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REPORT OF A WORKSHOP ON
ARCTIC MARINE MAMMALS

by

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ABSTRACT

Davis, R.A. 1981. Report of a workshop on arctic marine mammals. Can. Tech. Rep. Fish. Aquat. Sci. 1005: iv + 13 p.

A workshop of experienced biologists examined the potential effects of offshore hydrocarbon development and transportation on marine mammals in the Canadian Arctic. Important data gaps and research priorities to address these gaps are presented in this report. The workshop also examined the data needed to effectively manage arctic marine mammals. This analysis and the research needed to begin to establish the required data base are reported.

Key words: Canadian Arctic; marine mammals; offshore hydrocarbon development; management; research priorities.

RESUME

Davis, R.A. 1981. Report of a workshop on arctic marine mammals. Can. Tech. Rep. Fish. Aquat. Sci. 1005: iv + 13 p.

Un groupe de travail compose de biologistes expérimentés a examiné les effets possibles qu'auraient l'exploitation et le transport d'hydrocarbures dans les eaux côtières sur les mammifères marins de l'Arctique canadien. Ce rapport fait part d'importantes lacunes dans les données et suggère des priorités de recherche pour combler ces lacunes. Le groupe de travail a également étudié quelles données seraient nécessaires à une bonne gestion des mammifères marins de l'Arctique. Le rapport porte sur cette étude et sur les recherches nécessaires à l'établissement de la base de données requises.

Mots-clés: Arctique canadien; mammifères marins, exploitation d'hydrocarbures dans les eaux côtières; gestion; priorités de recherche.

INTRODUCTION

Recent hydrocarbon discoveries in the Beaufort Sea and the Arctic Islands have led to discussion of methods of development and methods of transportation to southern markets. In 1981, Dome Petroleum Ltd., Esso Resources Canada Ltd. and Gulf Canada Ltd. will be filing their development plans and environmental impact statement for Beaufort Sea production. Department of Fisheries and Oceans (DFO) will have to evaluate the effects of this development on arctic marine mammals and it will have to contribute to an evaluation of the relative impacts of tanker vs. pipeline modes of transportation. In addition, DFO recognizes the need for long range planning to properly manage the arctic marine mammal resources in the face of increased utilization by native hunters. Therefore, DFO sponsored a workshop on 'Arctic Marine Mammals' in Winnipeg, Manitoba, on 8-11 December 1980.

The workshop brought together a small group of knowledgeable and interested scientists with research and management experience with arctic marine mammals. The objectives of the workshop were to review current knowledge and identify research priorities with respect to the potential effects of offshore hydrocarbon developments on arctic marine mammals, and with respect to management of arctic marine mammals.

Department of Fisheries and Oceans retained LGL Limited to organize the workshop and to produce a report on its results. A draft report was prepared and circulated to the workshop participants in early January 1981. Comments from the participants were received and a final report prepared in March. The report attempts to reflect the consensus opinion of the workshop. Clearly, this is not always possible given the variety of issues discussed and participants involved. In cases where no clear consensus evolved at the workshop, this report presents the majority view with a discussion of contrary opinions.

OBJECTIVES AND ORGANIZATION

The four day workshop was divided into two two-day sessions. The first session addressed questions relating to offshore hydrocarbon development and the second session concentrated on questions pertaining to the exploitation and management of arctic marine mammals.

The general objectives of the first session were

- to review what is known about the potential effects of impending offshore hydrocarbon developments,
- to identify mitigative measures

that are available to alleviate potential problems.

- to identify biologically important data gaps,
- to identify species and areas that are most at risk, and
- to identify and to establish a priority ranking of key research initiatives that should be undertaken before, during and after industrial activities,
- to recommend policies to DFO to protect marine mammals from potential industrial impacts.

The last objective was not specifically addressed at the workshop. The topics 'Important Data Gaps' and 'Critical Research Initiatives' constituted the main emphasis of the workshop and form the basis of the report of this session.

The objectives of the second session were to review briefly the present biological data base on arctic marine mammals and to identify present and future management problems. The principal output of this session is a list of priorities for research initiatives needed to address the problems identified. The list of research initiatives includes general recommendations on the types of biological studies required, as well as the topics requiring study.

It is recognized that division of the workshop into two sessions was arbitrary. There was much overlap between the sessions and it was clear that information required for management would also provide information required for impact assessment. The division into two sessions was necessary to accommodate participants who were unable to be present for the full four days of the workshop.

PARTICIPANTS

Attendees at the workshop represented a wide cross-section of workers interested in arctic marine mammals, and the exchange of views among workers with different perspectives was a valuable if intangible benefit of the workshop.

Participants from DFO included workers with research responsibilities (A.W. Mansfield, T.G. Smith), management and policy responsibilities (J.S. Loch, R.F. Peet, R.W. Moshenko, D.G. Wright, B.W. Fallis, L. de March, and A.M. Kristofferson--Winnipeg; R. Paterson and D. Goodman--Ottawa; B. Smiley--Sidney), and field and enforcement responsibilities (D. Moshenko--Yellowknife; R.T. Barnes--Inuvik; and G. Williams--Frobisher Bay). The regulatory Department of Indian Affairs and Northern Development was represented by T. Langtry from Ottawa and D. Stone from Yellowknife. Particularly insightful contributions to the workshop

were made by H.W. Braham of the U.S. National Marine Mammal Laboratory, Seattle, and by J.J. Burns of the Alaska Department of Fish and Game, Fairbanks. The oil industry was represented by J.G. Ward of Dome Petroleum Ltd. and N.B. Snow of Petro-Canada. Other participants with research and impact assessment experience with arctic marine mammals included J. Donaldson of Tundra Consultants, and R.A. Davis, K.J. Finley, M.A. Fraker and W.J. Richardson of LGL Ltd.

