INITIAL ENVIRONMENTAL EVALUATION

(I.E.E)
without appendices

APRIL 5, 1981

DISCUSSION DRAFT

INITIAL ENVIRONMENTAL EVALUATION FOR THE BOREALIS EXPLORATION LIMITED MELVILLE PENINSULA IRON ORE DEVELOPMENT

Sections 1 through 7.

April 5, 1981

TABLE OF CONTENTS

INITIAL ENVIRONMENTAL EVALUATION

PAGE

1. OVERVIEW SUMMARY

The Borealis iron ore deposits on the Melville Peninsula have decided economic and environmental advantages over most other large scale iron deposits now in production:

I: A Superior Ore -- the Borealis ore is a recrystalized banded magnetite with quartz as the only significant impurity. The ore is easily crushed and can be magnetically separated using an entirely dry process.

II: On Tide-Water -- The eastern deposits, where the operation will begin, are only three miles away from a large and deep natural harbour. With appropriate port facilities this harbour will accommodate any size ore carrier now in service.

III: An Extraordinarily Large Ore Body -- With an estimated reserve of 4.3 billion tons of high quality magnetite and a mine life in the hundreds of years, the Borealis deposits are among the largest in the world.

Unlike other mining operations in the Canadian Arctic, this project need occasion little short term dislocation - either environmentally or socially- while in the long term, it should provide a base for massive economic development in the area. The Borealis project is a long term investment in the North.

I Ore Quality

The grade, that is percent of iron in the raw ore, of the Borealis deposits in the east is well above average for a magnetite deposit and some of the deposits in the west are running grades with "the highest magnetite iron content (36.1%) of any known operating mine in North America."*

Grade, however, is no longer a reliable single criterion for ore quality. In today's market, ore quality is almost entirely a function, not of grade, but of the ease with which an ore is concentrated to 64%+ iron and the quantity of troublesome chemical contamination in that ore. In fact, most of the ores, hematite as well as magnetite, being mined in the United States and in such Canadian operations as Sidbec Normine are technically low-grade ores - that is ores with iron content well under 40%. This is true not simply because the accessible high grade ores have been depleted but because new technologies developed in the fifties to concentrate and agglomerate certain low grade ores have made such ores more economical for the making of steel than most high grade ores. The new technology, introduced originally to process low-grade Minnesota Taconite deposits, has revolutionized the iron ore industry.

Minnesota taconite is a low-grade exceedingly hard ore which, simply because much of its iron is in the form of magnetite, can be concentrated by low intensity magnetic separation. The taconite is ground to 325-mesh and then beneficiated to 64% iron or better. The

---

*L.H.E. Neal and Associates. Metallurgical Testwork Melville Peninsula Samples for Borealis Exploration Limited. Toronto, January 31, 1969. pg. 3.

fines are then agglomerated into pellets and used as a furnace feed. Although the taconite pellet is a more expensive product to produce than the unconcentrated high grade ore, it has a much higher iron content and is much more easily processed into steel. In other words, the increase in the processing costs of the pellet are more than recovered by the decrease in smelting costs. By and large, the high grade ores, most of them hematite, could not be beneficiated in so simple a manner.

The technologies for beneficiating non-magnetic ores, or weakly magnetic ores, have since been developed but these methods still tend to be expensive and the resulting product tends to be high in troublesome chemical impurities such as phosphorus and sulphur.

Magnetite concentrates have other intrinsic advantages. Because magnetite, Fe_3O_4, is less oxidized than hematite Fe_2O_3 the exothermic reaction when the fines are heated provides much of the energy for agglomeration in the standard pellet operation. By the same token, it requires less energy to reduce magnetite in a process using either magnetite sinter, fines, or magnetite pellets.*

Similar to Minnesota taconite in some respects the Borealis magnetite ores have advantages. The Borealis deposits are higher grade. Even in the east, the percentage of magnetic iron in the Borealis ores is significantly higher than any Minnesota Taconite now being mined. Moreover, the Borealis deposits have virtually no troublesome chemical impurities and all of the trace elements found in the concentrates are well below the limits set by the iron concentrate or pellet buyers.**

---

* So-called "cold pellets" or pellets formed without oxidizing the magnetite.

**Neal, page 29, January 31, 1969 Report.

Finally Borealis deposits have been recrystalized and the resulting increase in grain size seems to be responsible in part for the significantly more friable* character of the Borealis ore and for the fact that comparable separation is achieved at significantly larger sizes. In addition, the separation can be achieved in a dry circuit** without more expensive wet magnetic separation, flotation,*** or spiralling techniques, and the resulting concentrate is easily reducible.****

All non-dry techniques for separation are relatively expensive both economically and environmentally. For example, were Borealis to use water proportionately to the U.S. Steel Minntac operation in Minnesota, the Borealis mill would require something in the order of 100,000***** gallons of water per minute. The Reserve Taconite operation used 45 tons of water for every ton of concentrate,****** and unlike some other operations, that water was returned directly into Lake Superior. Such a contamination

---

*The Bond Work Index (a measure of the energy requirement to grind iron ores) of the deposit to be mined is 6.1 as opposed to 20-24 for Minnesota taconite.

**Feasibility Study of the Beneficiation of Magnetite Bearing Iron Ore for Borealis Exploration Limited RR #80-233, ERIEZ Magnetics, Central Test Laboratory, Aug. 12, 1980.

***Neal, page 3, January 31, 1969.

****Ontario Test Lab, 1970 Report on Reducibility, and 1980 Test Work On Reducibility, Allis-Chalmers.

*****Minntac hits 18.5 million LTPY of pellet capacity, Engineering and Mining Journal, September 1979, p.99.

******Pioneering with Taconite, Minnesota Historical Society, W.E. Davis, 1964, p.125.

of the environment is profligate where other alternatives are available. The Borealis deposits provide such an alternative.

In summary:

(a) The Borealis ores are cleaner and less expensive to beneficiate than are either the Minnesota taconites or the Labrador hematites.

(b) The resulting concentrate is very low in phosphorus and sulphur contamination.

(c) Borealis ore is easily reducible, making it a premium feed for an energy and environmentally conscious steel industry.

II Transportion

With any high-volume low value resource the cost of transportation usually exceeds the cost of mining and often exceeds the cost of concentrating as well. Unfortunately it has become an article of faith that transportation, anywhere in the Arctic, is prohibitively expensive. This is not universally true, and it is not true of the Borealis project.

The Borealis deposits in the east are just a six mile regenerative conveyor run down to our shipping point in a deep and large natural harbour -- Roche Bay.* A channel greater than 85 feet deep extends well into the Bay. The bay is also wide enough to allow maneuvering of 200,000 ton plus ore carriers and is protected from the predominant winds. Tidal fluctuations are in the range of four to five feet. To be sure the season during which Roche Bay would be open to conventional shipping is only 63 days** although

*See Roche Bay, C.H.S. Field Sheet (Collector) No. 4328 Project #57-11-4, surveyed by Mr. M.G. Swim, assisted by Mr. C.G. Miller, Captain P. Tooke and officers of the C.C.G.S. Labrador, September 1970.

**The open Class E vessels (100A1) dates and zones are Zone 8 (Foxe Basin) Aug 20 to Oct 20, Zone 15 (Hudson Strait) July 20 to Nov 5, Zone 14 (Foxe Channel) July 20 to Oct 13, as defined by Arctic Water Pollution this could be extended with the help of the Coast Guard if such help is available and with the use of ore carriers of some ice capability.* Fortunately Roche Bay can accommodate, for those 63 days, any ore carrier now in service, and with the proper loading equipment and port facilities the projected output of five million tons of concentrate could easily be shipped during those two months.

A considerable advantage over most iron mines now in operation is that Borealis, with easy access to a deep water port in the east, will not require a railroad. Rail transportation is expensive.**

An examination of the map shows that most large scale iron mines now in operation require relatively extensive rail lines to reach tide-water. In the Labrador Trough, Sidbec Normine is operating at Fire Lake with a total of about 253 miles to reach Port Cartier -- which has an open season of two hundred days. The Brazilian operations use about 300 miles of rail to reach open water and, while their ports are open year round, the distances to North America and European Markets are greater. The Hammersley operations in Australia require a railroad of 179 miles to

---

*Captain J.C. Smith and Carol Stevenson of Canadian Coast Guard. At the present there is no guarantee that either Coast Guard ice breaker or large ice capable ore carriers would be available for Borealis use.

**In The Making, Shaping, and Treating of Steel; United States Steel, ninth edition. It is pointed out that one of the reasons the United States has turned to imported ores is that "Imported ores can be delivered to seaboard plants at costs comparable to or lower than the cost of Lake Superior ores at such plants." Because under favorable conditions it may cost less to ship ores 2000 miles by sea than 100 miles by rail.

open water. And, it might be noted, that even the Lake Superior deposits are at least fifty miles from the Lake ports.

In summary, although the Borealis open shipping season is not long and there will be costs associated with stockpiling, the easy access to tidewater is of tremendous economic advantage to the project.

III The Size of the Ore Body

The Borealis open pit magnetite reserves are estimated at 4.3 billion tons with additional hematite deposits estimated at several billion tons.* The company currently owns 100% of the working interest in these reserves in the form of seven groups of twenty-one year Government of Canada leases.

Most of the magnetite deposits are well above ground or in areas where there is relatively nominal overburden. It is a near ideal circumstance for open pit mining.

The size of the deposits are so large that, on any reasonable anticipated estimate of production, the Borealis mine life must be calculated in the hundreds of years. At ten million tons a year mined, for example, the estimated mine life of the magnetite reserve is something in the neighbourhood of four hundred and thirty years.

Relative to the reserves of 4.3 billion tons, the projected ten million tons per year seems a very small amount although the Borealis project will be a large operation by world industry standards and by the

---

*See Wilson and Underhill, The Discovery and Geology of Major New Iron Deposits, Eastern Arctic. Canadian Mining Journal, July 1971, p.45.

standards of the Northwest Territories.

In 1976 Canada's total iron ore sales in all forms including raw ore, fines, pellets, and sinter totalled approximately 55 million tons. The Borealis project with a start up of four to five million tons of concentrate would be equal to about ten percent of the total Canadian production.

Unlike other Arctic mines which are exhausted in ten or twenty years, Borealis should bring virtually permanent advantages to both Canada and to the North. In fact, much of the criticism of the entire policy of extracting non-renewable resources from the North is that these mines are easily and quickly exploited. A short-lived mine, by its very existence, forces rapid population and cultural changes on its employees and, when the mine closes, Northerners who have, at much real social and psychological expense, adapted themselves to industrialization, will find themselves abandoned jobless in a new and foreign life-style or converted into members of a migrant work force moving from mine to mine. These are not attractive alternatives for the long-term development of the North. In contrast, the Borealis iron mines will provide a rich opportunity for the next generations of Northerners, at their option, to slowly and gradually adjust to an industrial economy.

2. PROJECT RATIONALE

2.1 DECLARATION

This Initial Environmental Evaluation (I.E.E.) is being made by Borealis Exploration Limited for Borealis Exploration Limited. Borealis Exploration Limited (hereinafter referred to as Borealis) owns a 100% Working Interest of the subject properties, and it with its environmental consultants, advisers and staff personnel, will take responsibility for the statements and judgments in the I.E.E.

<u>Qualifications</u>:

The engineering for this project has not been completed. The schedule for this work is described in section 3.1. Until the project has been completely engineered there will probably be some gaps in our knowledge, particularly in those areas which apply to the pit design and specific crushing, grinding, and separating equipment.

2.2 NEED

(a) World Needs

With iron estimated to constitute about 4% of the earth's crust there is, at least theoretically, no shortage of iron. But, of course, the vast majority of this iron is not in a form which is economically recoverable and, given the current state of the art and the current cost of energy, many operating iron mines are no longer profitable. Therefore there have been informed predictions of a world iron ore shortage by 1985.* Borealis will be competitive in such a market.

(b) Canada

For some years, in the 1950's Canada was the largest exporter of iron ore in the world and virtually unchallenged in that respect. That is no longer the case. The mining of the Borealis deposits will contribute significantly to the maintenance of Canada's position in the world iron ore and steel industry and to Canada's balance of payments. Borealis will be one of the most competitive iron operations in the world. To the best of our knowledge, there exists no other magnetite deposit approaching this quality or this size within easy access to tidewater.

Moreover, in the case of Borealis, Canada will be selling a high quality concentrate, not raw ore. In addition, Borealis will be in a good position to supply Canadian steel operations in the Maritime provinces and indeed to help establish a steel industry in those places in the North that have an adequate source of labour and an excess of energy.**

In the future, a steel industry on Melville Peninsula is a possibility. The feasibility of such an industry will depend on the expansion of the existing labour pool and on the ultimate disposition of the High

*Engineering and Mining Journal, March 1980, pp. 139. Also see Mining Annual Review, Published by Mining Journal, London, June 1980, p.73, and AMAX, World Outlook for Crude Steel and Iron Ore.

**It might be noted that with the current increase in the costs of fossil fuels the technology for producing steel electrically is being updated and so, theoretically, even Churchill could become a northern steel center,so could any place in Canada with excess hydroelectric power.

Arctic gas reserves of Panarctic. Borealis could, if the price of the gas were competitive, use a dedicated pipe line from the Panarctic fields to Melville Peninsula.

A steel industry on Melville is of course something for the distant future. Borealis is planning to operate in the coming years simply as a producer of concentrate.

Since, however, the Borealis project will be producing something in the order of five million tons of concentrate a year and the total Canadian steel output is only about twenty-five million tons, much of it on the Great Lakes, it is expected that, at least in the short term, most of the Borealis concentrate will be exported to Europe.

Were Borealis concentrate used to produce steel in Canada, the increased production should not be a threat to the very strong domestic industry. Most of the production would probably be directly or indirectly exported.

(c) The North

Ultimately, a project in the Northwest Territories can be justified only if it means long-term benefits for the people of the Northwest Territories. The population of the North is growing. The population growth, substantially higher than the average Canadian rate of growth,* will have a great impact on the northern communities in terms of their economic needs. For example, given a relatively stable animal population, a rapidly growing human population will not be able to support itself exclusively in the tradi-

---

*<u>Community Planning and Development</u>: Northwest Territories Canada, March 1980, page 40. Note, for example, that 45% of the population of Frobisher is under the age of twenty.

tional manner. Borealis will help provide the Inuit with an opportunity for choice between a land-based and a wage economy, or some combination of the two.

