The monitoring of bird harvests is seen as a necessary component of resource management by the appropriate government agencies. It will be necessary to monitor both the native (Hypothesis 12A) and non-native (Hypothesis 12B) harvests, and different methods will be necessary for each program.

For native harvest, a socio-economic survey of Inuit hunting patterns and harvest is recommended. In addition to estimation of harvest rates, this survey should be designed to examine the amount and distribution of time spent hunting, the location of areas hunted, the type of equipment and transportation used, the age and experience of the hunters and the size of hunting parties.

For the non-native harvest, it may be more difficult to estimate harvest rates. However, the recommended monitoring program could include a hunter questionaire combined with a more active approach (e.g., on-site interviews) coordinated with regular wildlife management and enforcement activities.

HYPOTHESIS NO. 13

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



LINKAGES

Link 1: Moving ice causes rubble fields and open water in the lee of offshore structures.

On the basis of aerial photography, this was shown to be true.

Link 2: Particulate emissions and fugitive dust will decrease albedo of the ice around offshore structures leading to increased melting and earlier formation of open water areas around offshore structures.

This linkage was concluded to be incorrect through a series of calculations leading to estimation of the expected level of dusting around offshore structures.

Link 3: Thermal discharges from offshore production facilities, released under or onto the ice, will enhance melting and formation of open water areas around offshore structures.

This linkage is correct, but the expected amount of open water from thermal discharges will vary greatly depending on methods of release and ambient conditions.

Link 4: Eiders and diving ducks are attracted to open water areas during migration and staging.

Recent evidence (provided by Dome Petroleum) indicates that there is no significant attraction of birds to artificially created open water areas around structures. Extreme situations, when the only open water is around offshore structures, and substantial numbers of birds could be expected to land there, are expected to be rare.

Link 5: Chronic releases of hydrocarbons from offshore structures will cause periodic formation of oil slicks in open water areas around offshore structures.

This is true, but is likely to be an uncommon event. In addition, the localized nature of the problem would facilitate rapid cleanup.

Link 6: Oiling of birds around offshore structures will cause mortality.

This linkage was previously described in Hypothesis 11.

CONCLUSION

This hypothesis was considered correct (except for Linkage 2), although it describes a rare event which would not justify a monitoring program. The maximum frequency of occurrence of combinations of circumstances resulting in eider or diving duck mortality is expected to be less than once a decade at any individual structure, and would probably be even less frequent. The regular observations described in relation to Hypothesis 11 will provide data to further evaluate the linkages and assess this conclusion.

HYPOTHESIS NO. 14

Frequent low level aircraft flights over staging brant will cause increased overwinter mortality.

INCREASED BRANT MORTALITY
DURING WINTER

↑ 3

DECREASED FAT ACCUMULATION BY
BRANT DURING FALL STAGING

↑ 2

INCREASED DISTURBANCE WITH RESULTING
INCREASED ENERGY EXPENDITURE BY BRANT

↑ 1

OVERFLIGHTS DURING STAGING

LINKAGES

During fall, a large proportion of the Canadian Beaufort Sea brant population passes along the coast and occasionally stops to feed and rest (stage) in a number of locations. Since they normally remain in these areas for no more than a day or two (depending on weather), low level aircraft flights will only cause significantly increased energy expenditures when they occur frequently over the staging areas. The maximum proposed scale of Beaufort Sea hydrocarbon development will result in infrequent low level flights over staging areas.

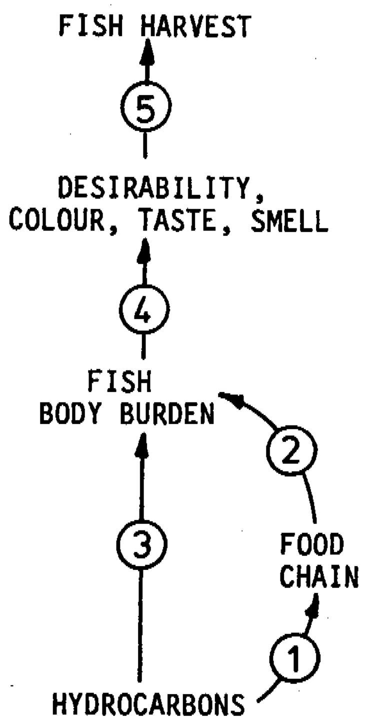
CONCLUSION

The hypothesis is not valid. No monitoring or research is recommended.