WORKSHOP RESULTS

SESSION I -- OFFSHORE HYDROCARBON DEVELOPMENT

The first part of this session consisted of a general review of the hydrocarbon developments that have been proposed for Canadian arctic marine waters. These developments range from the ongoing or planned exploratory drilling in the High Arctic, Lancaster Sound, Baffin Bay and Davis Strait to the massive plans for production (offshore production atolls, dredging, marine pipelines, workboats, drillships, ports, aircraft, etc.) and transportation (Class 10 ice-breaking tankers, pipelines, etc.) of oil from the Beaufort Sea. Other proposals such as the Arctic Pilot Project and Polar Gas Project were also reviewed. The discussion of proposed developments was followed by a review of the potential impacts to marine mammals of activities that would be associated with the above developments. This included an evaluation of (1) the perceived severity of the impacts and (2) the data gaps that need to be filled before a confident prediction of the severity of the impacts can be made. The discussion was organized under the following headings:

Release of Contaminants

- Drilling fluids
- Formation cuttings
- Cement slurry/scrap steel
- BOP fluids
- Methyl alcohol
- Sewage
- Heated water

Release of Natural Gas

LNG Accidents

Release of Crude and Refined Oils

Dredging

Shock Waves--Seismic Exploration, Ice Management

Underwater Noise

- Major sources

- Source levels
- Transmission loss
- Ambient noise
- Hearing thresholds
- Masking
- Direct effects
- Indirect effects

Ice-breaking

- Direct effects
- Creation of artificial leads
- Disruption of ice-edges
- Disruption of ice-sheets

General Disturbance and Physical Presence

- Drilling rigs
- Artificial islands
- Ice-breakers
- Workboats
- Aircraft
- Ports, harbours, dry docks, etc.
- Undersea oil storage
- Undersea pipelines

Recreation and Increased Access

- Workers
- Inuit
- Tourists

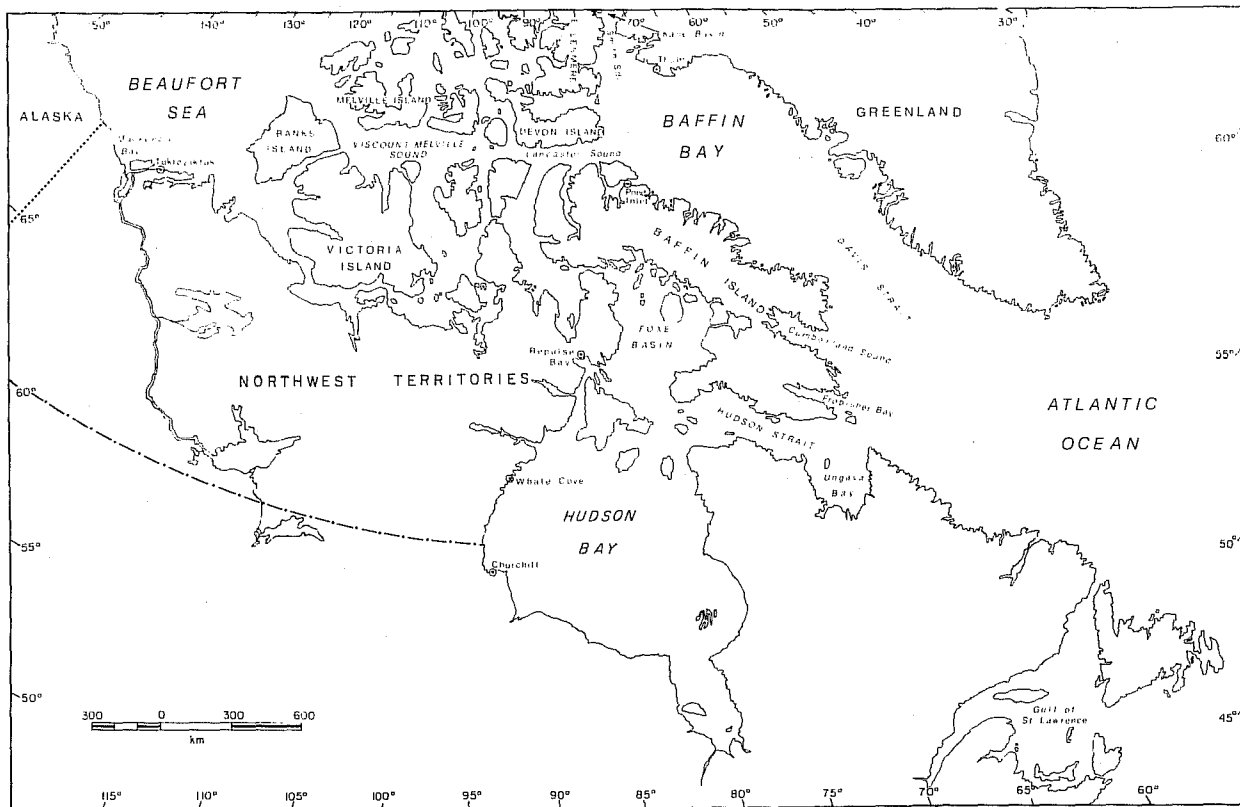
Cumulative Effects

- Compensatory?
- Additive?
- Synergistic?
- Indirect?
- Food Chain?

The discussions of the above topics were wide-ranging and reflected a variety of viewpoints and approaches. These discussions are not repeated or summarized here except for those issues that were considered to be most important or those issues for which data were considered insufficient to make a judgement on potential effects. The terms of reference for this project did not include provision of a state-of-the-art literature review of the potential effects of industrial activity on marine mammals since it was assumed that workshop participants would be familiar with the most recent information and would take it into account when evaluating research recommendations. A recent state-of-the-art review (Geraci, J.R. and D.J. St. Aubin 1979, Possible effects of offshore oil and gas development on marine mammals. Rep. to U.S. Mar. Mammal Comm.) was distributed to participants and used as a background document.

Discussion of research initiatives

This section of the report briefly reviews the principal data gaps identified during the discussion of potential impacts from offshore hydrocarbon developments. The following section discusses priorities--i.e. the relative importance of the research initiatives proposed from this discussion of data gaps.



Release of contaminants (other than hydrocarbons): The workshop considered the following potential contaminants: drilling fluids, formation cuttings, cement slurry, scrap steel, BOP fluids, methyl alcohol, sewage and heated water. The principal concern was the potential effects of drilling fluids. The other contaminants were considered to be less important or adequately covered by existing regulatory mechanisms.

The concern about drilling fluids centred on the release of heavy metals into the marine system. Large scale exploration and production in the Beaufort Sea would require large amounts of drilling fluids and their constituent heavy metals. Because of uncertainties about the chemical makeup of drilling muds that will be used, the relative use of water- vs. oil-based fluids, the amount of recycling that will occur, and the biological availability of the released heavy metals, the participants could not make confident predictions about the overall level of contamination.