However, if a natural-resource based project of this sort is to bring lasting and real benefits to the North, it is not sufficient to simply offer the people of the North short-term employment opportunities. If the North is to enter into an equal and not a dependent relation with the rest of Canada the infrastructure needed to support a non-traditional economic base must be developed.

In much of the South each job in primary industry can be expected to produce 2 to 3 jobs in the local economy. In the North this is not yet the case. For private industry the multiplier effect is somewhere between .3 and .6 and for government employment it is .1 to .3.* For real economic progress to come to the North, it is necessary that the multiplier effect be improved. Such improvement has proved very difficult. In part because, in order to create ancillary jobs and benefits, a more extensive economic infrastructure must be developed in the North. With a small population, a harsh climate, and costly transportation, such an infrastructure is difficult to build and virtually impossible to build quickly.

There are no easy or obvious solutions to this problem but, for a variety of reasons, Borealis will be in a good position to contribute to the growth of infrastructure in the Melville Peninsula. In order to stimulate the development of economic opportunity, the communities in our area need cheaper transportation, cheaper energy, and more extensive business support facilities.

---

*Community Planning and Development: Northwest Territories page 43.

Transportation -- The building of a deep water port and the road to Hall Beach will significantly lower the cost of transportation of goods to the community. The entire summer sea-lift out of Montreal carries under 200,000 tons of goods; the Borealis operation will carry five million tons, about forty ship loads, from the North and will provide the opportunity for relatively inexpensive backhauling without the need to unload goods in lighters.

Energy -- Borealis is working on developing water power in the area and also on the possibility of wind power. But, even in the short run, the existence of the port facilities will lower the cost of importing a wide range of fuels and supplies to Hall Beach and, perhaps, of backhauling coal from Eastern Canada.

Business support facilities -- "The lack of immediate access to commercial banks, accountants, lawyers, and other business support services in the smaller centres limits management capability in the community."* A project of Borealis size and permanence will provide some of those services and, what may be of more importance, the Borealis project will, in the long term, provide the atmosphere for increased utilization of those services.

The North needs a project of this size and longevity. Longevity, because change, to be successful, must be gradual and freely structured by and for the North. And, by northern standards, Borealis is a large project. Assuming an estimated annual gross initially of about $200 million, the Borealis operation will be equal, in value of product, to about a third

---

*Community Planning and Development: page 45.

of the total of all mining operations currently in operation in the N.W.T. And the Borealis project will gross annually many times the $9 million coming to the North from the crafts industry and the less than $1 million from the trapping industry. Borealis should become a valuable addition to the northern economy.

In an effort to maximize the benefits to Northerners the company is (1) sending to the communities of Hall Beach, Igloolik, the Inuit Taperisat of Canada, the Baffin Region Inuit Association, the Inuit Development Corporation, the Arctic Federated Co-ops, and others a detailed examination of social planning alternatives together with a request for their judgment on these alternatives; (2) sub-contracting, as much as feasible, to Inuit organizations such as the Inuit Development Corporation, and the Canadian Arctic Co-Operative Federation Ltd.; (3) offering direct employment opportunities to the people of Hall Beach and Igloolik and, in part through the above mentioned organizations, to other Inuit in the region; (4) encouraging northern equity participation in the project through investment by the Inuit Development Corporation at a national level and through direct stock bonuses to employees of the company who have worked for the company either continuously or discontinuously for a specified length of time.

Eventually, a project of Borealis size and longevity should help produce the environment in which the people of the North can grow and prosper.

2.3 ALTERNATIVES

a. Selection of initial ore bodies to be mined. Borealis has deposits both in the east and west of Melville Peninsula approximately sixty miles apart. Since some of the western deposits extend hundreds of feet above ground level and are, generally speaking, of a higher grade than the deposits in the east, it was originally intended in 1970 to begin mining in the west. This decision has now been reversed. The eastern deposits are only about three miles from open water and the economic advantages at this time of avoiding a seventy mile rail run far outweigh the advantages of the higher grade deposit in the west.

b. Mining Methods. Open pit mining is the only economically feasible alternative for deposits of this sort. Particularly since there is very little overburden removal and, because the mining is on bed rock, very little vegetation should be disturbed. In addition, the Inuit population has shown a decided preference for working above ground. The pits will, as much as is practicable, be refilled with tailings and returned to near their original contours.

c. Tailing Disposal. The tailings will be in the form of dry particles (minus 200 mesh) of silicon dioxide (silica) with low concentrations of iron and minute quantities of other chemicals. In chemical composition, therefore, the tailings will be similar to very finely ground beach sand containing some iron. To begin with the tailings will be used for road building, earthfill at the dam site, sanitary landfill cover, and so on. Eventually, most of the tailings, as well as waste rock, will be returned to mined-out pits, so that the contours of the land can be returned to some approximation of the original state. As the tailings are laid down, during the winter, they will be wetted sufficiently so that they become frozen and, during the summer, they will be covered with a layer of water sufficient to prevent dust pollution from the pit.

The top layers of the tailings will eventually be enriched and seeded -- probably with local sedge grasses.

The alternative to the proposed dry system is to use a water-based tailings system. The water would be moved into settling ponds or, as at the Reserve Plant on Lake Superior, emptied into a large water body. If, as is indicated by our research thus far, dry processing is feasible, we do not see the use of water as an acceptable environmental alternative.

d. Mill Location. The mill can be located either adjacent to the pit or at the head of Roche Bay. Both alternatives have advantages. A mill adjacent to the pit involves less movement of materials while a mill adjacent to the Bay involves less movement of the milling equipment.

e. Mill Processes. The alternative to dry crushing/grinding and dry magnetic separation is to use a water-based process. The use of water produces some increase in the efficiency of magnetic separation and grinding at the cost of pumping and handling great quantities of water and managing settling ponds to dispose of the tailings.

The environmental disadvantage of dry processing is in the increased dust control difficulties. To meet this problem Borealis will be enclosing mill machinery, using electrostatic precipitators and other generally accepted methods of minimizing dust pollution.

f. Townsite Locations. We are considering several sites. The preferable alternative seems to be a site on the head of Roche Bay somewhat south of the proposed mill site and protected from the weather by the precambrian shield. The town can be built up the slope of the shield nearer to the Ridge but, while this might be more protected and improve the view, a site farther down toward the Bay with more housing adjacent to the beach will probably be preferable to the Inuit population.

g. Auxiliary Service Locations.

(1) The road. A road from Hall Beach to Roche Bay is not an intrinsic part of the Borealis project and the project is quite feasible without such a road. Although in order to offer the Inuit of Hall Beach the opportunity to work at the mine while commuting and to maximize the benefits of the port facilities to Hall Beach, a road to the area could be built from the town of Hall Beach to the Borealis properties. The road designed for Borealis by Northwest Survey does not appear to be feasible at this time. Although it seems optimum on the map, a detailed examination of the route indicates extended distances through sedge meadows where the maintenance of the road would become environmentally problematic and unnecessarily difficult. An alternative would be to upgrade a "road" currently in use by four wheel vehicles along the raised limestone beach coastline. While this road would be somewhat longer it would introduce no new environmental problems and would make the least necessary change in the environment.

(2) Airstrip. The location of the airstrip has not been determined. Again because of the wide expanses of limestone beaches on the peninsula jutting out into Roche Bay, there are several possible alternatives. The preferred alternative will be selected with the advice of Transport Canada.

(3) Port facilities. There are two good alternatives on the small peninsula extending into Roche Bay. A detailed examination of the fathom depth map of the Bay would seem to indicate that the site closer to the mine is quite as useable as the site further out but that the distant site will more efficiently accommodate larger ore-carriers. As the use of the port facilities is expanded, by both Borealis and the Community, it may be advisable to build both facilities. On the advice of Ports and Harbours and The Coast Guard however we will begin at the distant site.

h. Abandonment. The mine will not in the foreseeable future be abandoned for lack of ore but should the need arise, for any other reason, the mine may be abandoned by removing the mining and milling equipment from the site.

The various buildings that will make up the town site and the mill site will probably remain after such an abandonment provided that the community sees a need for these buildings and the regulatory agencies agree to this request.

The airstrip and port facilities will probably remain to service the community.

i. <u>Existing facilities</u>. The Borealis deposits are within fifty road miles of the community of Hall Beach. At Hall Beach there are two stores, the Hudsons Bay and the Co-Op -- as well as a grade school, a nursing station, two churches, and a good airport with twice weekly scheduled airline service from Montreal and extensive fuel storage capacity. By northern standards this represents a great deal of infrastructure. Particularly in the short run, there are considerable advantages to Borealis in being able to use some of the facilities of Hall Beach and there are some advantages to Hall Beach in increasing utilization - provided of course that this does not involve an undesirable deluge of Southerners into Hall Beach. For this reason, access to Hall Beach by mine personnel by road or air will be regulated.

Eventually, not only would Borealis benefit from the infrastructure of Hall Beach but conversely Hall Beach would benefit from the infrastructure at Roche Bay. In particular, a road between Hall Beach and Roche Bay would increase employment opportunities for the people of Hall Beach and it would increase community utilization of the neighbouring soap-stone deposits, and the superior port facilities at Roche Bay.

After 1952, three Dew Line Stations were built on Melville Peninsula; two of which are still in operation. The Foxe Main Station is located at Hall Beach; it is about 50 miles from the Eastern Deposits of Borealis. The Scrapa Lake station is about 15 miles from the Eastern Deposits - this station was operated in the late 50's and early 60's, before being abandoned. It is now being used as a research station by Dr. Martin Lewis of York University. Cambridge 5 is located on the west of the Peninsula overlooking Committee Bay. Borealis was informed in the late

60's that the Dew Line was considering abandoning the station.

2.4 ASSOCIATED PROJECTS

The development of the Borealis Eastern deposits will have an impact on other projects in the area.

Associated projects in transportation, energy, and employment have been discussed above.

Tourism. The development of Borealis should also have a beneficial effect on the tourist fishing operation which the Inuit Community is endeavoring to establish on Hall Lake. Generally, tourist operations in the North have benefitted greatly by the presence of industry because of increased infrastructure and increased business and transportation into the area,* provided of course that the actual industrial development is some distance from and out of sight of, the tourist operation.

Other Mineral Projects. The Inuit are acquiring soap-stone from a deposit near the Borealis iron deposits in the east. The existence of the port facilities and the road to Hall Beach will facilitate this operation. In fact the Melville Peninsula seems to be a storehouse of mineral wealth. Borealis will be continually exploring the possibility of other mineral development in the area. A large ongoing operation, once in place, will facilitate both the exploration and the development of such mineral projects.

---

* Community Planning and Development: Northwest Territories Canada: page 43.

Secondary Processing. In the future, Borealis may wish to upgrade its operation into the production of a higher grade concentrate, agglomerate, reduced iron product, or even steel. In each case the decision to upgrade will depend on such factors as government and community support, existence of a technology suited to the North, and, of course, existence of an infrastructure and a labour pool which could support and would warrant such development.

3. PROJECT PROPOSAL

3.1 DEVELOPMENT CONCEPT

In 1964, the Geological Survey of Canada, during the course of Operation Wager,a large scale reconnaissance survey, ascertained the existence of massive deposits of iron on the Melville Peninsula. W.W. Heywood, who led the Geological Survey party in 1964, published a paper in 1967 in which he outlined the deposit.* Borealis Exploration in late 1967 and 1968 applied for and was granted exploration licenses over much of the area that was subsequently converted to leases in 1976 and 1979.

From 1968 to 1970 Borealis carried out extensive field reconnaissance, testing, and studies of the area. During that period the consulting geologists were Norman H. Ursel working with Ian D.H. Wilson and Douglas H. Underhill. Wilson and Underhill published some of their findings in the Canadian Mining Journal, July 1971.** Also during that period extensive testing on the samples was done by H.E. Neal and Associates Ltd.***

---

*Heywood, W.W. 1967. Geological Notes Northeastern District of Kawaten and Southern Melville Peninsula, District of Franklin, N.W.T. Geological Survey of Canada, Paper 66-40.

**The discovery and geology of major new iron deposits on Melville Peninsula, Eastern Arctic, Canadian Mining Journal July 1971. This report is enclosed. For other reports see appended list of reports and studies on the property.

*** See enclosed reports dated January 31, 1969 and February 20. 1970.

From 1970 until 1978 additional survey work was done. In 1971 a German Group, Studiengesellschaft für Eisenerzaufbereitung,* acquired and tested bulk samples. During this period, most of the properties were brought to lease. From 1967 to 1978 Borealis and its partners invested approximately two million dollars in these properties.

During the 1970's the Geological Survey of Canada continued work in the area. That work included several papers on the Geology of the area as well as an aeromagnetic survey. In addition, other academic work was done on the deposits.**

---

*"Bericht über Voruntersuckungen zur Aufbereitung von zuri Eiztypen der Lagerstatte Melville, Kanada" prepared by Studien gesellschaft für Eisenerzaufbereitung.

**Some of current (last 10 years) Academic and Government Research done on Borealis Exploration properties.
Non-hydrocarbon Mineral Resource Potential of Parts of Northern Canada, by Economic Geology Division, Geological Survey of Canada, Open file 716, published Nov 1980.

Report of Activities, Geological Survey of Canada- Paper 73-1 Part A, April to October 1972 Project 720062 by Mikkel Schau.

Precambrian Geology of the Prince Albert Hills, Western Melville Peninsula, Northwest Territories - Unpublished paper by Dr. Homos Frisch - G.S.C. confidential.

Iron-Formation in Melville Peninsula, N.W.T., MS Thesis by David Watkins, Carlton University 1972.

Geological Studies in Western Melville Peninsula, District of Franklin, T. Frisch and N. Goulet. Regional and Economic Geology Division, C.G.S. Project Paper 75-1 720070 1975.