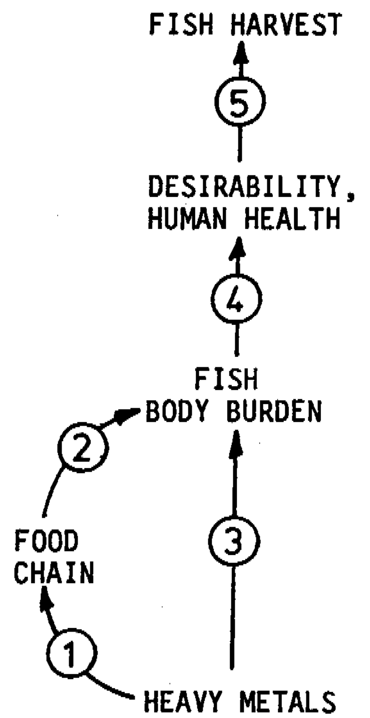
HYPOTHESIS NO. 15

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

HYPOTHESIS 15A



HYPOTHESIS 15B



HYDROCARBONS

The primary sources of hydrocarbons during Beaufort development were expected to be small amounts associated with cuttings and produced water, and small accidental discharges associated with oil storage, transportation and use in protected nearshore areas.

LINKAGES

Links 1 and 3: Hydrocarbons in water and sediments will enter fish and fish food organisms.

Fish and their foods can rapidly absorb hydrocarbons through gill epithelia, mucosa and other soft body surfaces. Storage and accumulation of hydrocarbons occurs in various tissues, particularly those with high lipid content. In general, rates of hydrocarbon depuration are considerably slower than rates of uptake.

Link 2: Hydrocarbons are passed through the food chain.

Hydrocarbon passage through food chains has not been shown to be a major pathway by which tainting occurs in higher trophic levels. Hydrocarbons ingested with tainted food are absorbed through the gut, but then appear to be rapidly excreted.

Links 4 and 5: Increased concentrations of hydrocarbons in fish flesh will lower desirability and subsequently affect harvest of fish.

Many case histories around the world provide evidence that fish flesh containing hydrocarbons has lowered desirability, primarily through an oily taste and occasional odour. Commercial and subsistence fisheries can be reduced or stopped as a result of perceived or actual tainting. Most cases of tainting are due to large "catastrophic" oil spills, but chronic releases of small amounts of hydrocarbons have also caused detectable tainting in some circumstances.

CONCLUSION

Tainting is extremely unlikely to be a significant concern in any area except sheltered bays (such as Tuktoyaktuk Harbour) where: (1) subsistence fishing takes place; (2) substantial numbers of fish are present for a relatively long period; and (3) hydrocarbons are used and handled on a day-to-day basis by a number of individuals.

MONITORING

It is recommended that a time series of measurements of hydrocarbon concentrations in fish flesh (selected species) be initiated in Tuktoyaktuk Harbour. An inexpensive method for measurement of hydrocarbons should be used to minimize analytical costs and thereby allow analysis of an adequate sample size.

It is also recommended that if (1) time series measurements suggest increases of hydrocarbons in fish flesh, or (2) complaints of tainting occur, complementary programs should be considered, to react to either or both of the above concerns. These may consist of a taste testing program and a program to determine where tainting occurs. The latter could involve placement of caged fish in experimental and control areas. Research would probably be necessary to establish which source of contamination was causing the actual tainting.

HEAVY METALS

Links 1 to 5: Heavy metals (particularly mercury) can affect human health or reduce desirability of fish and substantially reduce fish harvests.

The links between heavy metals, especially mercury, and human health/fish harvests are valid and have been well documented in the vicinity of several major industrial centres.

CONCLUSION

The workshop subgroup expected that sufficient quantities of heavy metals to represent an area of concern were unlikely to be associated with hydrocarbon development in the Beaufort Sea.

MONITORING

Continued compliance monitoring of discharges is recommended to assure that heavy metal concentrations in waste streams lie within existing regulatory guidelines.

HYPOTHESIS NO. 16

> Increase in human populations will cause an increase in the harvest of important anadromous fishes which will lead to reduced populations of these species.

DECREASED POPULATIONS OF ARCTIC CHAR,
BROAD WHITEFISH, ARCTIC CISCO

↑ 2

INCREASED HARVEST OF ARCTIC CHAR,
BROAD WHITEFISH, ARCTIC CISCO

↑ 1

DEVELOPMENT-INDUCED INCREASE IN HUMAN
POPULATION

LINKAGES

Link 1: Increases in the human population will increase the harvest of Arctic cisco, Arctic char and broad whitefish.