The workshop concluded that it was important to establish predevelopment baseline levels of selected heavy metals in selected species of marine mammals. It was also noted that studies of the physiological significance of heavy metal loads would be necessary if there were indications that heavy metals were accumulating in mammal tissue as industrial development proceeded.

Some additional points are important. Heavy metal monitoring is of more general concern than could be dealt with in a workshop on marine mammals. General ongoing monitoring should concentrate on sedentary benthic animals. If problems with heavy metal contamination develop, several measures can be implemented to reduce input of heavy metals into the sea via drilling muds. Also, the most important sources of 'unnatural' heavy metal contamination are likely to be the new mines (e.g. Black Angel, Nanisivik, Arvik) that have been or are being developed in certain coastal areas. These sources were considered to be potentially important chronic threats to marine mammals in at least some areas.

Release of natural gas: The accidental release of natural gas into the marine system was not considered to pose a significant threat to arctic marine mammals. Natural gas in open water would escape to the atmosphere, whereas even under complete sea ice only small areas would be affected.

LNG accidents: Accidents associated with liquefied natural gas (LNG) could occur at coastal liquefaction plants or at sea from LNG carriers. The probabilities of an accident are very low and further, the probability of an accident occurring in a concentration of marine mammals is even lower. By considering the distribution, migration and behaviour of marine

mammals when determining the locations of plants and the routes of ships, it is possible to further reduce the probability that an accident will seriously affect arctic marine mammals. Therefore, the workshop did not consider that LNG accidents pose a significant threat to marine mammals.

Release of crude and refined oil: The accidental release of oil, whether it be a major spill or blow-out or chronic small releases, is a major concern with respect to proposed offshore developments. The effects of oil on marine mammals are generally poorly known although some of the potential effects are currently being studied.

The workshop focussed attention on the following questions: Can marine mammals detect the presence of oil on the surface of the water? If they can detect the oil, will they avoid it? Answers to these questions are crucial to an understanding of the probable effects of oil slicks.

The question of oil detection can be partially answered with controlled laboratory experiments, and tests of the abilities of odontocetes to detect oil slicks visually and via echolocation are underway. However, these results may not apply to other groups, especially if echolocation proves to be the mode of detection by odontocetes.

The question of whether marine mammals will actually avoid oil slicks in natural situations probably cannot be answered by laboratory experiments. Two other approaches are available to address the question of avoidance. In some natural situations carefully planned, small scale, controlled spills could be conducted with minimal risk to the test animals (e.g. narwhal in leads). A wide-ranging discussion of the acceptability of such experiments concluded that valuable data could be gathered if approval to conduct the studies could be obtained. The second approach involves opportunistic studies at any spills that occur. The concept of a response team is discussed later in this section.

The effects of oil on the skin of marine mammals were discussed. It was concluded that effects on pinnipeds were reasonably well known but that effects of oil on the biologically active skin of whales were not known. This is a major data gap but it is currently being addressed in experiments with captive odontocetes by Dr. J. Geraci (University of Guelph) with funding from the U.S. Bureau of Land Management.

The effects of ingestion of oil by marine mammals were addressed by the workshop. Some studies have examined these effects and further work was not considered a priority at this time.

In view of political problems associated with oil-related experimentation on marine mammals, the workshop concluded that it was important to obtain a maximum amount of useful scientific information from any accidental oil spill in Canadian marine waters, including Atlantic and Pacific coastal waters. A broad scientific response plan with a small marine mammal component has been developed for the Beaufort Sea and this plan is being expanded to other arctic waters; plans will also be developed for the Atlantic and Pacific coasts. Plans will have two parts: provision of scientific assistance to the on-scene commander, and conduct of opportunistic scientific studies.

Participants stressed the importance of the scientific component of the response plans. There was a general feeling that useful information would only be obtained with careful pre-planning and knowledge of normal mammal distribution and behaviour patterns. A key element of such plans is the identification and on-going support of a scientific response team qualified to conduct useful studies at a spill. This approach has been taken in the United States where a scientific response team consisting of several key personnel is backed by experts across the country on an as required basis.

The general effects of oil on the marine system, particularly on important prey species of marine mammals, are of concern. Available information on these system effects is inadequate. It was felt that studies of these effects were of importance to general assessments of oil spills or blowouts and were not only of concern regarding marine mammals.

Dredging: The discussion of the effects of dredging was wide-ranging and many of the points made also applied to other industrial activities as well. In general, although large amounts of dredging are planned for the Beaufort Sea, only a relatively small portion of this area will be subject to dredging and natural recolonization will occur. However, the benthic and epibenthic communities of the Beaufort Sea are not homogeneous, and at least some species of marine mammals probably rely on patches of good habitat (e.g. bearded seals off southern Banks Island). The biological oceanography of the Beaufort Sea is not well known and the locations of important habitat patches are also unknown. Another major problem is the lack of information on the feeding dependencies of marine mammals, particularly bowheads and white whales, in the Beaufort Sea.

The most efficient approach to evaluating the effects of industrial activities, such as dredging, is to determine areas and seasons where concentrations of the various species of marine mammals occur and then to determine why the animals use the areas. Use may be related

to feeding, social behaviour or other factors. Definition of concentrations is a function of spatial distribution patterns of the species and the proportion of the population that would be affected by relatively site-specific industrial activities. Considerable information is available about the general locations of concentration areas of various marine mammals in the Arctic (although this knowledge is not complete for some places and seasons). Much less is known about the reasons why various species concentrate at specific locations.

Shock waves: Seismic activity on fast-ice along the north coast of Alaska may have led to reduced numbers of ringed seals. This has led to imposition of regulations which prohibit seismic activity on fast-ice after 20 March. This stipulation is intended to protect pupping ringed seals. Further work on this question is planned by the Alaska Department of Fish and Game beginning in 1981. The effects of open water seismic work on marine mammals are unknown.

Seismic exploration activity in Canadian waters is regulated and seismic work in areas with high concentrations of marine mammals can be controlled. The principal concern revolves around the small proportion of offshore seismic studies that utilize explosive techniques. The Department of Fisheries and Oceans is currently reviewing its policy on marine explosives; new guidelines will be issued in the spring of 1981.