Work done by G.S.C.

a. June, July, August 1973-1976. Airborne Magnetic Survey of Melville Peninsula by Geotemex Ltd., Survair Ltd., Northern Survey Corporation Ltd., Relevant Maps for BSX done by G.S.C: 8278G Sheet 47A/6; 7938G Sheet 47A; 82946 Sheet 47A/4; 8264G Sheet 47A/15; 8277G Sheet 47 A/11; 8265G Sheet 47 A/10; 8292G Sheet 47A/12; 7939G Sheet 47B; 8325G Sheet 47B/7; 8326G Sheet 47B/2.

b. Energy Mines and Resources - Surveys and Mapping Branch. Complete New Series topographical mapping relevant to BSX.
#47 A/6 Edition 1; #47 A/11 Edition 1; #47 A/4 Edition 1; #47 B/2 Edition 1; #47 A/12 Edition 1; #47 A/5 Edition 1; #47 B/7 Edition 1; #47 A/15 Edition 1; #47 A/10 Edition 1;

Base Maps: Melville North/Base Map 5th Edition 1975.
Melville South/Base Map 5th Edition 1974.

In December 1978, Borealis came under new management. During the next few months the new management examined in great detail the potential for the Borealis Melville Peninsula properties and the potential for other company properties in the North. It was decided to abandon all the other northern properties and to concentrate the company's efforts and resources on the Melville properties. Planning was begun on preliminary feasibility studies for the placing of these properties into production. The reevaluation of the Melville properties was based, in large part, on three sorts of considerations. First, several of the assumptions made in the original plans to put the property into production were reexamined. Second, the cost of fossil fuels had increased substantially. Third, the costs of required environmental controls had increased substantially for the other more complex iron operations in North America.

(1) New assumptions: At least two of the original assumptions were rejected. First, that year-round shipping was a requirement, and second, that the mining operation ought to begin in the west which would require the construction of a railroad across Melville Peninsula.

(2) Energy: The unparalleled rise in the cost of fossil fuels during the 1973-1980 period is of critical importance in determining the economic feasibility of the Borealis project. A great deal of the cost of beneficiating and pelletizing hematite ores is energy cost which could be minimized with the relatively simple crushing and dry magnetic separation of a magnetite ore.

(3) Pollution Control: A significant increase in the cost of iron operations in North America over the last twelve years can be attributed to more stringent environmental control especially with respect to airborn noxious chemicals and water born pollutants. The Borealis dry process will not pollute the water supply and the Borealis fines, because of their very small amounts of chemical pollutants, will provide an environmentally superior feed for Southern and European furnaces, where airborn noxious chemicals must be minimized during blast furnace operations.

Considerations of this sort were a major part of the Borealis decision to proceed with the development of the Melville Properties at this time and to seek Inuit cooperation, regulatory approval, and funding for the project.

Contingent on such approval and funding, Borealis hopes to complete the engineering and testing stage of the project by the end of 1982 and to have a pilot project and building in progress by the summer of 1983-4. Optimally the project will be in full scale operation by 1985.

The following flow sheet shows a more detailed outline of the planning stage (1980-1982):

Also attached see:

(a) Site map

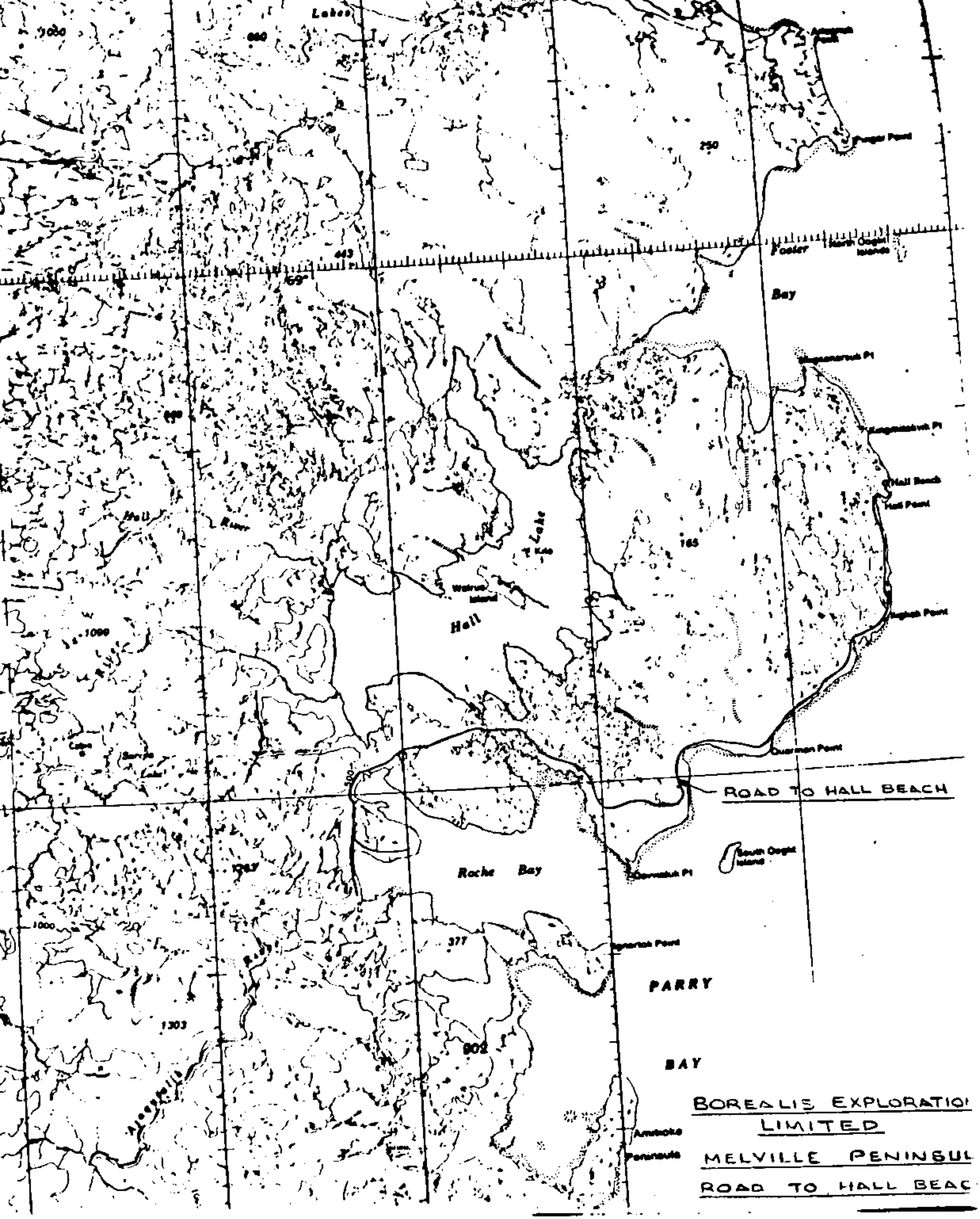
(b) Relief maps

(c) Proposed road routes from Hall Beach to property

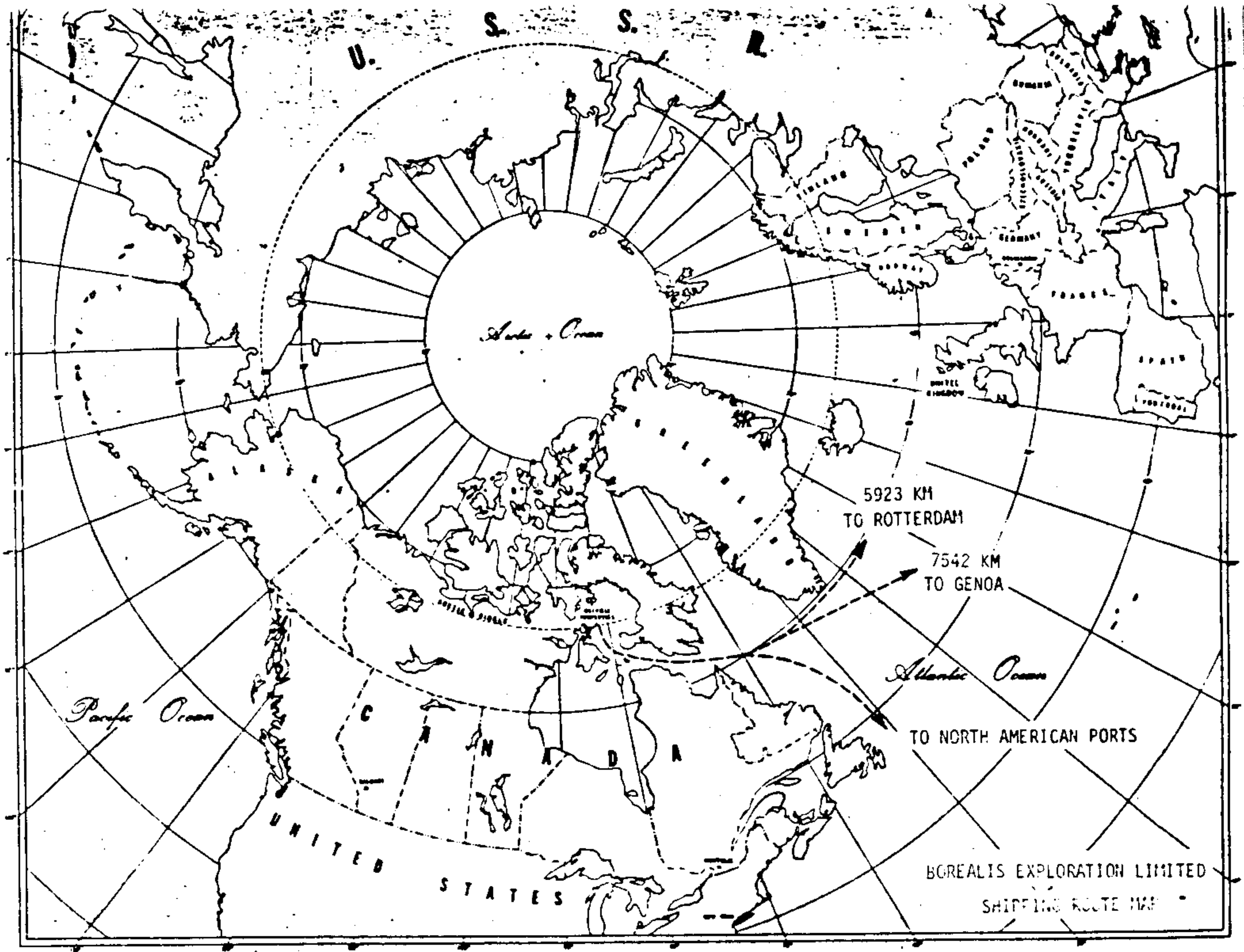
(d) Proposed shipping route Roche Bay - Foxe Basin - Foxe Strait - Hudson Strait - North Atlantic.

(e) Current population:

There are two hamlets located on Melville Peninsula -- Hall Beach with a population of about 300 and Igloolik with a population of about 800. Hall Beach is about forty miles from Roche Bay and Igloolik is about eighty miles from the property.



Lakes
Foster
Bay
Hall
River
Hall
Lake
Walrus Island
Roche Bay
Hall Beach
Hall Point
Quarman Point
ROAD TO HALL BEACH
South Ooglit Island
PARRY
BAY
Amitioke Peninsula
BOREALIS EXPLORATION LIMITED
MELVILLE PENINSUL
ROAD TO HALL BEAC


U. S. S. R.
Arctic Ocean
Pacific Ocean
Atlantic Ocean
CANADA
UNITED STATES
5923 KM
TO ROTTERDAM
7542 KM
TO GENOA
TO NORTH AMERICAN PORTS
BOREALIS EXPLORATION LIMITED
SHIPPING ROUTE MAP

3.2 ORE BODY

Together, there are seven distinct areas or mine sites which appear in the form of two large iron formations* - one in the east and one in the west. The eastern formation extends for a distance of about 30 miles southwest from Roche Bay and the western formation is intermittently exposed over a distance of about 15 miles.

In the east, the deposits range in average width from 400 to 520 feet and in length from 2700 feet to 14,000 feet. In the west the deposits range in average width from 300 to 1300 feet and in length from 9000 feet to 13000 feet.

Field evidence indicates that the iron formation is a metamorphized recrystallized metamorphosed algoma type ore. Algoma type ores are generally thought to have been deposited by chemical precipitation of fine silica and iron oxide entering a sedimentary basin. These precambrian deposits were later intruded by sheets of gabbro and peridotite of intermediate age and still later partially engulfed and assimilated by younger intrusive granites.

The formation consists predominantly of recrystalized magnetite and quartz. Iron silicates and hematites are also present in some areas.

The reserve estimates of 4.3 billion tons have been made without drill hole data but the calculations seem to be justified by a number of factors.

(1) The major deposits of the Melville Peninsula iron formation originated as sedimentary deposits which are now very well exposed both

*See attached maps for detail. Most of the following information is taken from the Wilson-Underhill paper in the Canadian Mining Journal, July 1971. Please refer to that paper for additional information.

vertically and horizontally in fresh outcrop.

(2) The beds of iron formation are continuously developed for miles along strike, and have characteristic thicknesses of several hundred feet, and exceed 1,000 feet in at least three areas.

(3) The beds are characterized by gradual rather than abrupt changes in thickness.

(4) The beds have been tectonically deformed into fold structures whose major dimensions are on the scale of thousands of feet.

(5) These major folds have geometric properties which indicate that they plunge steeply into the earth.

(6) All minor folds and linear structures associated with the major structures also plunge steeply.

(7) The deposits are located within a "Greenstone Belt" -- a geological structure characteristically thought to project to a depth of several miles.

(8) The presence of up to 800 feet of vertical relief has developed within the iron formation itself. The three-dimensional view provided by this relief supports the interpretation by exposing contacts and small-scale structures which are consistent throughout the entire range of elevation.

(9) Igneous intrusion, which might act to cut off the iron formation at depth, is present only with the southern section of the Borealis 5 deposit.

(10) Known faults within the area are steeply dipping strike-slip faults which will have little effect on the down plunge projection of the iron deposits.

(11) Finally, these estimates seem to be supported by the Geological Survey of Canada Aero magnetic surveys of the area.