Natural and development-induced increases in the human population will likely result in increased harvest of the above anadromous fish species. However, due to uncertainties related to (1) the size of the fish populations; (2) the magnitude of natural population changes in the region; (3) the possibility of development of a market for a commercial fishery; and (4) the increase in recreational fishing, the effect of increased human populations on the sustainable yield of Arctic cisco, Arctic char and broad whitefish can not accurately be determined at present.

Link 2: Decreases in the population levels of Arctic cisco, Arctic char and broad whitefish will result from increased harvest of these species.

It is possible that increases in the harvest of these species could result in population decreases. However, due to the large number of uncertainties and unknowns, the resultant effects on the population sizes of the three species cannot be determined at present.

CONCLUSIONS

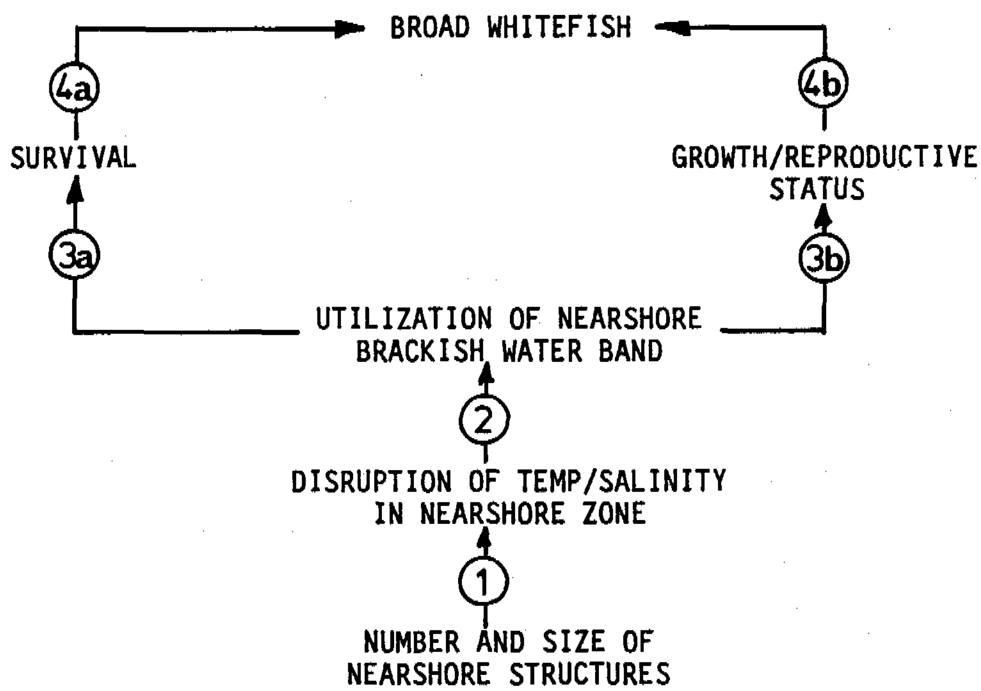
It was considered unlikely, but possible, that development-related increases in human populations in the region would substantially increase commercial, recreational and subsistence fisheries. In general, it was concluded that more information than is presently available would be required to design a monitoring program.

RESEARCH

There is a need to better quantify the existing subsistence catches, levels of effort, and the age and size composition of the catch in order to develop the indices of present stock sizes and catches which are necessary for sustainable yield stock management programs. Since the species in question are long-lived, changes in stock size and length frequency cannot be detected without time series data.

HYPOTHESIS NO. 17

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



LINKAGES

<u>Link 1: Shoreline modifications will change temperature and salinity characteristics of the brackish water band along the Tuktoyaktuk Peninsula during summer.</u>

Solid fill causeways perpendicular to shore could alter wind-generated current patterns in the vicinity of the structure. This, in turn, would cause changes in the temperature and salinity patterns that could persist for 2 to 10 days, depending on the duration of the wind events.

Link 2: Disruption of the brackish water band will result in decreased utilization of the nearshore zone by broad whitefish.

Studies along the Alaskan Beaufort Sea coast near the Prudhoe Bay causeway have shown that these structures can cause local perturbations in the nearshore hydrography, which in turn may have an effect on fish movements. In Alaskan waters, the abundance of broad whitefish was significantly and positively correlated with temperature, and in 9 of 16 cases was also found to be significantly and inversely correlated with salinity. These data suggest that in the absence of other limiting factors, broad whitefish prefer habitats having warm brackish waters.