Underwater noise: Because marine mammals rely on underwater sounds for communication and for information about their environment, the effects of large increases in underwater noise levels associated with industrial activities are a matter of concern. In most of the world's oceans, low frequency ambient noise levels are almost completely due to ship-induced underwater noise. Arctic marine mammals have not been exposed to significant amounts of industrial noise. There is a definite lack of data from arctic waters on such questions as noise source levels, propagation loss characteristics, and existing ambient noise levels. In addition, there are major gaps in knowledge of the hearing thresholds, frequency and intensity of calls, required signal-to-noise ratios, and functions of communication signals of arctic marine mammals. The principal concerns are that artificial underwater noise may disturb marine mammals and cause detrimental changes in distribution and behaviour, and that artificial noise may mask mammal communication signals and thereby disrupt feeding or social behaviour.

Two types of studies were identified as important. First, studies of normal, undisturbed behaviour patterns and vocal behaviour are needed to evaluate the functions and importance of the vocalizations of selected species throughout the year. These studies are

necessary for interpretation and prediction of the effects of increases in man-made noise levels. Second, experimental studies of the effects of man-made noise on marine mammals should be conducted to determine behavioural responses to man-made noise. Such studies are being conducted on bowheads in the Canadian Beaufort Sea with funding from the U.S. Bureau of Land Management. Similar studies on white whales in the Beaufort Sea have been conducted for Esso Resources Canada Ltd.

Underwater noise is perhaps the most all-pervasive effect that will be associated with offshore hydrocarbon development. Large tankers will produce measurable increases in ambient noise levels at distances of a few hundred kilometres in certain conditions. The consequences of this noise are poorly understood and some questions may not be answerable before development proceeds. Rigorous monitoring programs will be necessary.

Ice-breaking: Large amounts of ice-breaking will be associated with the proposed offshore developments, including year-round tanker traffic through Parry Channel and Baffin Bay. Ice-breaking will affect ringed seals directly (crushing of pups) and indirectly (ship noise and disturbance) although the severity of the effects is not well known. It was argued at the workshop that, by restricting tankers and LNG carriers to relatively narrow routes, the direct effects on ringed seals can be kept to a minimum. However, these ships will be operating at full power and generating their peak noise levels when ice-breaking. The effects of this noise on ringed seals at substantial distances from the ship's tracks have not been studied. Such studies are feasible and could provide useful predictive data.

Concern has been expressed about the possible creation of artificial leads behind the large ice-breaking ships and the potential for whales to move into these leads and become trapped when the leads refreeze. Calculations made by the Arctic Pilot Project and observations made from the MV Canmar Kigoriak and the MV Louis St. Laurent indicate that the tracks of ice-breakers remain clogged with ice and probably will not attract whales.

The effects of traffic by ice-breaking ships on ice-edges and on the stability of large ice sheets could lead to major changes in the habitat available to marine mammals. Such changes would not necessarily be detrimental to all species although they could severely affect harvest activities by Inuit hunters. Studies of the potential for changes in ice-edges and sheets were considered important, but were not identified as a research priority from the marine mammal point-of-view because similar studies would be conducted as part of the technical evaluation of the feasibility and economics of year-round shipping in the Arctic.

General disturbance and physical presence:

A great many activities will be associated with hydrocarbon development of the Beaufort Sea. These activities will include drillships, artificial islands, production atolls or platforms, ice-breakers, workboats, dredges, aircraft, ports, harbours, undersea oil storage, undersea pipelines and so on. It is not possible to separate the effects caused by the presence of these activities from the effects of noise associated with the activities. This section of the discussion concentrated on the combination of activity and noise rather than underwater noise per se.

It was concluded that, although studies of a few single activities have been done and have provided useful information, there is an overall lack of information about the effects of disturbance by many of the activities. This lack is particularly important when attempts are made to predict the combined effects, on marine mammals, of several types of activities occurring simultaneously at many places in an area like the eastern Beaufort Sea.

The workshop concluded that studies of the effects of these activities were important. Two related approaches were identified as having provided useful results: (1) experimental disturbance studies such as are being conducted on bowheads for the U.S. Bureau of Land Management; and (2) the Esso white whale monitoring program, which combines a long-term study of numbers, distribution and migration patterns with observations on the incremental effects of various industrial activities on these patterns.

Recreation and increased access: A brief general discussion of peripheral implications of major hydrocarbon developments was held. Implications include the recreational activities of a large work force, changes in Inuit hunting activities due to increased access and increased money for equipment, and increased tourist activities. It was concluded that these activities would lead to increased stress on marine mammal populations but the lack of information on the extent and details of these activities precluded specific recommendations about research initiatives.

Cumulative effects: An elusive theme throughout discussions at the workshop was the difficulty in coming to grips with the question of cumulative effects of major offshore developments. It is not known whether effects will be additive or compensatory or synergistic, or whether there will be some variable combination of the three for different species in different areas. Effects could be direct, or indirect through the food webs supporting marine mammals, or in some other indirect manner.

It is unlikely that an understanding of these complex effects can be achieved before further development begins. This is especially true given the economic factors that are forcing offshore hydrocarbon development in the North American Arctic. It is, therefore, critically important to institute properly funded long-term research programs on the biology and ecology of key species of marine mammals. These programs should begin before development proceeds further, and then should be conducted concurrently with development so the effects of development can be determined on an on-going basis. The availability of this information on a timely basis would allow for modification of developments to protect mammals should serious effects occur. Without on-going research and monitoring, it will not be possible to document detrimental effects until major changes in the populations have occurred; by then mitigative measures will be much more difficult, if not impossible, to institute.

Research priorities

At the conclusion of this workshop session, the participants formulated a list of general research initiatives with respect to the effects of offshore hydrocarbon development on arctic marine mammals. Priorities for each identified initiative were established using a general rating of 1 (high), 2 (medium) and 3 (low). The purpose of the rating exercise was to identify which research initiatives should be followed up in the event that not all could be funded. It is emphasized that 'Priority 3' studies should not be considered unimportant. Unimportant studies do not appear at all, in the following list of initiatives. This list is organized by the three priority levels. It will be noted that there is some unavoidable overlap among studies on the list, and there is also some overlap between studies recommended here and those recommended for management purposes in the second session. For example, the long-term biological/monitoring research identified as Priority 1 below is equally important for management and impact assessment.

Priority 1: The most pressing type of study was identified as long-term biological/monitoring research on key species of marine mammals. In the Beaufort Sea, these studies should be conducted on bowheads, white whales, ringed seals and bearded seals. These studies would provide the knowledge of the basic biology, distribution and numbers of animals, year-to-year variability, and habitat dependencies, that is necessary to predict and document behavioural changes in response to industrial activity and to evaluate the significance of such changes. Examples of the types of studies that most closely approach these objectives are the white whale studies in the Mackenzie estuary region and the long-term

government studies of ringed and bearded seals.