Because of these considerations and because of the clearly extensive nature of the Borealis deposits, we do not think it necessary to drill all seven deposits at this time in order to more accurately measure the extent of the reserves. Instead, in the summer of 1981 or 1982, Borealis will drill and test extensively in the "A" area which has been selected as the first deposit to be mined. The purpose of this drilling will be to block out sufficient ore reserves for ten years of operation and to acquire depth samples in order to complete the engineering and determine the processing for this particular area.

The A deposit is one of the smaller deposits averaging 435 feet in width and 4,400 feet in length. This deposit was selected partially because of its proximity to the port and partially because the indications are that the A deposit is somewhat coarser grained than the other eastern deposits.

The A deposit is about 700 feet above sea level and about three miles from Roche Bay. As are the other eastern deposits, A is located on the pre-cambrian shield which rises above the coastal limestone beaches of Roche Bay. This terrain seems to pose no major problems for an open pit mining operation of the sort proposed.

3.3 MINING

3.3a The mining operation has not been engineered but, generally speaking, the operation will resemble a rock crushing pit with magnetic separators.

The broad outlines of the process should be as follows:

(1) At least for the first few decades the operation will be open pit. In order to minimize exposure to wind and snow we are considering the possibility of mining under cover using fiberglass and aluminum temporary buildings similar to those being used in the Russian Arctic.*

(2) Electric drills and shovels will be used and, in order to minimize loss of production due to down-time, the equipment will have a rated capacity approximately three times the amount needed. At the present, we are considering the use of two Bucyrus Erie 45R blast hole drills and two Bucyrus Erie 155B shovels. Bucyrus Erie has assured us that these machines are being successfully adapted to Arctic conditions.

(3) The material will be shovelled directly into portable jaw crushers and from the jaw crushers it will be carried out of the pit by a mobile conveyor belt system.

(4) Once out of the pit, a fixed conveyor system will carry the material down to the head of Roche Bay to be milled. At this time, conveyor systems are being considered because they seem to have environmental and long-term cost benefits over the alternative -- trucking. The conveyor systems are quiet and fixed in place and, therefore, should be less of a disturbance to wildlife in the area. Moreover, the total energy requirements for the conveyor belts will be minimized by the use of a regenerative system -- that is, a system which uses electrical generators as braking mechanisms on the long downhill runs. The conveyor

* At this time we are considering Sprung Instant Structures.

system will be elevated in part to lessen damage to vegetation and to allow animal movement. In addition, an elevated system, in offering less resistance to moving water, should help to minimize erosion during spring run-off periods.

(5) In the mill the ore will be crushed and ground to at least 200 mesh and magnetically separated. Whether or not the ore will be ground beyond 200 mesh, will depend on the requirements of the purchaser and the economics of further processing on site.

(6) From the mill the concentrate will be moved by conveyor down to the storage facility where it will be stored under cover until the shipping season. The tailings will be used in a variety of ways described below.

3.3b Surface Disturbance

The ground will necessarily be disturbed in the areas of the pit and, to a lesser extent, in the area of the mill. The disturbance will be small because both the pit and the mill will be on bed rock or raised beaches where there is relatively little ground cover, and vegetation to begin with.*

There will be some surface disturbance around the footings of the conveyor belt system and in the vicinity of the roads although, since most of the roads in the area of the mine, mill, and town sites will be located on raised limestone beaches and on bed rock, this disturbance should be minimized. There may also be some areas of glacial drift affected but such terrain will, as much as is feasible, be avoided.

There will also, of course, be some surface disturbance in the area of the town. Again, the town should be located on bed rock or limestone beaches to minimize such disturbance.

Plans for ameliorating the long term surface disturbance at the mine site have been discussed. Basically, most of the silica will eventually be returned to the mined out pits. Unlike other mine tailings, the Borealis tailings will be relatively inert and, free of inorganic salts

---

*Note that the mill site and town site were selected from an examination of the map and imperfect memories of the actual landscape - they are tentative. Detailed examination of the actual sites and consultations will be required to place the mill and town.

and toxic metals. With some fertilization these tailings may support vegetation but, in spite of abundant work on revegetation in the North, there are still no guaranteed methods for assisted revegetation in the Arctic.* The Borealis pits, will be designed to minimize erosion. As they are deposited in the pit, the tailings will be kept sufficiently wetted to prevent wind erosion. As the pit or natural excavation is filled, physical and possibly chemical means may be used for achieving erosion control while work continues to establish self-sustaining plant communities.

3.3c Mine Water Balance

As the deposits are in an area of bedrock and permafrost, there is no water table in the conventional sense. There may be some pockets of water in the bedrock and, near the surface, these may melt as the pit is being mined, but the major source of water in the pit will probably be rain water. The rain water accumulating in the pit will be minimal because Melville Peninsula is an area of low precipitation - averaging 9" annually. In addition, the mining operation may be operating under cover.

The mine water should be no more acidic than other surface water in the highland area above the limestone beaches, (see 3.3d).

There are at least two options with regard to this water. -- (1) the water can be pumped up and out of the pit into a natural drainage channel or (2) The pit can be designed so that the water will naturally

*Revegetation Information Applicable to Mining Sites in Northern Canada, Everett B. Peterson and N. Merle Peterson, DIAN Environmental Studies No. 3; pages viii to xxii.

drain down into Roche Bay. In each case, which option is used, will depend on a detailed examination of the terrain.

3.3d Discharge Effluent and Tailings Disposal

The mine will have no discharge effluent. The only waste material produced by the mining operation will be waste rock and tailings. In the first few years of operation much of the waste rock and tailings will be used as building materials e.g. road beds, airstrips, landfill for dam construction. The tailings may also be used as a year round source of cover for the sanitary landfill. Until it is feasible to return excess tailings to a mined-out pit some of this material will be deposited in natural excavations and wetted to prevent wind erosion. If feasible, vegetation of these areas will be attempted.

Chemical analysis has indicated that the tailings will consist of silicon dioxide (silica) with some unrecovered iron. A ten year leach test has been performed, at the request of The Regional Manager, Water Resource Division, Dept. of Indian and Northern Affairs, to determine the potential for acid leach. The test results are included in the appendix. In summary, the tailings are somewhat alkaline and will, under the conditions of the test, consume 14.12 #/ton of acid and produce 3.67 #/ton of acid. Therefore, while the tailings may tend to neutralize the surrounding rain water, there will be no acid mine drainage.

3.3e Types and Estimated Quantities of Explosives

When and if production expands to the fifteen million tons range, Borealis will have an on-site plant for the manufacture of explosives. At this time we are considering the use of hydromex M-10. A very rough estimate of quantity would be .41 lbs of hydromex per ton of ore to be blasted.

The product now being considered is produced by Continental Explosive in Bel Isle Quebec and would be shipped north from Mahone Bay which is a licensed explosive port some twenty miles north of Halifax. The contracts for the shipping will be separately negotiated and, once transported to Roche Bay, the material will be stored in an appropriately designed dynamite magazine.

3.4 PROCESSING

The final engineering on the processing will not be completed until depth samples have been taken from deposit A. Please note the enclosed report Feasibility Study of the Beneficiation of Magnetite Bearing Iron Ore for Borealis Exploration Limited RR#80-233 from Eriez Magnetics. In broad outline the processing will consist of reducing the ore size to about 200 mesh and dry magnetically separating to achieve a concentrate of 62%-65% Fe. The extent of the grinding operation and the degree of concentration will depend, to some extent, on the needs of the purchasers.

It should be noted that the process will require no water, no flotation, and no spiralling. It is a relatively simple clean process where the major environmental contaminant is dust. Stringent methods of dust control will be necessary not only to avoid unnecessary air pollution but also because dust in any quantities can be expected to interfere seriously with the operation of the mining and processing machinery. To control dust we plan to enclose much of the operation in buildings, enclose machines and conveyor belts, and to make extensive use of electrostatic precipitation.

As the planning of the project progresses, other methods will be considered.

3.5 TAILING DISPOSAL

See section 3.3.

3.6 MINE PRODUCTS

As described in section 3.3, the product will be moved out of the pit, down to the mill, and then down to the storage facilities using a conveyor belt system approximately thirty-five thousand feet long.

From the storage facilities, the concentrate will be loaded onto ore carriers. At this time we are considering the use of an automatic moveable continuous feed bulk loader with a minimum rated capacity of 10,000 tons per hour. The loaders will be equipped to service ships in two berths. The dock will be patterned after the dock at Nanisivek - a cellular design with steel piles.

The shipping route will be from Roche Bay-Foxe Basin-Foxe Strait-Hudson Strait - to points on the North Atlantic rim.

3.7 MISCELLANEOUS WASTE

(1) Domestic Solid Waste Collection and Disposal.

Solid waste will be picked up in a garbage packer truck as is the practice in the South. A suitable landfill site will be selected and operated as a sanitary landfill. Unlike many such locations in the North, the landfill will be "sanitary" in the technical sense, because a year round supply of cover material is available in the form of tailings.

The availability of the ground cover material will prevent the site from becoming either an eyesore or a "quick food outlet" for the local wildlife population.

(2) Water Distribution and Sewage Collection. The townsite permanent residences will be equipped with pressure water tanks, waste holding tanks, and low water use toilets or chemical toilets. To supply the domestic water there will be a trucked water delivery and a sewage pumpout system. Primary treatment of sewage will be incorporated into the townsite design. Whichever one of a number of commercial systems for sewage treatment is best suited to the town needs will be used. The town will be planned so that when and if the community expands a piped system will be feasible.

3.8 Supporting Industrial Services and Associated Projects

Unfortunately, in the North, it is often necessary to depend on non-renewable fossil fuels to generate electricity and insofar as it is necessary to depend on fossil fuels, any industrial project, especially one operating in a remote area, is at a disadvantage.

Borealis will have a diesel generating plant sufficient to supply the needs of the project and the project is feasible without the use of hydroelectric power. Moreover, a hydroelectric system could not be completed for several years after the commencement of operations. However, any lessening of the project's dependence on fossil fuels will have economic and environmental benefits.

Hydroelectric power in the N.W.T. can and does provide an alternate energy source. As of March 31, 1978, the Northern Canada Power Commission had installed 102MW of hydro capacity and 134MW of thermal capacity. Although thermal capacity was somewhat higher than hydro capacity, four times the amount of hydro power was actually generated -- 490 million KWH of power of hydroelectricity as opposed to only 145 millim KWH of thermally generated power.* Clearly, where feasible and environmentally acceptable, hydro power must be the preferred method of electrical generation.

The Ajagutalik,** a river of considerable size flows into Roche Bay to the South of the mine site.

In the summer of 1980, Borealis had Northwest Survey of Edmonton survey the river and take aerial photographs.

The survey report is not complete but, by extrapolation from the NWT Water Resource Study of March 1966, it seems that there is a 95% chance that the mean annual runoff of the Ajagutalik, in any year may fall within the range of 22 cu.m/s to 54 cu.m/s.

If the river is dammed it should provide a substantial amount of the electrical energy needs for the Borealis project and the company has begun the necessary discussions with the NWT Water Board concerning the utilization of the river.

A tentative dam site has been selected*** which because it is relatively up-river at the head of a long canyon should provide for maximum

---

*Northern Power Commission 1978 Annual Report, page 23.

**"Ajaqutalik" or "Ayergotadlik" may not be the name that Northerners know this river by and in some maps and papers it appears as the un-named river. The nearest permanent settlement, Hall Beach, is about fifty miles north-east of the mouth of the River.

***See attached site map.

reservoir capacity with a minimum of environmental damage from flooding. The dam, which would probably be constructed after mining had begun would be an "earth fill" structure. Mine tailings could be used as the fill material.

The Ajaqutalik River is not one of the rivers flowing into Hall Lake and it does not seem to be a major char fishing river.* And therefore the damming of the river, miles from the mouth, should not interfere with the fishing/tourist industry now being established on Hall Lake or have a significant impact on local fishing harvests.

In addition, hydroelectric power generation may offer secondary benefits beyond the value of the electricity produced.** Of course care must be taken to interfere as little as possible with existing resource use.

In summary, if the damming of the Ajaqutalik River can be carefully planned and executed, the dam will provide a more cost efficient source of energy and should cause less long-term environmental damage than the burning of fossil fuels.

---

*"The un-named river system (Ajaqutalik) emptying into Parry Bay west of Ignertok Point: There is a limited amount of char at its mouth. The rapids in the middle reaches prevent char from reaching the large lake upstream" Northern Foxe Basin -- an Area Economic Survey, 1965, G. Anders, page 17.

The Borealis management however is of the opinion that char are very bright fish and it is probably the case that some char, at least, are able to work their way up a river of that size no matter what the rapids.

**See section 4.4c: Proposed Hydroelectric Generator on the Ajaqutalik River.

3.9 Hazardous Material Control

Dynamite will be stored in specially designed and located magazines.

Diesel fuel will be stored in a tank farm protected by dykes, and sized to hold 100% capacity of the tanks. Leak protection will be achieved by the incorporation of a plastic sheet membrane placed on well compacted ground and covered with fill. The fuel is to be transferred from the ships to the tank farm by pipeline.

3.10 Construction Details

Not determined at this time.

3.11 Abandonment

Control of contaminated seepage and runoff water from mine workings has been described in section 3.3c.

Stabilization and reclamation of disturbed lands and tailings impoundment areas, had been described in sections 3.3b and 3.3d.

Abandonment of the townsite, mill and other facilities has been described in section 2.3h.

3.12 Energy Conservation

The process by which the Borealis ore will be concentrated is exceptionally energy efficient because (1) the ore requires relatively little energy to grind. (2) No water is used in the process, and (3) separation is achieved using low intensity magnetics. Moreover, Borealis' transportation costs, primarily energy costs, should be among the lowest in the world. In fact, much of the economic advantage of the Borealis project lies in its intrinsic energy efficiency.

In addition, we have introduced other refinements to conserve on energy and in particular on the use of electricity generated from fossil fuel resources.

The conveyor system has been designed so that it is always operating at a downward slope and should, at least in the initial stages of the operation, be a net producer of energy since the system is being braked by electrical generators. Ten million ton of material moving down 700 vertical feet should produce a substantial amount of electricity. Eventually, most of the tailings will be returning to the mine site but the alternative, trucking both the ore and tailings, would be considerably less energy efficient.