Link 3a: The reduced time spent in the nearshore brackish zone will cause an increase in mortality of broad whitefish.

Broad whitefish may be forced to spend time in waters of low temperature and high salinity which may make them more susceptable to predators and/or direct mortality due to elevated salinities. This hypothesis is based on observations of fish in temperate regions, and has not been examined in the arctic.

Link 3b: Disruption of nearshore habitat will cause a decrease in feeding time and consequently a reduction in growth and/or fecundity.

Broad whitefish may reduce their feeding as a result of exposure to lower temperature waters. Since this species achieves almost all its growth during the 70-90 day open-water period, each day that individuals are prevented from feeding is expected to be more critical than would be the case in species where growth occurs over a larger portion of the year. Studies conducted along the Tuktoyaktuk Peninsula indirectly support this linkage.

Links 4a and 4b: Increased mortality of broad whitefish would lead to a decrease in the number of spawners and reduced fecundity.

Fish that reach the spawning ground may produce fewer eggs due to loss of feeding time and resultant poor condition. Egg survival could also be reduced.

CONCLUSIONS

It is extremely unlikely that stocks of broad whitefish will be affected if a development involving the use of a lengthy causeway or other major shoreline alteration is not proposed within the area encompassed by the distributed range of the Mackenzie stock of broad whitefish. However, if lengthy causeways are proposed, more biological and hydrological data would be required to determine the potential need for monitoring.

RESEARCH AND MONITORING

If a monitoring program is necessary in relation to a specific major shoreline development, it should include the following components:

Oceanography: In the event a major causeway is proposed, the monitoring program should include measurements of temperature, salinity, currents and wind in the vicinity of the proposed structure before and after construction on a time scale suitable to establish a reasonable daily measure of plume variability. This program should be based on the results of a preliminary numerical model which uses satellite imagery to determine small scale (to 80 m resolution) temperature variability in surface waters.

Fisheries: The recommended approach for a fisheries program associated with a major shoreline development would be (1) to examine the effects of temperature and salinity on growth through laboratory studies; (2) to predict changes in growth resulting from causeway-induced changes in temperature and salinity using simulation modelling; and (3) predict the changes in fecundity resulting from altered growth rates based on empirical relationships between fish weight and fish fecundity. In addition, a tagging program continued over several years may be necessary to establish the distribution and migration patterns of the population, and the proportion of the population which is influenced by the presence of the causeway.

HYPOTHESIS NO. 18

> Nearshore structures will disrupt the nearshore band of warmer brackish water and will reduce the Alaskan population of Arctic cisco.

ALASKAN POPULATION OF ARCTIC CISCO

↑ 3

YOUNG FISH (70-100mm) PREVENTED FROM MOVING ALONG THE YUKON COAST

↑ 2

DISRUPTION OF TEMPERATURE AND SALINITY IN NEARSHORE ZONE

↑ 1

NUMBER AND SIZE OF NEARSHORE STRUCTURES

LINKAGES

Link 1: Shoreline modification will change temperature and salinity patterns of the brackish water band along the Yukon Coast during summer.

Offshore structures (i.e. solid fill causeways) would cause a disruption in wind-driven coastal currents and a resultant alteration in temperature-salinity patterns in the vicinity of the structure.

Link 2: Disruption of the brackish water band will result in decreased movement of young Arctic cisco from the Mackenzie Delta to the Alaskan Beaufort Sea coast.

Gallaway *et al.* (1983) postulate that the Mackenzie River system contains the only breeding stock of Arctic cisco in the Beaufort Sea, and that the Arctic cisco found along the Alaskan Beaufort Sea coast are migrants from the Mackenzie system. Laboratory studies have shown that small Arctic cisco have a temperature preference of 6-15°C, suggesting that they are most likely to be found in the warmest water available. Numerous studies conducted along the Alaskan and Canadian Beaufort Sea coasts have shown that all size groups of Arctic cisco tend to be most abundant adjacent to the shoreline.

Link 3: Decreased movement of Arctic cisco will cause directly proportional decreases in the Alaskan population of Arctic cisco.

Evidence presented in Gallaway *et al.* (1983) suggests that the harvest of Arctic cisco (both commercial and subsistence) is directly dependent upon the number of small (age 1 to 2) cisco which migrate into Alaska from the Canadian Beaufort Sea.