Surveys to determine the locations, sizes and importance of concentration areas used by marine mammals are basic to rational decisions about offshore industrial activities. It was noted that several large surveys have been conducted and many concentration areas have been identified. However, several important data gaps remain (e.g. distribution of bowheads in the Beaufort Sea; winter distribution of narwhals, bowheads, white whales and walrus in Baffin Bay, Davis Strait and Hudson Strait).

Although it is important to know the locations and timing of use of concentration areas, it is also important to know why and how the animals use these areas. Without this information it will not be possible to predict the probable effects of industrial activities in the concentration areas. An example that was discussed was the summer concentration of white whales in parts of the Mackenzie estuary; it is not known with certainty why white whales concentrate there. Thus, the consequences of the possibility that white whales may be forced out of these areas for several years during hydrocarbon development and production cannot be evaluated. Therefore, studies of the reasons for use of concentration areas are of high priority for areas that will be subject to industrial activity.

Studies to document the normal behaviour and vocal repertoire of marine mammals are considered important. Particular emphasis should be placed on the functional significance of the vocalizations. Since function and significance can change over the year, studies should be conducted during all seasons that the species occurs in areas affected by development.

Experimental studies of the effects of noise and of industrial activities on marine mammals were identified as important. Studies using a control/disturbance/control sequence of observations, together with observations of undisturbed behaviour, can provide useful information about the short-term effects of noise and related activities on marine mammals. Several studies on white whales (Esso) and a preliminary study on bowheads (U.S. B.L.M.) have been conducted already. Species of particular concern include bowheads and white whales in the Beaufort Sea, and narwhals, bowheads and ringed seals in the central and eastern Arctic.

In addition to the above research initiatives there was general agreement that a properly prepared and adequately funded scientific response team could provide useful information by studying any oil spill that

occurred in Canadian waters. The workshop noted that unless the response team was properly prepared (both logistically and scientifically) and independent of other on-scene activities (e.g. oil clean-up), the concept would not rate a high priority. There is already a plethora of anecdotal and semi-scientific observations at oil spills, and it can be argued that this 'information' has done more to cloud an understanding of the effects of oil on marine mammals than to clarify the situation.

Priority 2: Research initiatives classed as priority 2 were the most controversial with several participants arguing for a Priority 1 status for some of them. The best example of this problem was the priority to be assigned to studies of the ability of marine mammals to detect a surface oil slick and whether they will avoid such a slick. Six participants considered these studies to be priority 1 whereas seven considered them priority 2. Four participants considered this type of study to be priority 3 but at least some of these ratings were low because laboratory research is currently being conducted on the ability of toothed whales to detect oil slicks. Valuable approaches to these questions include expansion of on-going laboratory studies and initiation of field experiments. Studies at oil spills could also, if well designed, provide useful information.

Studies of the effects of oil on the biologically active skin of whales were considered to be priority 2. Again, this ranking was partially a function of the fact that some studies are already on-going and participants thought that results from these studies should be examined before assigning a higher priority.

Studies of the direct effects of ice-breaking on ringed seals were given a priority 2 rating. Major year-round ice-breaking will be associated with offshore developments and associated transportation and thus these effects undoubtedly will occur. In contrast, the probability of major oil spills is the subject of much debate. Studies of underwater noise from ships were discussed earlier and given a priority 1 rating.

Studies of the effects of offshore development and potential spills on the system supporting marine mammals were identified as priority 2. The medium rating was partially a function of the belief that the lower trophic levels should be studied in their own right, and partially because many key plants and animals in the food webs leading to marine mammals may be less vulnerable to the effects of development than are the mammals themselves.

Priority 3: Four research initiatives were classed as Priority 3 studies:

Studies of the effects of ingestion of oil by marine mammals. These studies would also include studies of the potential for oil to foul the baleen plates used for feeding by baleen whales. Some studies on these questions have been conducted, and others are underway.

Two types of studies of the effects of heavy metals were identified: (1) documentation of baseline levels of the relevant metals in various tissues of selected key mammal species, and (2) studies of the physiological significance of increased heavy metal loads. These studies might have a higher priority if consideration were also being given to the input of heavy metals from mining operations.

Determination of present hydrocarbon levels and on-going monitoring of baseline hydrocarbon levels in marine mammals were identified as Priority 3 studies. It was considered more efficient to measure and monitor these levels in the water column, sediments, and in animals at lower trophic levels.

Hydro-electric developments

Although the workshop was convened to consider the potential effects of offshore hydrocarbon developments, it was noted that the many major hydro projects planned and/or constructed on rivers flowing into arctic waters also could have serious consequences for marine mammals. Proposed developments on the Liard and Slave rivers could affect flow regimes in the Mackenzie River and these in turn could affect the dynamics of the Mackenzie estuary and plume. This could affect the marine system of the southeast Beaufort Sea and could have direct effects on the white whale population that summers in the estuary.

The major developments in Manitoba on the Nelson and Churchill rivers may affect the estuarine habitat of most of the west Hudson Bay population of white whales. Similarly, planned and proposed developments in Quebec could affect the estuarine habitat of white whales on the Great Whale, Nastapoka and Mucaluc rivers.

Many participants at the workshop expressed great concern about the potential effects of these hydro developments on white whales and about the lack of research to determine these effects.

SESSION II -- MARINE MAMMAL MANAGEMENT

Available information on the status and management of arctic marine mammals was recently summarized in a report prepared for the N.W.T. Science Advisory Board (Davis, R.A., K.J. Finley and W.J. Richardson 1980, Sci. Adv. Board of N.W.T. Report No. 3. Yellow-

knife. 93 p.). A detailed review of this information was not conducted at the workshop. The information was used as background and discussions focussed on new information and specific research required to form the basis for future management decisions. The following report of this session reviews briefly some general considerations as background and then discusses the research priorities that were identified. This report does not present a review of the current status of arctic marine mammals.