The potential for wind-powered generators is being examined but the technology for such systems is still relatively untested.

The use of a community center rather than a greater number of free standing buildings should reduce heating inefficiencies.

Where possible all the mining equipment, the drills and shovels, will be operated electrically to reduce pollutants and to allow for the conversion of the entire mining and milling operation to hydroelectrically generated power.

4.1 CLIMATE

The mean monthly temperature for the period from December to March is minus 29^{o}C while the summer months average 5^{o}C. In the summer temperatures 16^{o}+ are not uncommon. Precipitation is low averaging about nine inches annually, of which roughly 50% fall during July, August, and September. Total snowfall is 49 inches.

There are no on site weather or wind observations. The weather information is from DEW Line Stations in the area and the wind information is from the Scarpa Lake DEW Line Station about fifteen miles from the mine site. A heuristic examination of the Scarpa Lake wind records has indicated that the wind velocity tends to be high but not exceptionally so for the Eastern Arctic. The wind information will be analyzed in order to determine the feasibility of wind-power applications for the Borealis project.

4.2 Terrain and Geology

The terrain of the area of the proposed project can be divided into two general types. There is a highland area of largely exposed precambrian Shield rocks. And a lowland area consisting largely of limestone beaches. The highland area rises about 700 feet above the beaches and consists predominantly of exposed bedrock with shallow irregular pockets of drift and peat. Very slow weathering of the Shield bedrock results in acidic soils (usually peaty). However the drift contains limestone material which results in pockets of basic soils.* There may be deeper drift and solifluction particularly on any southeasterly exposures of the ridge.

There are a quantity of rivers and small lakes along the East Coast of Melville Peninsula and there are some wet meadows but there should be no wet meadows in the areas selected for mine, mill, storage, and town sites.

---

*Most of this information on the highland areas is taken from "The Vegatation of Scarpa Lake, NWT." by Martin Lewis and David Belyea, Biology Department, York University, 1977. Scarpa Lake is about fifteen miles northwest from the mine site and the assumption is that the highland terrain is essentially similar.

Bedrock, where exposed, makes a good building surface even in an area of permafrost,as do the limestone beaches in the area.* All buildings should be erected on either bedrock or limestone beaches.

4.3 Hydrology

There should be no waters receiving waste materials. There will be no acid leach from tailings. See section 3.3d. Information on the proposed damming of the Ajaqutalik River is included in sections 3.8 and 4.4c.

*Limestone "shingle provides excellent building sites." K.J. Crowe, A cultural geography of Northern Foxe Basin, N.W.T. Department of Indian and Northern Development, 1969. Page 91.

4.4 Biological Characteristics.

4.4a VEGETATION OF THE ROCHE BAY AREA: ITS ECOLOGICAL SIGNIFICANCE AND THE POTENTIAL EFFECTS OF MINE DEVELOPMENT*

Summary

The minesite near Roche Bay is situated in sparsely vegetated "polar semi-desert", with some proposed facilities to be situated on "low shrub-tundra complex" which is sparsely vegetated compared to areas of this tundra complex just north of Roche Bay. Because of the sparse vegetation on the proposed minesite, indicating a very low plant productivity there, the actual minesite area apparently attracts very little wildlife, especially when compared to certain locations nearby.

Because there is so little vegetation and wildlife on the actual minesite, mine development there, including land disturbance, should have very little ecological effect on this region. However, steps should be taken to minimize any air pollution such as might result from using petroleum or fossil fuels, because harmful residues released into the air could be carried by prevailing winds to areas which are ecologically more sensitive because of greater vegetation.

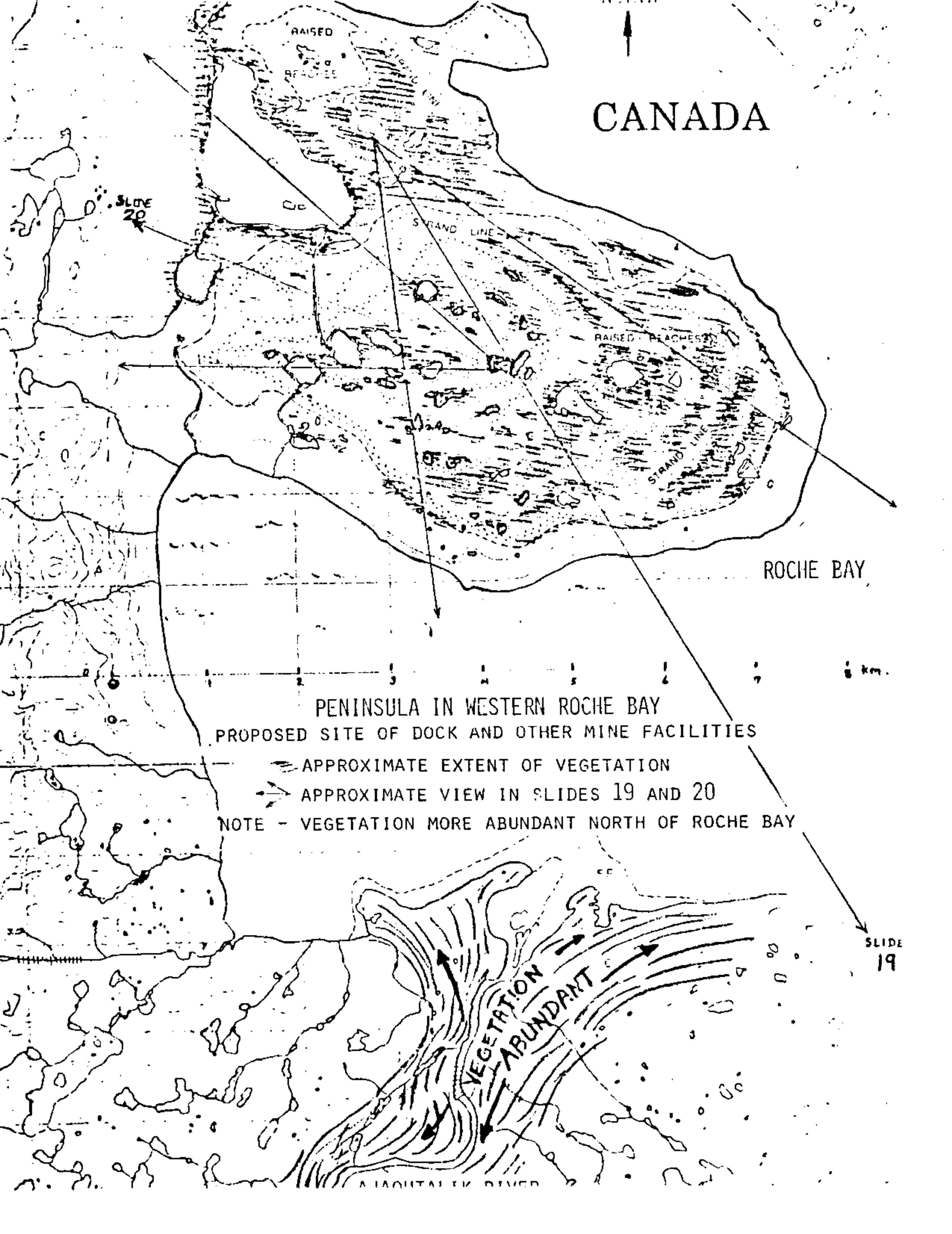
*Clive and Crystal Elliott, the company's consultant Wildlife Biologists are responsible for section 4.4.

General Description of Vegetation around Roche Bay

Most of the Melville Peninsula is "polar semi-desert", being a high plateau of the granitic Canadian Shield and holding only a small amount of soil, which is usually acidic. However, the low-lying coastal areas on the east, south, and southwest fringes of the peninsula have basic soils on a limestone base, and support a "low shrub tundra complex" (Nelson, 1975).

"Polar semi-desert" is a mosaic of "polar desert" and "upland shrub-heath tundra". Polar desert is an area of less than 5% vegetative cover, usually found on plateaux where there is little soil, very little snow accumulation in winter, and rapid drainage of any moisture from snow-melt or rain. "Upland shrub-heath tundra" consists of communities of normal upland tundra plants such as: mountain avens (*Dryas integrifolia*), arctic heather (*Cassiope tetragona*), purple saxifrage (*Saxifraga oppositifolia*), some sedges (*Carex*), grasses, and lichens (mostly *Cetraria* and *Crustose*), most of which are found in upland locations containing soil and moisture. (Moist soil is usually found in depressions and at the base of slopes).

"Low shrub tundra complex" is characterized by approximately equivalent amounts of "upland shrub-heath tundra" as outlined above, and "lowland grass-sedge community", consisting largely of sedges (*Carex*), and grasses, such as foxtail (*Alopecursus*), blue grass (*Poa*), cottongrass (*Eriophorum*), and lichens (such as *Cetraria*,


CANADA
RAISED BEACHES
SLIDE 20
STRAND LINE
RAISED BEACHES
STRAND LINE
ROCHE BAY
km.
PENINSULA IN WESTERN ROCHE BAY
PROPOSED SITE OF DOCK AND OTHER MINE FACILITIES
APPROXIMATE EXTENT OF VEGETATION
APPROXIMATE VIEW IN SLIDES 19 AND 20
NOTE - VEGETATION MORE ABUNDANT NORTH OF ROCHE BAY
VEGETATION ABUNDANT
SLIDE 19

Thamnolia, *Cladonia*, and *Crustose*), which are found usually on low flat areas that retain much moisture.

The land over the iron ore deposit near Roche Bay is "polar desert" at fairly high altitude, and looks extremely barren. Adjacent to the ore deposit, the land becomes "polar semi-desert" because of a few small areas supporting small amounts of vegetation near ponds and runoff channels.

The large peninsula projecting east into Roche Bay (the "Roche Bay Peninsula") supports some "low shrub tundra complex", as does the low flat land north of Roche Bay. As one approaches Hall Lake to the north, this land becomes quite productive of grass and sedge; but the peninsula in Roche Bay in not nearly as productive, because of its large areas of dry raised gravel ridges.

South of Roche Bay, the mouth of the Ajaqutalik River valley appears to be very productive of most of the tundra plants in this region, with grasses and sedges being the most obvious.

Ecological Significance

The vegetation in the immediate vicinity of Roche Bay and the mine site is the main factor determining the distribution and abundance of wildlife in that location. Most arctic herbivorous mammals will eat most species of green plants, mushrooms, and lichens if conditions make this necessary, but each species has its food preferences, and will usually be found where its preferred food plants are most abundant. In this way, the abundance of each type of animal in an area is dependent mainly on the abundance of preferred food plants in that area (relative to their abundance nearby). Given the existence of a food source, other factors become influential, such as the occurrence of predators, etc.

Looking at the Roche Bay area in this light, we find that most of it (with the exception of the Ajaqutalik valley mouth and some of the Roche Bay Peninsula) is quite barren, and seems to attract very little wildlife. Because of the large number of plant species in this region (Porsild, 1964, pp. 161-203; and Lewis, 1977) and because there are likely to be one or more individuals of most of these species somewhere within the Roche Bay area, the presence of these plants can encourage or support the occasional wanderings or brief residence of some mammals within this area. However, because most plant species are uncommon at the mine site (especially relative to their abundance in the Ajaqutalik valley to the southwest, and the Hall Lake area to the north), wildlife will also be very uncommon at the minesite (especially relative to these other adjacent locations).

The abundance of important bird species, such as geese, swans, and ducks, will also reflect the relative availability of plant foods. Thus, while we saw six ducks, 42 pairs of snow geese with young, and 14 pairs of whistling swans in the vicinity of southern and southwestern Hall Lake in early August 1980, we saw none within the minesite area, including Roche Bay Peninsula and the mouth of the Ajaqutalik valley, (although we saw a flock of about 50 ducks in the water of Roche Bay, southeast of the peninsula).

Falcons are other important species found on the Melville Peninsula, but were not observed in the Roche Bay area in 1980.

Falcons will reside only in areas where there is a food supply (i.e. smaller birds and mammals) in sufficient quantity, along with suitable nesting cliffs. Because of the sparse vegetation at the minesite, birds and mammals necessary to feed falcons will be relatively scarce in this immediate area; and with the apparent lack of suitable nest sites at the minesite, it is unsuitable for falcons.

Effect of Mine Site Development on the Local Vegetation

Because most of the land within six or seven miles west of Roche Bay is sparsely vegetated polar semi-desert, development of a mine at the site proposed by Borealis Explorations Ltd. should have very little effect on the terrestrial ecology of this area. Because vegetation is very sparse at the minesite, land disturbance should have very little effect on plant productivity there. Extensive land disturbance around the mouth of the Ajaqutalik River might be an exception, but nothing is planned for that location.

However, any potential source of air pollution should be severely limited and closely monitored, because air pollutants, such as SO_2 and other combustion products from fossil fuels, will be carried south by some of the prevailing winds into areas where vegetation is much more abundant and productive, and which are very important to the ecology of the Melville Peninsula. Such pollutants are very harmful to vegetation, and if released in significant amounts could seriously damage the eastern Melville Peninsula.

POLAR BEAR (*Ursus maritimus*)

(Inuktitut: *Nanook*)

Summary

Polar bears sometimes occur in the Roche Bay area, but are not known to den near there. Probably most bears that occur near Roche Bay are from the Southampton Island or the Simpson Peninsula denning areas, more than 130 miles (230 km) away. The number of polar bears occurring along eastern Melville Peninsula is believed to be small, as reflected by Hall Beach's 1979-80 quota of seven (of which only five were taken).

Winter denning areas are selected by polar bears, usually on land, apparently on the basis of nearby wind and sea-ice drift conditions. Snow drifting conditions, and any meat source or abundant vegetation nearby are further attractions. Polar bears usually occur and den within 10 miles (16 km) of the coast, but occasionally den up to 30 miles (48 km) from the coast, and travel much farther inland. Most polar bears den in certain specific "core areas", but some occasionally den irregularly in other places.

The Roche Bay area is probably unsuitable for polar bear denning because of local wind and drift-ice conditions and

the lack of abundant vegetation or ready meat supply. The only possibly favourable condition for polar bear denning is snow drifting. The presence in that area of humans, moving vehicles, etc. would probably only add to its unsuitability as a denning area, but the occurrence of polar bears in Churchill many times, and in Broughton Island and Hall Beach occasionally, indicates that a mine with associated facilities at Roche Bay would not significantly disturb polar bears in their normal travels.