CONCLUSIONS

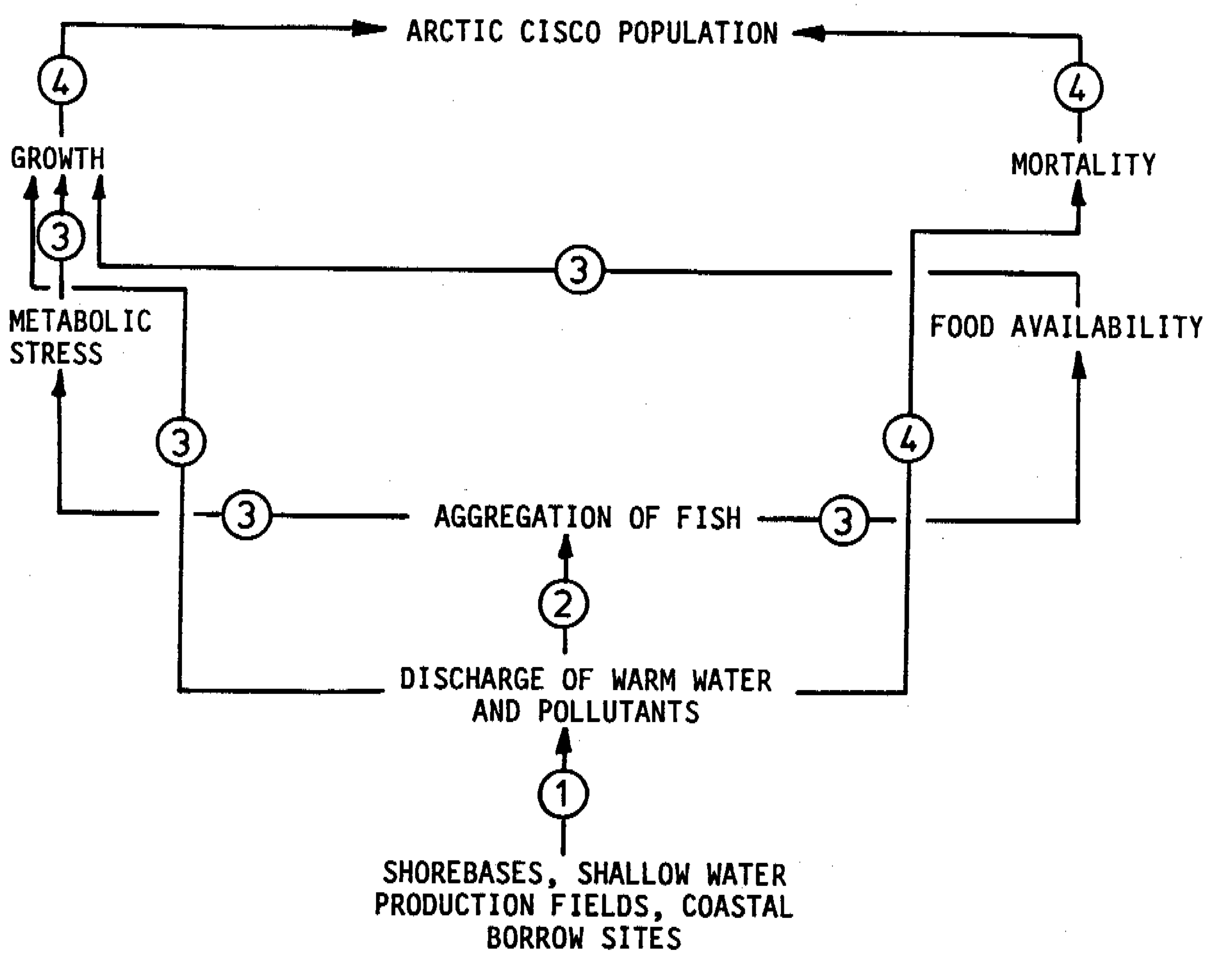
The hypothesis was judged to be valid and would merit a monitoring plan if (1) research on both physical conditions and Arctic cisco migrations indicate that changes are likely, and (2) major causeways that have the potential to disrupt longshore currents are planned along the Yukon coastline.

MONITORING

If major causeways or other extensive shoreline alterations are planned on the Yukon coastline, a monitoring program similar to that outlined in Hypothesis 17 is recommended.

HYPOTHESIS NO. 19

The construction of shorebases and shallow production fields will result in a decrease in the population of Arctic cisco.



LINKAGES

Links 1 to 4: The construction of shorebases, shallow water production fields, etc., will involve the discharge of warm production water and pollutants which will result in increased stress and mortality, decreased food and growth and eventually decreases in the Arctic cisco population.

Due to the small volumes of the discharges and very large dilution factors, the members of the workshop subgroup suggested that the effects of discharges would likely be minimal and not transmitted through Links 2 to 4.