General considerations

Increased harvest levels: The general trend in the North American Arctic is for rapidly increasing populations of Inuit (Hamelin, L.E. 1979, Rep. to Sci. Adv. Board of N.W.T., Yellowknife). This trend will undoubtedly lead to increased harvest levels. In some areas, Inuit population levels now clearly exceed the carrying capacity of the marine system. Associated with population increases has been a trend toward wage employment. Wage employment reduces time available for hunting but the cash earned allows use of faster and more sophisticated equipment. It was suggested that part-time hunters tended to be less experienced and to have less time to devote to hunting, and that this resulted in higher loss rates of animals killed. Other factors such as the establishment and support of outpost camps, hunter support programs and inter-settlement trade are also expected to increase harvest levels and pressure on marine mammal populations.

There was general agreement among participants that changes in the species composition of the harvest were occurring. Such changes were most pronounced in Alaska and least pronounced in the eastern Canadian Arctic. The large increase in the number of hunters pursuing bowhead whales in Alaska was one example, and the increases in pressure on walrus and narwhals because of the commercial value of their ivory was another example.

Thus, in general, it was concluded that harvest levels will increase and that pressure on species such as narwhal, white whale, walrus and, perhaps, harp seal will increase most rapidly.

International aspects: Many of the populations of marine mammals in the Canadian Arctic are international and management decisions and research must recognize this. These considerations are particularly important with respect to bowheads, white whales and ringed seals in the western Arctic and bowheads, narwhals, white whales (high arctic population), harp seals, ringed seals and probably walrus in the eastern Arctic. Organizations such as the International Whaling Commission (I.W.C.) and North Atlantic Fisheries Organization (NAFO)

are also involved with some of these situations.

Research initiatives and priorities

This section reviews on a species-by-species basis the key research initiatives that were identified during the session. Priorities are assigned to each initiative on the following scale: 1 (high), 2 (medium) and 3 (lower). It should be emphasized again that all initiatives that were assigned priorities are considered to be important. Unimportant research initiatives were not assigned priorities. Rankings reflect the perceived urgency of studies in the near future. Lower ranked studies may become extremely important in the medium or longer term. Effective management requires that appropriate studies be done before situations develop into problems rather than waiting for a problem to develop so that research funds can be justified.

White whale: The various populations of white whales in the Canadian Arctic were reviewed. The harvest of the Beaufort Sea population was not considered to provide management problems although several industry-related studies were recommended in Session I. The High Arctic (= Lancaster Sound) population of white whales winters off west Greenland where they are possibly being overharvested. This is an important question but the workshop did not make specific research recommendations.

The principal short-term problems with respect to white whales concern the size, status and interrelationships of groups in Cumberland Sound, Frobisher Bay, Ungava Bay, Hudson Strait and Hudson Bay. Substantial harvests are taken by hunters from several communities. In some cases, it is not even known which stocks are being harvested. The workshop identified studies of stock size, distribution and discreteness of white whales in Hudson Bay, in Hudson Strait and off SE Baffin Island as an urgent (priority 1) research need. Three approaches were suggested: well-designed aerial surveys, tagging studies, and biochemical techniques. Results of the ongoing studies in Hudson Strait and eastern Hudson Bay (conducted by Makivik Corporation and LGL) will be necessary for detailed design of an appropriate aerial survey program. LGL is currently testing biochemical techniques of assessing stock identity using samples from Hudson Strait and the Mackenzie estuary. No good technique for tagging white whales (and narwhals) has been demonstrated. The workshop concluded that development of methods to mark and track white whales and narwhals should be considered as a Priority 1 research initiative.

Preliminary results from the recent studies in Hudson Strait indicate that most of the

many white whales harvested along the Quebec coast are animals that do not summer in the area. This implies that the animals belong to the so-called West Hudson Bay population that summers in SW Hudson Bay. The only estimate of the size of the West Hudson Bay population (10,000 animals) is based primarily on data collected along the Manitoba coast in 1965 but also includes data from other areas in other years; the estimate has very wide confidence limits. In addition, the substantial commercial fishery at Churchill and Whale Cove was terminated in the late 1960's and the population has had ten years to recuperate. The workshop recommended that detailed, systematic aerial surveys be conducted as a Priority 1 item to determine the size of the white whale population along the west coast of Hudson Bay.

The workshop noted that no method of unequivocally ageing white whales existed. Until such a method exists, several key aspects of the life history of the animal cannot be determined, and reliable estimates of sustainable yield will not be available. Development of an ageing technique for white whales was identified as a Priority 1 research objective.

In view of the high harvest levels of white whales and the uncertainties about stock size and discreteness, the workshop recommended that a program to biologically monitor the catch in the Cumberland Sound, Hudson Strait and Hudson Bay areas be instituted as a Priority 2 item. This initiative should include periodic censuses of the size of the Cumberland Sound population.

Two themes that recurred in discussions of most of the species considered were the uncertainties about (1) the reliability of available harvest statistics, and (2) the number of animals that are killed but not landed. The workshop noted that although there have been recent improvements in the reliability of the harvest statistics, further improvements are necessary, particularly in the Hudson Bay area. Also, estimates of hunting loss are required in the Hudson Bay, Hudson Strait and Cumberland Sound area in order to determine the total removals from the population(s). These were considered Priority 1 items.

Narwhal: The basic population dynamics of the narwhal are poorly known. Biological studies to determine the sustainable yield of narwhals are extremely important and were classed as Priority 1. Related to these studies is the need to develop a technique for reliably ageing narwhals. Development of an ageing technique was considered important enough to warrant a Priority 1 rating on its own. It was noted that methods using a racemization technique appear promising but that the relevant study has not been completed; this inexpensive avenue should be pursued.

The question of the size of narwhal populations in the eastern Arctic was the subject of heated debate at the workshop. The question is important because the population may now be overexploited if the actual numbers are at the low end of the range of estimates. The problem centres on the fact that estimates (based on extrapolations) made during spring migration suggest that there are 20,000 to 30,000 animals in the Baffin Bay-Davis Strait population, whereas a survey of summering areas found only about 10,000 animals in 1979. However, bad weather affected the summer survey. Surveys during fall migration have also accounted for only a portion of the spring population estimates. One group argued that high priority should be assigned to another survey of summering areas to provide independent verification of the spring estimates. Others suggest that the extrapolations used in the spring estimates are valid and further verification is unnecessary. This debate was not resolved at the workshop. However, an arbitrary decision by the sponsors of this report assigns a Priority 2 rating to the need for a re-survey of the summering areas. A successful summer survey could provide an independent verification of the spring estimates and it would provide valuable information about the distribution of various age and sex classes of the animal.