Polar bears can hurt people and damage man-made structures, but they normally do not damage buildings or machinery unless they think from the scent, that food is available. Polar bears rarely attack people. If people exhibit fear by running away (and possibly by shouting), the bear might be encouraged to attack; but if people stand still, facing the bear, or especially if they advance a few steps toward it, the bear normally flees. Exceptions include relatively rare cases of starving polar bears, which hunt any creature they can find, including humans.

Several weapons including ammonia spray bottles, dispensers of other irritating gases or liquids, and powerful rifles or pistols can probably serve for defense against any polar bears. One or more dogs at a camp or settlement will give adequate warning of the arrival of a polar bear, and will usually distract it or chase it away. Some type of portable flexible wire mesh fence having little influence on snow drifting, might serve to isolate specific areas from polar bear intrusion.

Discussion

Polar bears occur in the Roche Bay area at least occasionally, but little is officially known about the polar bear situation in this area. Polar bears used to be fairly common along the each coast of the Melville Peninsula, but became quite uncommon in this area around 1965 (Anders, 1965). The known polar bear denning areas ("core areas") nearest to Roche Bay are on northern Southampton Island about 220 miles (352 km) from Roche Bay, and on northern Simpson Peninsula about 140 miles (225 km) from Roche Bay (Harrington, 1968). The size of the population along eastern Melville Peninsula is believed to be fairly small, so the 1978-79 quota for the settlement of Hall Beach was seven, and five bears were actually taken. We do not know whether the entire quota was allowed to be taken in the zone which includes Roche Bay. Probably the number occurring in the Roche Bay area varies from year to year, due to variable ice conditions in that area (see below). From the reports of a veteran hunter of Igloolik and a Canadian Wildlife Service polar bear biologist, it appears that polar bear hunting is much more fruitful north of the Melville Peninsula than along its east coast.

Polar bears occurring in the Roche Bay area are probably mostly from the Southampton Island core area, although some might be from the Cape Simpson denning area. Generally, "winds, currents, and tides prevailing when the ice breaks up in autumn cause polar bears to be drifted to these core areas. Strong northeasterly winds in

August and September drive masses of Foxe Basin ice, often inhabited by bears, to the east coast of Southampton Island. According to Manning (1942), the number of polar bears visiting Southampton Island varies considerably from year to year, probably due to ice conditions" (Harrington, 1968, p.11).

As well as having the right wind and ice conditions, other factors that may attract or hold polar bears to these core areas are meat caches or animal remains in that area, or the local vegetation. "Abundant vegetation may also attract bears, for occasionally they demonstrate a definite desire for plant food" (Koettlitz, 1898 in Harrington, 1968, p.11).

Polar bears generally begin to den in October but do not stay in dens later than April. Mainly it is pregnant females which den, to give birth to and shelter their cubs, but polar bears of different sex, age or pregnancy status also sometimes den. They "den" by digging a cave shelter into a large snow bank, so dens are generally on the leeward side of slopes, or in depressions. "Polar bears excavate their dens from the level of sea ice to 1800 feet (548.6 km) above sea level" (Harrington, 1968, p.13), almost always on land.

Polar bears are found mainly on sea ice or on land near the coast, although occasionally they travel very far inland. (We were told of one polar bear being seen far inland, west of Roche Bay area.) Also their denning areas are usually near the coast. Of 113 dens on land, 61% were within 5 miles (8 km) of the coast, 81% within 10 miles (16 km) of the coast, and none more than 30 miles (48 km) inland (Harrington, 1968, p.13).

While most polar bears den in the "core areas" outlined on the included map (from Harrington, 1968, p.7), some pregnant polar bears den elsewhere. Some evidently give birth out on the sea ice with little or no protection from the environment (Van de Velds, 1957). It was also the opinion of a person working on polar bear ecology with the Canadian Wildlife Service, that some polar bears den widely spread out along the coast of southern and eastern Melville Peninsula, but this has not been confirmed.

Thus, although polar bears are not very common in the Roche Bay area, they could be met there occasionally, at almost any time of the year, and at any stage in their life history. We must therefore consider the effect of the development and operation of the proposed mine on polar bear ecology in the Roche Bay area, as well as the effect of polar bears on the development and operation of the mine.

1. There are no major core areas anywhere near the minesite.
2. If one of the polar bears that occasionally den outside these core areas was to encounter the minesite around denning time, it would most likely find this site unsuitable for denning because of the activity of humans and vehicles, and would simply want to flee from the minesite. (There are very many places to the south of Roche Bay that are more suitable for den sites than this area.)
3. In regard to the suitability of the Roche Bay area for denning (without the mine and its accessory facilities), there appear to be no features other than the potential for good snowdrifts to make this a suitable denning area, or to attract or hold polar bears. If the mining development stores its food supplies

carefully, and properly disposes of wastes, and if no carcasses of seals, fish, etc. are left in this vicinity by hunters, then there will be little or no food to attract bears. Regarding vegetation, the minesite area between the Ajaqutalik valley and the low flat land north of Roche Bay is quite barren except for some sedge on the peninsula in Roche Bay, and would offer almost no attraction to polar bears. Ringed seals are abundant in Roche Bay during some years, so this could be an attraction to polar bears.

4. Polar bears have come into the settlements of Hall Beach, Broughton Island, and Churchill - the latter many times - so they do not seem to be disturbed by human activity or vehicle traffic if they are just travelling or hunting for food.

Thus, based on available information, we can say with high probability that the development and operation of a mine and its associated facilities near Roche Bay will have little or no detrimental effect on polar bears or any aspect of their ecology.

The affect polar bears can have on mine development and operation, mainly through their interaction with humans and equipment at the minesite, is a matter subject to extreme variation in cause and effects and their interpretation.

Generally, polar bears avoid places of human activity, unless they find themselves there at some time when there are no humans moving about (which usually happens at night or early morning), or unless they are introduced to these areas by other bears already conditioned to them as safe places, (such as might be happening at Churchill). However, they have come into settlements on the Melville Peninsula on rare occasions.

When polar bears enter places where there are man-made structures and equipment, they can do significant damage. They generally do not touch machinery unless it has parts such as padded seats, which they have been known to tear up; or is fragile, with some kind of "interesting" scent such as an inverted canoe or canvas covered building, which they have been known to tear into. They do such things probably out of curiousity, to find out if the "interesting" scent is from something edible. They might break into buildings if they think the building contains food (from previous discoveries), or if the building emanates an interesting scent; but they usually ignore buildings, or do not harm them.

When polar bears encounter people, they usually seem fearful when the people stand still or advance toward the bear (even if it is a single person). The one time I encountered a female polar bear with a young cub (about 8 months old), the female seemed wary, not wanting to approach while I stood in one place (about 40 metres from her), but the cub showed great interest and came toward me slowly until the mother signalled it back. When I advanced one step toward them, they ran away. Other polar bears I encountered did not want to come closer than 40 or 50 yards, but showed interest in the "strange creature" near them, and fled if I moved one or two steps toward them with my attention focused on them. However, polar bears have attacked and killed people several times. One of these cases (on rough Beaufort Sea ice) was where a starving polar bear carefully stalked several people who were unaware of its presence until it attacked. I also heard from

Inuit on southeastern Baffin Island of a polar bear stalking one or more people working on a canoe on shore, and not fleeing when they turned and shouted at it.

In the cases I know of, the polar bears did not try to attack or stalk people who were making dominant or aggressive movements toward them. They were stalking people who were not aware of their presence, and in the last case, shouts from one or more people being stalked apparently did not frighten the bear.

Polar bears are large predatory mammals, and from the few encounters I have had with them, they behave like most predators - i.e. if an unfamiliar creature or one that they considered to be another predator that hunts them, makes dominant or aggressive advances toward them, or even holds its ground, they will not attack it, and usually flee; but if these "strange creatures or smaller predators" are unaware of the bear's presence, and the bear is hungry, it is likely to attack. One way for humans to invite attack by polar bears, is for the humans to turn and run, or to express fear of the bear in some other way, such as giving "alarm calls" (shouts or screams) when they see it. Dogs are also predatory, and even very small dogs will often chase and attack large humans if they run away from them in apparent fear.

I do not say that aggressive behaviour by humans toward polar bears will cause them to flee in all cases, even though it has in all cases I have seen (where the bears were not conditioned to humans as being harmless creatures, as a bear from Churchill might be). However, as stated, running from polar bears in fear might cause them to attack.

Effective self-defense weapons to stop even the extreme cases, such as an attack by a starving polar bear, include things like small ammonia spray bottles, guns or sprayers to discharge tear gas, or any implement discharging any gas or liquid very irritating to the bear's nose and eyes. Other weapons such as guns are suitable in the hands of people who know how to use them. Almost all Inuit men are very familiar and usually very adept with high powered rifles, and one could be kept safely in readiness (with cartridges in the magazine but not in the chamber) in areas where people are working. A powerful revolver is also an effective weapon for people experienced with them, and can be safely carried ready for instant action, without being in the way, or a heavy encumbrance, like a rifle on a sling often is. However, it takes considerable training to effectively use a powerful pistol, and the law enforcement departments in Canada will usually not allow their use, even where Canadian law says their use is acceptable.

Another possible protection from polar bears for the townsite and other areas of the minesite might be some type of fence. Something like a flexible wire mesh fence, about 5 feet (1.6 m) high, which was portable, easily anchored where desired, and had little effect on snow drifting, might be ideal for this purpose. This type of fence could be moved to protect different areas of the minesite in use, and moved from different areas of shoreline or sea ice to allow access as needed.

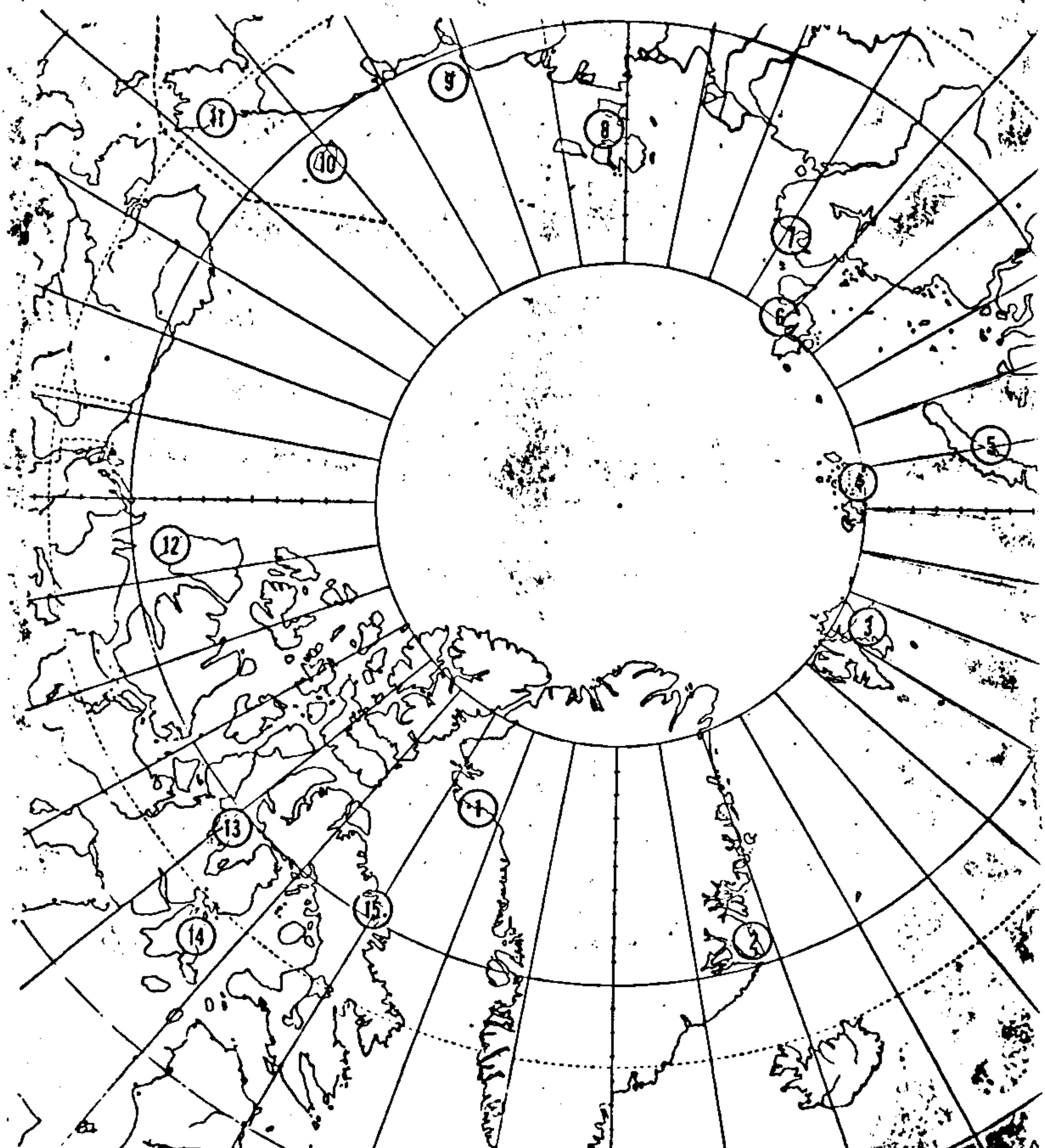
Dogs in a camp or settlement usually give adequate warning if anything like a polar bear approaches, so any necessary action can then be taken. If dogs are untied, they will usually harass the polar bear, distracting it and chasing it away, (although in so doing they may make it angry and aggressive.)

Oil and mineral companies working in the arctic may have more information on polar bear-people interactions, and methods or devices for repelling polar bears, and should be consulted about this.

In any event, in any arctic situation involving people and polar bears, dangerous encounters can generally be avoided if simple precautions are taken.