CONCLUSIONS

This hypothesis was examined with the understanding that no developments are planned which involve production facilities sited in less than 3 m of water. Consequently, the likelihood of interaction of discharges with fish is low since the preferred habitat of many anadromous species occurs in less than 3 m of water. Contaminant concentrations are also not expected to reach levels that could be hazardous to biota, except perhaps in the immediate vicinity of the discharge (approximately limited to within 200 m of the discharge). The workshop participants therefore indicated that the hypothesis was remote and not worth testing.

MONITORING

Other than compliance monitoring to assure that regulatory guidelines are achieved in both shorebase and offshore waste streams, no special monitoring is considered necessary if discharges occur in waters greater than 3 m deep.

HYPOTHESIS NO. 20

Water intakes will reduce populations of broad whitefish and Arctic cisco.

BROAD WHITEFISH AND ARCTIC CISCO POPULATIONS

↑ 2

ENTRAINMENT AND IMPINGEMENT

↑ 1

WATER INTAKE FOR INJECTION

LINKAGES

<u>Link 1: The intake of water for reservoir injection will result in entrainment and impingement of juvenile broad whitefish and Arctic cisco.</u>

Present plans in the Canadian Beaufort Sea suggest that most intake structures would be constructed offshore beyond major concentration areas of broad whitefish and Arctic cisco. In the case of the single potential nearshore field (Adgo), the volumes of water which may be required are extremely small compared to similar water intakes in Alaska (110m^3/d vs 320,000 m^3/d).

Link 2: The mortality associated with entrainment and impingement will reduce broad whitefish and Arctic cisco populations.

Given (1) the offshore location of the majority of the intake structures and (2) the small water volumes required for potential nearshore intakes, it was suggested that water intakes would have little impact on broad whitefish and Arctic cisco stocks.

CONCLUSIONS

Several large water intake structures are presently in operation or will soon be going into operation in Alaska, and these will be monitored under the auspices of the U.S. Environmental Protection Agency, Army Corps of Engineers and the National Marine Fisheries Service.

It is suggested that these monitoring studies be reviewed when they become available, and if results indicate that potential problems may exist for fish in the Canadian Beaufort, a re-evaluation of the hypothesis should be undertaken.

HYPOTHESIS NO. 21

> Air emission associated with aircraft and marine traffic, and operation of drill rigs, offshore platforms and shorebases will adversely affect air quality.

AIR QUALITY

↑

PRODUCTION ACTIVITIES

- Mobile Sources (Marine and aircraft)
- Drill Rigs
- Offshore Platforms
- Shorebases

LINKAGES

Operation of production platforms, shorebases, drill rigs and logistical support in the form of aircraft and marine traffic will result in a variety of emission to the atmosphere. A large proportion of these emissions are not considered harmful, including nitrogen, carbon dioxide and water vapour. However, a small portion are classified as pollutants, and are regulated by Federal guidelines. The latter compounds include various nitrogen and sulphur oxides (NO_x and SO_x), hydrocarbons and particulates.

Air emissions in the Beaufort Sea will result from the following activities associated with development, production and transport of hydrocarbons: (1) combustion of solid wastes; (2) combustion of diesel fuel; (3) combustion of aviation fuel; (4) gas flaring; (5) fugitive release of hydrocarbons from fuel tanks; and (6) the combustion of separated gas. The percent composition of emissions from each of these sources are described on a per weight basis in the Beaufort Sea-Mackenzie Delta Hydrocarbon Development EIS (1982). The combined daily and annual emissions from shorebases and both mobile and stationary offshore activities/facilities have also been estimated.

Due to the direct link between air emissions and air quality, dispersion calculations were completed prior to the workshop using a "box model" approach, and estimated pollutant concentrations compared to the regulatory guidelines (see following table).

	POLLUTANT					
ELEMENT	CO $\mu g/m^3$	NO_x $\mu g/m^3$	SO_x $\mu g/m^3$	HC $\mu g/m^3$	SUS. PART. $\mu g/m^3$	DUST FALL $g/cm^2/mo$
Computed 24 hour average	2	8	1	8	3	0.002
Regulatory Guideline	6000 FED (8 hr)	200 FED (24 hr)	150 FED (24 hr)	NA Urban Areas	120 FED (24 hr)	0.525 FED Residential
Ratio (Factor of Safety)	3000	25	150	O[100's]	40	250

These calculations show that on a regional basis, air quality will not adversely be affected due to the very small contributions (less than background) resulting from operation of facilities.