Most important, however, is the fact that the spring estimate of 20,000 to 30,000 is unacceptably vague. If the actual population size is 20,000, present quotas may be dangerously high (allowing for hunting losses); in contrast, if the population size is 30,000, present quotas may be unnecessarily low.

A narwhal population of unknown size summers in the NW Hudson Bay area. This population is hunted by residents of Repulse Bay and the harvest level is governed by a quota. The existing quota has no biological basis but was determined on the basis of average annual harvests in recent years. It is expected that there will be demands for increases in quota levels in the immediate future. The consensus of the workshop was that studies to determine the size of the NW Hudson Bay population of narwhals were of immediate high priority (Priority 1 status). An aerial survey approach was recommended. It should be noted that some workshop participants argued that the major harvests and the bulk of the narwhal population both occur in the eastern and High Arctic; since so little is known about the biology of the species, they argued that research efforts should be concentrated on the larger, more heavily utilized population. The Priority 1 rating for surveys of the NW Hudson Bay population is maintained here partly because this study can be conducted in conjunction with a Priority 1 survey recommended in a later section.

There is no information on the relationships of the animals that summer in NW Hudson Bay to the Davis Strait--Baffin Bay animals. Similarly, there are no data on the relationships between narwhals that summer in the Canadian High Arctic and those that summer in the Thule District of Greenland, although both groups presumably winter in Baffin Bay and Davis Strait where they are at least theoretically in contact. Recent studies in the Pond Inlet area have found that a high proportion (20 to 40%) of the narwhals have scars from old bullet wounds. It is possible (but not proven) that these high percentages indicate that sub-populations occur in certain areas. The workshop concluded that a study of the sub-population structure of the narwhal was a Priority 1 item. Related to this question was the development of tagging methods for narwhals and white whales; this was identified as Priority 1 research initiative in the previous section.

Surveys of the numbers and distribution of narwhals in the Smith Sound and Kane Basin area between Thule District and Ellesmere Island were identified as Priority 3 research. These studies would provide data necessary to determine overall population size and would provide some information useful for interpreting stock discreteness.

Some studies of hunting loss have been conducted during the narwhal hunt at Pond Inlet. These studies showed that loss rates can be very high but that they vary with type of hunt, hunter experience, weather and ice conditions. Collection of additional information on loss rates was identified as a Priority 1 item. It was noted that some information was being collected on an on-going basis by fisheries officers. Studies of techniques to reduce losses in narwhal hunts were also considered to be Priority 1.

Bowhead: Although the bowhead is an endangered species, the current management strategy is that no studies are necessary because the species is, at least in theory, totally protected in Canada. There is an indication that some communities will demand that a quota be established on bowheads in Canada, and the absence of management data may be a problem at that time. The workshop did not recommend any studies of bowheads from a purely management point-of-view; however, several studies related to the potential effects of offshore hydrocarbon development on this endangered species were identified. While current funds and manpower dictate that the management philosophy is most feasible with regard to bowheads, it is worth noting that the approach is narrow in scope. In general, North American management agencies are becoming more concerned with non-harvested species and are taking a more ecologically oriented approach to management.

Walrus: In the recent past the harvests of walrus in the Canadian Arctic declined because of the changeover from dog teams to snowmobiles by the Inuit. Walrus used to provide a major source of dog food. Indications are that the harvest of walrus is now increasing and that the economic return from walrus tusks is likely to lead to further increases.

The workshop noted that there are major gaps in our knowledge of the numbers and distribution of walrus in eastern and central Canadian waters. There has never been an estimate of the size of the apparently large walrus population in Foxe Basin, where much of the presently increasing harvest occurs. Estimates of the numbers of walrus in northern Hudson Bay are restricted to a few aerial surveys of some haul-out sites in NW Hudson Bay. There are no estimates of the numbers in the waters off SE Baffin Island. The workshop recommended that a series of aerial surveys to determine the size of the walrus populations in Foxe Basin, northern Hudson Bay (including NE Hudson Bay) and SE Baffin Island be given a Priority 1 rating.

The workshop also recommended that studies of the stock discreteness of the above animals be given Priority 3 status until the results of the above survey programs are available. Studies of stock discreteness could use specially designed aerial surveys, radio-tagging (techniques available), and measurements of morphological differences among groups.

Insufficient data on the reproductive biology of eastern and central arctic walrus are available to allow determination of the sustainable yield of these populations. It was not considered to be realistic to directly apply the more complete data from the Pacific walrus to Canadian populations. Studies to determine sustainable yield levels were considered important. The workshop recommended that biological sampling of the current harvest in Foxe Basin begin as soon as possible on a Priority 1 basis. A full-scale population biology study was given a Priority 2 ranking pending the results of the proposed aerial surveys in Foxe Basin and northern Hudson Bay.

Information on harvest levels has not been adequate and the gathering of reliable data, particularly in Foxe Basin, northern Hudson Bay and SE Baffin Island, was identified as a Priority 1 objective. Because of recent changes in hunting techniques in Foxe Basin, studies of hunting loss in this area were also identified as Priority 1.

Harbour seal: Participants noted that essentially nothing is known about the present status and distribution of the small numbers of harbour seals that occur (or occurred) along

eastern arctic coasts. No specific recommendations for research on harbour seals in the Canadian Arctic were made by the workshop.

Harp seal: The principal concern about harp seals in the Arctic is that the harvest levels in the eastern Arctic and west Greenland are higher than previously thought. In addition, the few studies available indicate that hunting losses can be substantial, especially in July and August. Thus, removals from the population are substantially higher than is allowed for by the models presently used to determine quotas for the harvest in the Gulf of St. Lawrence and the northwest Atlantic. This underallowance for the arctic harvest is made more significant by the fact that the harvest in the Canadian Arctic is mainly of older seals. The workshop recommended (Priority 1) that the available information from arctic areas be used to update the current models used for management of harp seals. Cooperation with Danish scientists in collection of harvest statistics from Greenland is necessary.

Studies to refine estimates of hunting loss should be conducted. The principal harvest occurs in Cumberland Sound and the studies should be conducted there. A Priority 3 rating was given to these studies.

Hooded seal: Only small numbers of hooded seals are harvested in eastern arctic waters, and there is no evidence to suggest that this small harvest is affecting this species. No specific management research priorities were identified for hooded seals in the Canadian Arctic.