Harington (1968)

Figure 2 Distribution of polar bear core areas (important denning and cubbing places): 1) Northwestern Greenland, 2) Northeastern Greenland, 3) Eastern Svalbard, 4) Franz Josef Land, 5) Novaya Zemlya, 6) Severnaya Zemlya, 7) Taimyr Peninsula, 8) New Siberian Islands, 9) Bear Islands, 10) Wrangel Island, 11) Chukchi Peninsula, 12) Southern Banks Island, 13) Simpson Peninsula, 14) Eastern Southampton Island, 15) Eastern Baffin Island. (5, 6, 7, 8, 9, and 11 are of secondary importance.) Dots indicate weather stations.



MAMMALS OF THE MELVILLE PENINSULA AND THE POSSIBILITY OF THEIR DISTURBANCE BY THE PROPOSED MINE AT ROCHE BAY*

ARCTIC WOLF

Rare on eastern Melville Peninsula and, since the pelt is saleable, they are usually hunted whenever seen. They are very wary of humans except where they are convinced they will not be hunted. If no hunting is allowed in the immediate vicinity of the mine site, wolves will probably approach it and "scrounge" for food as they do in the area around some DEW line sites.

MUSKOXEN

There is some controversy about whether Muskoxen ever existed on Melville Peninsula and on Baffin Island.** And Harington (1961) suggests that there may have once been a sparse occupation of the area by the species with its possible extinction by primitive man.

---

* This section is also attributed to the Elliots

**J.S. Tener, Muskoxen in Canada, 1965, pg. 17.

Joanasi Uyarak, a hunter at least eighty years old, presently living in Igloolik, has, from his youth, often travelled in the Roche Bay area and he says he has never seen or heard of a muskoxen sited on the Melville Peninsula in his lifetime.

Thus it can be stated that no muskoxen (or, at most, extremely few for very brief time periods,) have occurred anywhere on the Melville Peninsula since 1900 and probably none in the Roche Bay area.

Since 1956, surveys conducted for the Canadian Wildlife Service (Banfield, Harrington, Kelsall, Macpherson, Tener, and Decker) indicate that the likelihood of muskoxen moving into even the southwestern portion of the Melville Peninsula within the next ten years is extremely remote and there is basically no chance of muskoxen appearing near Roche Bay in the foreseeable future.

Thus, there is virtually no chance of a development near Roche Bay, or the road between Roche Bay and Hall Beach, in any way interfering with muskoxen, or any aspect of their ecology, within the foreseeable future.

ARCTIC FOX (Alopex lagopus; Inuktitut: Tireganierk)

Summary

Arctic foxes are quite common throughout the arctic. Their abundance varies with that of their main food species, the lemming, which is noted for its population cycles. Thus, arctic fox are sometimes quite common on the Melville Peninsula, where they are trapped in winter. Their importance to the Inuit economy fluctuates with the price of their pelts.

Because arctic foxes prefer vegetated soft ground areas for denning, and most of the mine area is barren bedrock or limestone gravel, probably no foxes ever den there.

Both the present knowledge of arctic fox ecology, behaviour, and response to humans and industrial developments in the arctic, when they are not hunted or harassed by humans, and our observations of arctic foxes in several such situations, indicate that the existence of the mining operation, per se, should not disturb foxes, or interfere negatively with their ecology. Much evidence indicates that man-made developments in the arctic attract foxes, especially if there is any food or shelter available to them at those locations.

Discussion

It can be assumed that arctic fox are sometimes quite common on Melville Peninsula. By and large, the number of foxes in an area is proportional to the number of lemmings. Lemmmings are their principal food source at all times of the year and in all areas that have been investigated. In the breeding-denning season, lemmings constitute 50% to 90% of the diet of arctic foxes in the Keewatin (Macpherson, 1969, p.46). Their diet in the Keewatin was also found to include birds, caribou, insects, and berries in that order of quantity. They will also forage for food in garbage dumps whenever possible, and the caribou in their diet probably comes from scavenging the remains of animals killed by wolves or people. Arctic fox living near coastlines usually get some seal and fish from carcasses on the shoreline.

Denning

Arctic fox raise their pups in dens, which are dug into the ground the previous summer or before, usually in sandy, well-vegetated areas of gentle slope. Fox dens are usually in or near areas where their main food, the lemming, is found in reasonable abundance (Macpherson, 1969). Fox dens will therefore not be found in rocky or poorly vegetated areas, such as the mine site near Roche Bay, although they are known to den near there (Macpherson, 1969, p.8). In the minesite area, the nearest suitable habitat for fox denning is probably the Ajaqutalik valley, or possibly land near the western edge of the coastal plain north of Roche Bay. Under natural conditions there would probably be only two fox dens near this minesite at the best of times, as arctic foxes are apparently territorial, and rarely den less than a mile apart. The density of fox dens in an area studied in Keewatin was one per twenty-seven square miles (Macpherson, 1969, p.46), although they are reported to be higher in some places in the U.S.S.R. (ibid), and on Banks Island (Urquhart, 1971).

Potential Disturbance from Mine

The mine and associated facilities should have no disturbance effect on arctic foxes, and according to the evidence from camps, construction sites, and settlements where arctic foxes are not harassed, the mine development will probably be an attraction to them. Foxes were found to concentrate around staging sites for northern oil exploration, "...probably due to the availability of food and permanent shelter" (Urquhart, 1971). An unusually high den density of one den per 3.9 square miles (10 sq. km) was calculated by Urquhart near one of these sites. (This high denning density may have resulted from the food or garbage at the site - being significant attraction to arctic foxes.)

Arctic foxes quickly condition to moving vehicles, humans, and the sounds and smells associated with settlements, as long as they have not learned to associate any of these things with danger. Garrott (1979, p.44) while doing a study of arctic foxes in northern Alaska, noted that they "seem to adapt readily to the human activity of the oil fields", and observed them moving between or through piles of gas and oil pipe, and foraging in camp dumps. As further examples of their adaptability, we have seen arctic foxes approaching to within less than three feet (1 m.) of people in a Geological Survey camp that had been in its location for about one month. We have seen evidence that arctic foxes frequently used buildings at an abandoned DEW line site, and a crashed plane, as shelters. Young arctic foxes wander into human settlements in late summer or fall (Macpherson, 1969), until they find out that dogs and people will chase and harass them in those locations. People at some camps and DEW line stations on the other hand, have considered arctic foxes to be their "pets", and these foxes have become quite tame, although they would never allow people to handle them.

Thus arctic foxes will avoid the minesite only if they are harassed by people or dogs there, but the mine and associated facilities should otherwise have no detrimental effects on any aspect of arctic fox ecology (except to possibly cause abnormal concentration _if_ food is regularly provided).

BARREN-GROUND CARIBOU (*Rangifer tarandus groenlandicus*)

(Inuktitut: *Tuktu*)

Summary

All caribou surveys since 1972 on the Melville Peninsula indicate that there are very few caribou in the immediate vicinity of the proposed mine site near Roche Bay, although caribou are reported as sometimes plentiful in the Ajaqutalik River valley, within four miles of Roche Bay, and occasionally southeast of Hall Lake.

All evidence from several studies on human-industrial developments in the arctic reveals that caribou are not seriously disturbed by these things. Observations made during caribou studies on adjacent Baffin Island indicate that caribou can adapt fully to the presence of humans and industrial development, as long as they are not harassed, frequently startled, or physically harmed.

From this evidence, we conclude that the iron mine proposed near Roche Bay will not be detrimental to the caribou situation in this area.

If caribou are not hunted or harassed within one mile of the minesite, and if there is very little snowmobile traffic

around the minesite, they will probably learn to identify it as a place of safety; but if there is hunting in the immediate vicinity, they will probably identify the minesite in the same way as they identify most settlements from which they are hunted - a place to be avoided as the home of their enemies. Whether hunting is allowed in that area should be decided partly by Inuit who hunt in that immediate area, who are mostly residents of Hall Beach and Igloolik.

Information on which these conclusions are based is presented and analyzed below.

INTRODUCTION

Caribou are still an important source of food for the people on the Melville Peninsula, and, as such, are the most important terrestrial wildlife resource in that area. Because of the conflicting or confusing information released on the Melville Peninsula caribou situation, because caribou are the most important terrestrial wildlife resource in that area, and because human and industrial activities can influence caribou ecology, we will deal with the Melville caribou situation thoroughly as it applies to the proposed Roche Bay iron mine area.

From studies of caribou in the Melville Peninsula area, by Anders, Bowden, Bailey, Helmer, Pendergast, Gates and Elliotts, from 1965 to 1980, where surveys were flown over parts of the Melville Peninsula, and Inuit hunters from Repulse Bay, Hall Beach, and Igloolik were interviewed, the following information was learned about the caribou population in the Hall Beach - Roche Bay area of the Melville Peninsula.

DISTRIBUTION AND MIGRATION OF CARIBOU, AND ASSOCIATED HUNTING PATTERNS OF INUIT IN THE ROCHE BAY AREA

Winter: Caribou winter in significant numbers in southeastern Melville Peninsula and this major wintering area extends up the east coast (generally from the coast to about 10 miles inland), north to within about 25 miles (40 km) of the southern edge of Roche Bay. North of this main winter range, caribou are occasionally found in winter on the Amitioke Peninsula, and further north past the mouth of the Ajaqutalik River, and the Roche Bay and Hall Lake region. However, survey flights in this area by Rippin and Bowden in May 1972 indicated no caribou or tracks in the Roche Bay - Hall Lake area or north of there. Of several Inuit hunters and local Wildlife Officers interviewed, one hunter, Joanasi Uyarak, who is at least 80 years old according to Dept. of Health and Welfare records, who once lived near Roche Bay, and who is still an active hunter, said that caribou were once more abundant in winter in the Hall Lake area than presently. Other hunters said that caribou are still taken occasionally in the Hall Lake - Roche Bay area in winter, but now most hunting south of Hall Lake (by hunters from Hall Beach and Igloolik) takes place along the main coastal wintering area south of the Roche Bay - Amiotioke Peninsula area, or inland, southwest of Roche Bay, along the Ajaqutalik River.

During late winter and early spring according to Inuit hunters and the Wildlife Officers Ron Allen and Jake Ikeperiar, caribou from

Hall Lake south to the main winter range begin heading southwest or west, going further inland. At this time of year, hunters from the Hall Beach area find few if any caribou immediately around Roche Bay or Hall Lake, but the Ajaqutalik River valley provides easy access by snowmobile or rarely-used dog team to the interior of Melville Peninsula, where most caribou have gone.

As calving time (May 28-June 20) approaches, most caribou on Melville Peninsula move further inland toward a major calving area north of Lyon Inlet in southern Melville Peninsula. This is the only calving area known on the Melville Peninsula, and its northern boundary is about 58 miles (93 km) southwest of the Roche Bay mine site. Most males and non-pregnant females are found just south of the calving area at that time.

In late spring and early summer after calving, the caribou move out from the south Melville calving area (in all directions apparently), and many reappear near the Melville east coast, far to the south of Roche Bay. Some caribou (mostly females with calves, and yearlings) travel north past the Roche Bay area. Generally in early summer, caribou are seen and hunted along the coast south of Hall Lake, but they are not considered numerous in the immediate vicinity of Roche Bay. Calef and Heard (1980, p.19) implied that no caribou were observed north of 67° 45'N (a line 45 miles or 72 km south of Roche Bay) on survey flights between June 19 and 21, 1976.

As summer progresses, most caribou move to higher country inland (possibly to escape the mosquitoes near coastal lowlands). Again, the

Ajaqutalik River valley once provided a route inland for hunters from Hall Beach area to reach these scattered caribou in mid to late summer, but it is seldom if ever used any more at this time of year. On a 100-mile survey from Roche Bay to about 20 miles (32 km) inland, including the Ajaqutalik and Kingora River valleys, on August 7, 8, 9, 1980, only six caribou were seen, so the population in this area was small and very scattered in 1980. However Anders (1965) reported that "during observation flights in early August 1965, caribou were most frequently sighted on Melville Peninsula in the area west and southwest of Hall Lake"; so the number of caribou in the vicinity of Roche Bay in summer possibly varies from year to year.

In late summer and through the fall (possibly when mosquitoes are greatly reduced) many caribou return to coastal regions. Again, they appear in significant numbers near Cape Jermain (about 50 miles or 80 km south of Roche Bay), and some appear near the coast through the Amitioke Peninsula - Roche Bay - Hall Lake area in numbers which may vary considerably from year to year.

In late fall most of the caribou which returned to the Hall Lake area travel south, past Roche Bay, but a few caribou remain in the Hall Lake area.

Regarding the late summer and fall caribou migrations and distribution in the Roche Bay area, 80-year-old Joanasi Uyarak says that more than 45 years ago (when local Inuit began getting rifles) caribou were much more numerous during late summer in the Hall Lake area than they are now, and the fall migration south past the Roche Bay - Amiotioke Peninsula area was something his camp counted on for much of their winter caribou supply. However, this migration became very much smaller and less regular since then, and is no longer important in providing the annual caribou requirements of Inuit in the Hall Beach area. (Anders' report (1965) suggests that this reduction may have occurred since 1965.)

Hunters and Wildlife Officers from Hall Beach and Igloolik were in agreement that in recent years a very small percentage of the annual caribou harvest on eastern Melville Peninsula (no figure available) is actually taken very near Roche Bay or the proposed mine site. Roche Bay and Ajaqutalik River are, however important, easily reachable access points through most of the fall, winter and spring, from which the caribou ranges in the interior of the Melville Peninsula can be reached. Most of the harvest for Igloolik is taken from the Baffin herd.

MELVILLE PENINSULA CARIBOU POPULATION ESTIMATES

Hunters interviewed by Anders in 1965 (p.34) and A. Wight (1962, cited by Anders, 1965, p. 132) were of the opinion that caribou numbers were increasing on the Melville Peninsula. However, no estimate of the Melville Peninsula caribou population was indicated for this period. In 1971, Northwest Territories Government began survey work to determine actual population size and other aspects of caribou ecology on Melville Peninsula. In 1972, Rippin and Bowden (N.W.T. Government) concluded there were 4400 to 6600 caribou on the Melville Peninsula, occurring mostly in the southern half of the peninsula. However, another survey in 1973 (Bowden and Pendergast, N.W.T. Government) resulted in a population estimate of 3000 to 4500 (based on the same method of estimating population as used in 1972), and a survey in 1974 (Bowden and Helmer, N.W.T. Government) indicated a further decrease in the Melville caribou population to 1859 (or 1520 to 2280 using the above calculation method).