Although the Beaufort EIS does not provide estimates of the quantity of water vapour emissions that could give rise to the formation of ice fog during cold spells, the following points are worthy of mention: (1) ice fog will begin to form when ambient air temperatures are less than -20°C and will definitely form when temperatures are less than -40°C; (2) ice fog formation is caused by the emission of large quantities of water vapour from combustion processes, and the formation is enhanced at the lower temperature limits in the presence of particulate matter in the atmosphere; (3) accumulation of ice fog locally during prolonged periods of calm and cold temperatures can cause localized obstruction of visibility thereby affecting human activities; and (4) there are no mitigation measures available to reduce ice fog formation other than elimination of the source of emission.

CONCLUSIONS

Based on the projected emission levels and the dispersion calculations, the group rejected the hypothesis that air quality will be adversely affected to an extent that would warrant the design and implementation of a regional monitoring program. This conclusion, however, does not preclude the possibility of the operators implementing air quality monitoring program(s) at major shorebases as part of their operational permits to monitor local effects.

SUMMARY

This report briefly summarizes the results of the second workshop in the Beaufort Environmental Monitoring Project. As indicated in a previous submission to the BEARP panel during the Inuvik General session, the primary objective of the first workshop held in May, 1983 was to develop a simulation model for the biophysical environment as a tool to focus interdisciplinary communication and information exchange amongst the 50 participants in the project. The underlying objective of the second workshop (November 28 - December 2, 1983) was the establishment of preliminary research and monitoring priorities, through a detailed, interdisciplinary examination of twenty-one hypotheses regarding the potential impacts of hydrocarbon development on the 'Valued Ecosystem Components' of the Beaufort Sea. Documentation of the results of this latter workshop is now being completed and the report is expected to be ready for distribution by 1 March 1984. Consequently, this summary must be regarded as preliminary and subject to revision.

The hypotheses, conclusions, and proposed research and monitoring that were discussed in the second workshop are summarized further in Table 1.

TABLE 1

PRELIMINARY RESEARCH AND MONITORING SUMMARY

VALUED ECOSYSTEM COMPONENT	HYPOTHESIS	CONCL.*	RESEARCH	MONITORING
BOWHEAD WHALE	Ship traffic, seismic programs and active offshore platforms/ artificial islands will cause reductions in the western arctic population of bowhead whales.	V,T	Summer/winter energy balance dynamics; distribuion of food supply; acoustical behaviour monitoring methodology.	Annual distribution of bowheads and behavioural responses to industry activities/facilities; reproductive success; ambient noise monitoring.
WHITE WHALE	(a) Offshore structures will reduce the white whale harvest; (b) frequent icebreaker traffic in the landfast ice will increase harvest; (c) open water ship traffic in the Mackenzie estuary will alter white whale distribution and lead to changes in harvest levels; (d) Inuit employment in the industry will change the white whale harvest.	(a) U (b) U (c) V,T (d) V,T	Factors controlling distribution of white whales in Niakunak and Kugmallit bays.	Annual monitoring of regional landfast ice extent, distribution and breakup; continuation and revision of existing white whale monitoring program.
RINGED AND BEARDED SEALS	Marine vessel activities, seismic programs, dredging operations, aircraft overflights and active offshore platforms/islands will reduce the size of ringed and bearded seal populations.	V,UT	None	None

TABLE 1 (Page Two)

VALUED ECOSYSTEM COMPONENT	HYPOTHESIS	CONCL.*	RESEARCH	MONITORING
RINGED SEALS	Increased frequency of icebreaker traffic (a) through landfast ice and (b) through Amundsen Gulf will reduce ringed seal pup production.	(a) U,UT (b) V,T	Further analysis of seal samples collected near Holman Island (1971-1982) in relation to Amundsen Gulf ice conditions; ice stability research.	Dependent on research results: aerial photography of icebreaker traffic/ice regime in Amundsen Gulf; possible remote sensing of ringed seal birth lairs.
BEARDED SEAL	Icebreaker traffic in the transition (shear) zone will reduce bearded seal pup production.	V,UT	Bearded seal vocalization rates in control area and area exposed to icebreaker traffic (low priority).	None
POLAR BEAR	Icebreaker traffic in Amundsen Gulf will affect the polar bear population.	I	Data on ice cover and seal (prey) populations (1971-1983) should be examined for correlations between population parameters and annual ice conditions.	Not at present time; pending evaluation of research results.
POLAR BEAR	The presence of active facilities will result in increased polar bear mortality	V	Continued research on methods of detecting and deterring bears	Existing polar bear monitoring and deterrent programs should be supported and improved.