Ringed seal: The biology of the ubiquitous ringed seal is relatively well known compared to that of other arctic species of marine mammals. The workshop concluded that management priorities for this species were relatively less pressing than for some other species. This conclusion is probably valid in the short term but will need to be re-evaluated in the longer term.

Studies of population organization, territorial and social systems, reactions to disturbance, and options available to disturbed animals were identified as Priority 1 importance from an industrial point-of-view but were given a Priority 3 ranking from a strictly management perspective.

Expansion of studies of the interspecific interactions of ringed seals, polar bears, arctic foxes and Inuit were considered important for management because of the complex interactions involved. The studies were given a Priority 3 rating pending publication of the results of studies that are now being completed by Dr. T.G. Smith.

The status of the populations of ringed seals and bearded seals that inhabit the Baffin Bay pack ice requires further study to elucidate their contribution to the numbers that are harvested in the coastal waters of Baffin Island and Greenland. The workshop assigned these studies a Priority 3 ranking although there was some discussion of a higher ranking. Studies of these offshore populations were given a higher priority in the session considering industry-related priorities.

The general harvest statistics for ringed seals were not considered to provide adequate estimates of trends in the harvest levels. A mechanism for gathering reliable statistics was considered to have a Priority 1 rating. This is true for marine mammal harvest statistics in general, not just for ringed seals.

Bearded seal: Few specific recommendations for bearded seal research were made by the workshop. Monitoring of harvest levels was given a Priority 1 rating as part of a general program to gather harvest statistics. Data on hunting losses were also considered to be important but can probably only be obtained on an opportunistic basis. Similarly, information on numbers and population trends should be collected on an opportunistic basis. The recommendations on population size and trends should be re-evaluated when the current review of eastern arctic data has been completed by Dr. T.G. Smith at Ste. Anne de Bellevue.

Discussion

Some of the studies recommended above may provide important information of high priority for more than one species. For example, development of a tagging technique for small whales will be useful for studies of both white whales and narwhals. Similarly, an ageing technique for white whales might also be useful for narwhals and vice versa. Improvements in the quality of harvest statistics from arctic communities will provide important information for several species.

Aerial surveys of walrus and narwhal populations in Foxe Basin and northern Hudson Bay were each given Priority 1 status. Both of these species could be surveyed at the same time although design modifications would be necessary to provide adequate coverage of the habitat of each species.

It should be noted that research priorities assigned by the workshop are subject to change as more information becomes available, as hunting patterns change, and as political pressures change. The research identified is basically short-term and addresses presently identifiable problems. Some of those problems are acute. Present arctic marine mammal management in Canada is crisis oriented and consists of ad hoc

responses to biological or political problems. This reflects a lack of long-term management goals and research and is partly caused by the diversion of management researchers and funds to impact-related studies. This has led to a patchwork of management and impact information that is often inadequate for either management or impact assessment.

SUMMARY

In response to the imminent large-scale development of offshore hydrocarbon resources and the marine transportation of these resources, and in response to the need for rational management of arctic marine mammals in a period when harvest levels are increasing and species composition is changing, the Department of Fisheries and Oceans convened a workshop of biologists with expertise in research on and management of arctic marine mammals. The workshop, held in Winnipeg in December 1980, was divided into two phases: offshore hydrocarbon development, and management of marine mammals. The workshop considered the principal areas and species of concern and identified the major research initiatives that are required. After identifying the principal research needs, the workshop then assigned priorities based on a subjective scale of high (1), medium (2) and low (3) priority.

The high priority studies are summarized below.

Highest research priorities related to offshore hydrocarbon development

<u>Priority</u>	<u>Required Research</u>
1	-long-term biological/monitoring studies of key species (e.g. bowheads, white whales, ringed seals, bearded seals in the Beaufort Sea). These studies are necessary to evaluate responses to development.
1	-determine the locations of marine mammal concentration areas (some studies has been done but gaps exist--e.g. bowheads in Beaufort Sea; narwhals in Baffin Bay in winter). These studies will determine the potential for interaction with development.
1	-determine how and why concentration areas are used so that effects of development in these areas can be predicted (e.g. white whales in the Mackenzie estuary).
1	-document the normal behaviour and acoustic capabilities of marine mammals so that responses to development can be assessed and so

that potential effects of industrial noise can be predicted.

- 1 -undertake experimental studies of effects of noise and industrial activities on marine mammals.

Highest research priorities related to arctic marine mammal management

<u>Priority</u>	<u>Required Research</u>
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|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | -undertake long-term ecological studies for all species of arctic marine mammals. These studies are essential for total management in a multi-species context. Until such studies are conducted, management will be rudimentary and subject to many unpleasant surprises. |
| 1 | -determine the stock size, discreteness and distribution of white whales in Hudson Bay, Hudson Strait and SE Baffin Island area. These animals are being overharvested, at least locally, and are threatened by hydro developments that affect their summering estuaries. |
| 1 | -establish methods for tagging or marking white whales and narwhals. Many critical questions about stock discreteness can only be solved by tagging. |
| 1 | -determine the present size and seasonal distribution of the west Hudson Bay stock of white whales using systematic aerial surveys. Hydro development and harvesting in Quebec may threaten this stock. |
| 1 | -establish methods for ageing white whales and narwhals so that the population dynamics of these species can be determined. |
| 1 | -establish a system to obtain accurate harvest statistics for all species of marine mammals and conduct studies to determine hunting loss rates for selected species (e.g. narwhal, white whale, walrus). Without such information, reliable management is not possible. |
| 1 | -determine the basic population dynamics of the narwhal. Current estimates of sustainable yield are guesswork. Combined harvest levels in Canada and Greenland are high. |
| 1 | -refine estimates of the size of the Baffin Bay narwhal population and evaluate summer distribution patterns. |

- 1 -determine the size and distribution of walrus and narwhal populations inhabiting northern Hudson Bay and Foxe Basin, since no estimates exist and harvest levels are increasing.

- 1 -undertake biological sampling of the current harvest of walruses in Foxe Basin to provide information on dynamics of this species.

Other research priorities are identified in the text. Although not given a Priority 1 rating, these studies are important and will be necessary in the near future.

The workshop concluded that the present database on arctic marine mammals was not sufficient to allow confident predictions of the effects of offshore industrial activities. Similarly, the database is not sufficient to allow adequate management of arctic marine mammals.

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