TABLE 1 (Page Three)

VALUED ECOSYSTEM COMPONENT	HYPOTHESIS	CONCL.*	RESEARCH	MONITORING
POLAR BEAR (HARVEST)	Offshore hydrocarbon development activities will reduce the harvest of polar bears.	U	None	None, see text
MARINE BIRDS AND MAMMALS (HARVEST)	Increased native employment in industry will reduce marine bird and mammal harvests.	V,T	Analysis of data from past and existing surveys (see text).	Modification of existing native and government programs.
POLAR BEAR	Chronic/episodic oil spills resulting from normal petroleum hydrocarbon development activities will result in localized mortality of polar bears.	V	Support of existing research on polar bear detection and deterrents.	Support and improvement of existing monitoring programs and contingency plans.
BIRDS	Chronic/episodic oil spills resulting from normal petroleum development activities will cause localized bird mortality.	V	None (see text)	Regular observation of bird abundance, distribution and mortality at shorebases and offshore islands by trained on-site personnel.
BIRDS (HARVEST)	(a) Increased Inuit employment in industry will alter the harvest of birds; (b) a consequence of the increased human population in the Beaufort Sea region will be increased recreational hunting of waterfowl.	(a) V,T (b) V,T	Analysis of the results of past harvest surveys in the NWT.	Socio-economic survey of Inuit hunting patterns and harvest; estimation of non-native harvest rates.

TABLE 1 (Page Four)

VALUED ECOSYSTEM COMPONENT	HYPOTHESIS	CONCL.*	RESEARCH	MONITORING
EIDERS AND DIVING DUCKS	Oil slicks in open water areas around offshore structures during normal periods of ice cover will cause increased mortality of eiders and diving ducks.	V,UT	None	None
BRANT	Frequent low level aircraft flights over staging brant will cause increased overwinter mortality.	IV	None	None
FISH (HARVEST)	Shorebases and shallow water production facilities will release (a) hydrocarbons and (b) heavy metals at sufficient levels such that fish harvest will be reduced through tainting and heavy metal accumulations.	(a) V,T (b) U	None unless monitoring shows tainting, and then research would be required to identify source.	Time-series measurements of hydrocarbons in fish from Tuktoyaktuk harbour; possible taste testing/ caged fish programs.
ARCTIC CHAR, BROAD WHITEFISH, ARCTIC CISCO	Increase in human populations will cause an increase in the harvest of important anadromous fishes which will lead to reduced populations of these species.	U,UT	Better quantification of existing subsistence catches, level of effort, age and size composition for stock management programs.	None

VALUED ECOSYSTEM COMPONENT	HYPOTHESIS	CONCL.*	RESEARCH	MONITORING
BROAD WHITEFISH	Nearshore structures will disrupt the nearshore band of warm brackish water and reduce the broad whitefish population.	V,T (see text)	If a major nearshore structure is proposed development of a numerical model of nearshore temperature variability; laboratory and modelling studies of fish growth and fecundity.	If a major nearshore structure is proposed, measurements of temperature, salinity, currents and wind; possible tagging of broad whitefish.
ARCTIC CISCO	Nearshore structures will disrupt the nearshore band of warm brackish water and reduce the Alaskan population of Arctic cisco.	V,T	Same as immediately above	Same as immediately above
ARCTIC CISCO	The construction of shorebases and shallow production fields will result in a decrease in the population of Arctic cisco.	U,UT	None	None (see text)
BROAD WHITEFISH, ARCTIC CISCO	Water intakes will reduce populations of broad whitefish and Arctic cisco.	U,UT	None	None (see text)

TABLE 1 (Page Six)

VALUED ECOSYSTEM COMPONENT	HYPOTHESIS	CONCL.*	RESEARCH	MONITORING
AIR QUALITY	Air emissions associated with aircraft and marine traffic; and operation of drill rigs, offshore platforms and shore-bases will adversely affect air quality.	U,UT	None	None (see text)

*KEY:
- I - Improbable
- IV - Invalid
- V - Valid
- U - Unlikely
- UT - Too hard to detect or not worth testing
- T - Testable

APPENDIX 1

LIST OF PARTICIPANTS AT THE SECOND WORKSHOP OF THE BEAUFORT ENVIRONMENTAL MONITORING PROJECT

NAME	AFFILIATION
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Wolfe, Douglas, A.	Ocean Assessment Division, NOAA