Then in 1976 and 1977, G. Calef (N.W.T. Wildlife Service) was in charge of further wildlife studies on Melville Peninsula, and a brief abstract of the resulting report indicated about 42,000 caribou estimated for the Melville Peninsula. (This original report is apparently unavailable, although the estimate of 42,000 ±7200 is presented as the result of this study in another N.W.T. Government report (Donaldson, 197?). In 1980 at a conference in Norway a paper by Calef and Heard was presented which says a population of 52,000 caribou was estimated for the Melville Peninsula from the same 1976-77 work (Calef and Heard, 1980). (No explanation is given for this significant alteration in their estimate.)

We met no one else living or travelling in Melville Peninsula who had detected this major increase of the Melville caribou population.

Since then an aerial survey flown over southern Melville Peninsula between June 5 and 9, 1980, indicated about 4000 to 4500 adult female caribou on the known calving areas and a total population of about 10,000 for the Melville Peninsula (C. Gates, personal comment).

In 1980 we talked with three Wildlife Officers concerned with areas on or adjacent to the Melville Peninsula, and with several Inuit hunters living there, and the opinion of all these people was that the caribou population of the Melville Peninsula has been increasing, but they have noticed this increase mainly during the last two years. They say the caribou are increasing mainly on the northern and central parts of Melville, where they have been uncommon for the last ten years or more (in spite of habitat that appeared quite good on our 1980 flights). When asked about the Roche Bay area, these people said they saw no significant increase in numbers in that immediate area, even though they saw an increase in an area about 20 miles (32 km) north of Roche Bay and 30 miles (50 km) west of Hall Beach.

But this is not the first time such increases have been reported. Most reports based on observations and/or hunter interviews since Wight (1962), conclude that the caribou population of Melville Peninsula is increasing. However a comparison of numbers and distribution estimates from earlier and later reports and hunter interviews does not indicate a significant overall increase, but rather a population fluctuating irregularly in numbers and distribution from year to year.

From the opinions of Wildlife Officers and hunters we interviewed in 1980 and 1981, we conclude that there has probably been a caribou population increase on the Melville Peninsula during the last two or three years, that the present Melville caribou population is probably in the order of about 10,000, and that this increase is most noticeable in areas of northern and central Melville Peninsula, where the habitat appears suitable but caribou have been uncommon for more than 10 years.

In regard to these apparent caribou population variations, Joanasi Uyarak, who has been living and hunting on the Melville Peninsula for 80 years, told us that caribou numbers on Melville have increased and decreased in times past for reasons he did not know, just as they are doing now. Kelsall (1968, pp. 118-131) discusses many caribou population shifts that have occurred on the Canadian mainland, and some possible reasons for them; and Donaldson (197?, pp. 23-25) discusses how the temporary increase reported by Calef and Heard might have come from herds southwest of the Melville Peninsula.

ECOLOGICAL DISTURBANCE EFFECTS OF A MINE AT ROCHE BAY

For the caribou situation in the immediate vicinity of the proposed mine, all the evidence from the above-mentioned surveys and interviews indicates that the caribou population within 10 miles (16 km) of Roche Bay was thinly scattered in 1980, and that some caribou, but not a large number, may occur occasionally in the immediate vicinity of Roche Bay and the mine site in summer, fall or winter. A migration of small numbers past Roche Bay probably occurs in early summer and fall in some years.

On August 7, 8 and 9, 1980 we flew surveys of approximately 100 miles (160 km) in the Roche Bay area: from Roche Bay along the Ajaqutalik River for 20 miles (32 km), then to Scarpa Lake, back to the Ajaqutalik River and to Scarpa Lake by more easterly routes, then along the Kingora River to Hall Lake, and south to Roche Bay. These surveys indicated that the caribou population throughout this area was very small and widely scattered, at least at that time of year in 1980. We saw only six caribou, and all were several miles inland from the mine site.

The surface area near Roche Bay which would be directly affected by the proposed mine and associated structures (such as the mine pit, mining equipment and service buildings, living quarters, diesel power generating stations, power lines, dock facilities and loading equipment, and roads connecting these facilities) will eventually probably be from 30 to 38 square miles (76 to 98 sq. km). (This does not include a possible hydroelectric dam on the Ajaqutalik River and roads and power-lines from it, or a road from Hall Beach to Roche Bay.)

Most of this area is quite barren, and of very little productive value to caribou or any other animal life, but some caribou do pass through part of this zone. "One of the basic adaptations caribou have to their extrinsic environment is their continuous movement" (Bergerud, 1971, p. 580), so the mine site will only be a temporary part of the environment of any caribou. This is confirmed by the observation of Joanasi Uyarak of Igloolik, who states that the caribou of Melville Peninsula never stop travelling, except on the calving grounds.

THE REACTIONS OF CARIBOU TO PROPOSED MINESITE DEVELOPMENTS

Because caribou are the most important terrestrial wildlife resource in this region, even with numbers quite low, one important question must be considered: Will the development of a mine near Roche Bay, as proposed by Borealis Exploration Ltd., be a significant disturbance factor to the fluctuating numbers of caribou in that area?

Possible Disturbance Factors:

To answer this question, the reaction of caribou to any physical barriers to travel and to any sensory stimuli produced by the mine or its facilities will have to be investigated. Buildings, the mine pit and piles of dirt and crushed rock, ore conveyor systems, pipes, powerlines, roads, and ocean water kept open to later than normal date by ship traffic to and from the minesite, will have to be considered as potential physical barriers. Sensory stimuli include any odours and sounds produced by the minesite, and visual images of stationary and moving objects, including men.

The study of caribou reactions to all these factors must take into account the initial reaction of caribou encountering these factors for the first time, and the capability of caribou to adapt to these new stimuli.

How Caribou React to These Factors:

To begin with, all studies have shown caribou (or reindeer, as they are called in Eurasia) to be extremely adaptable or tolerant, and quite curious about new stimuli they encounter. The greatest adaptation caribou have, to make them successful in the varied, rugged and near-marginal arctic environment, is their adaptability (Bergerud, 1971, p. 582). And caribou adaptability to various disturbance stimuli has been mentioned or studied by Bergerud (1971), Child (1971), Geist (1970), McCourt et al. (1974), Miller and Gunn (1979) and Elliott (to be published).

Generally, in their reactions to new and unfamiliar stimuli, caribou will consider something to be dangerous if it orients its attention and movements toward them. If it does not do this it is not considered dangerous and they adapt to it. These traits have made the caribou suitable for many purposes as a domestic animal, and in northern Eurasia, the reindeer was domesticated hundreds of years ago. When reindeer are used as draught animals for pulling sleds or carrying packs and riders, they are brought into contact with every type of humanly altered environment and activity that would occur in the Canadian arctic, and they quickly adapt to them.

Now we will look at how these adaptable animals will react to the disturbance factors listed above, which will occur at the Roche Bay minesite.

Physical Barriers:

1. Buildings: The minesite will have three large buildings, with smaller structures such as housing etc. to be determined. Stationary objects such as buildings do not disturb caribou. Caribou have been photographed walking within about 30 m. of mobile buildings in a seismic camp, which these caribou had not previously seen anywhere near that location. A caribou herd in the western arctic "during migration... exhibited the usual lack of caution in passing through villages or campsites that lay in their path" (Banfield, 1971, p. 801). We have seen caribou on Baffin Island and the Melville Peninsula walking within 3 m of buildings at old DEW line stations which were abandoned most of the year, and one bull caribou was seen standing in the doorway of a large garage at one of these stations.

As physical barriers to travel, buildings will be no hindrance; caribou will simply walk around them.

2. Mine pit and piles of rock and dirt: The mine pit may be covered with a domed tent-like roof, but any areas uncovered will present no barrier, as caribou will usually walk around such things. Piles of tailings also will be no barrier, as caribou will usually walk around them. However, should caribou for any reason have to cross piles of dirt or rock, this will be no serious problem for them. "In mountainous terrain, they regularly climbed over the steepest mountain slopes" (Banfield, 1971, p. 801). On Baffin Island, we have seen caribou in a more comparable situation, where they were

climbing, descending, and travelling horizontally along the steep, bare clay slopes of badlands. We have also seen caribou, including three-week-old calves, travelling regularly along steep rocky mountain slopes that looked like mountain goat habitat.

Thus all indication is that the mine pit and piles of tailings or ore will not prevent caribou travel through the mine site.

3. Ore conveyor systems, conduit pipes, and powerlines: Several studies have been done to determine the effects of long structures such as fences, raised powerlines, and raised pipelines up to 48-inch diameter, on caribou, with the fear that such structures would seriously impede caribou travel on migrations. The results of these studies indicate that most caribou will first try to go around such structures, but in one study (Child, 1971), 0.6% of 1102 caribou which had never before seen such things crawled under a simulated pipeline even where it was raised only 20 inches (51 cm) above ground. A ramp was built as an overpass across the structure. 12.3% of these non-adapted caribou used this very quickly; and 5.4% of the non-adapted caribou went through an underpass built under the structure (Child, 1971, p. 808).

The caribou in the above tests were encountering those types of barriers for the first time in their lives, yet many took advantage of any available method to pass the barriers. In reports presently available to the writer, no effort was made to test caribou which had encountered such structures more than once, so these studies do not indicate how quickly all caribou will adapt to them and pass over or under them without hesitation. However, reference to their reaction and adaptation to buildings (#1 above) indicates that they will adapt to underpasses or overpasses quite quickly; and our personal observations of caribou around DEW line sites on Baffin indicates complete adaptation to stationary structures in a short time.

As a further illustration of the probable capabilities of caribou to cross strange new physical barriers, consider their southern relatives, antelope, deer, elk and moose, which travel unimpeded over or under barbed wire fences with less than 12 in. (30 cm) of free space (personal observation).

Plans for the mine and its facilities call for underpasses or overpasses to facilitate travel past anything that might represent a barrier to caribou, and potential barriers here are less imposing than those tested above.

4. Roads: Since major northern developments were first planned, many people have been concerned about the effects of roads or vehicle trails on caribou generally, and on annual caribou migrations in particular. As a result, many studies have been done on this (Banfield, 1971; Bergerud, 1971, p. 580; McCourt et al. 1974; etc.), and "the behaviour of barren-ground caribou of crossing roads and railroads and even passing through communities is well documented" (Bergerud, 1971, p. 580).

Results of these studies have proven that many caribou are curious when encountering a road or new trail for the first time, and some will follow it, usually for a short distance. All caribou quickly adapt to roads and trails, which are inanimate stationary parts of the physical environment; and they frequently use them to make their own travelling easier. Caribou will follow a road or trail as long as it is going in the direction they want to travel, but leave it where it turns a different direction. Some caribou hesitate when they first encounter a road that rises so high that they cannot see across it. They then usually follow it to a lower point, and cross.

Evidence indicates that the physical structure of a road is usually more of a help than a hindrance to caribou.

Roads in the area of the Roche Bay mine will probably be topped with local limestone gravel, and will thus look very much like a raised beach ridge, of which there are hundreds in the area. Thus, roads in this area will represent a new stimulus for caribou only if the smell of them differs from a normal raised beach. (It will be shown later that smells elicit disturbance behaviour only when they are associated with a known danger.)

Because of the nature of the country in the Roche Bay area, roads will be no hindrance to caribou, and roads around the mine site will also be of little benefit to them.

5. Shipping channels: Shipping channels through the ice forming on Roche Bay may be kept open into early winter. This should not be a significant obstruction to caribou movement in or through this area. According to Joanasi Uyarak, caribou used to occasionally cross the mouth of Roche Bay on the ice and/or by swimming, but younger hunters interviewed indicated that this happens rarely or never in

recent years. In any case, thousands of caribou in the Canadian arctic regularly cross large bodies of water over ice or by swimming. However, they cannot cross from ice through water onto more ice, and it appears that most or all of them know that. (Breaking of thin sea ice, probably near open water, is believed to have caused the deaths of many caribou that migrated between Baffin and Bylot Islands; and thousands of caribou on Baffin Island wait until the Koukdjuak River is relatively clear of ice before crossing it in the early summer.)

While it is now apparently very rare for caribou to cross near the mouth of Roche Bay, could this situation be mainly due to two factors; the frequent presence of hunters and canoe traffic in this area, and the often unsuitable ice conditions here? As indicated in the report on sea mammals, the condition of sea ice in Roche Bay may be quite variable from year to year, making the mouth of the bay unsuitable for crossing through early winter of some years. Also, caribou are probably aware that crossing the mouth of Roche Bay is not a necessity, because they can see the higher land around the west side of Roche Bay.

Generally, for the longest extended shipping season being considered, traffic would keep water channels open through sea ice for possibly two months, and such an extended shipping season is not yet certain. If this does occur, evidence indicates that the resulting open water channels will not be significant barriers interfering with any significant amount of caribou movements in or through the Roche Bay area.

Sensory Stimuli:

1. Odours: Caribou, like most animals, apparently can remember specific odours and their associations quite well. In terms of the odour or scent of known dangers or enemies, "Scent seems to be the most discerning sense which can release flight behaviour. A strong scent received prior to visual contact commonly will cause immediate flight" (Bergerud, 1971, p. 579). However, caribou appear to react with inquiry and alertness when encountering a strange new odour. We have observed caribou near DEW line stations in the presence of significant smells from diesel and turbine engines, burning garbage, etc., showing no apparent reaction to these smells, and probably conditioned to them. Odours from the mining operation should not disturb caribou, since they will not be associated with danger or harassment.

2. Sounds: "Noise disturbances in the absence of sight or scent usually have little impact (cf. Kelsall, 1968)" (Bergerud, 1971, p. 579). Caribou are not usually alarmed by unfamiliar noises, either steady or irregular, when these noises are not significantly louder than normal environment sound levels. By testing caribou, including pregnant females migrating toward a calving area, McCourt et al. (1974, pp. 31, 40, 53) found that caribou showed very little reaction to simulated gas compressor station noise (which is not extremely loud), even when this noise was turned on suddenly. However, very loud sudden noises like gunfire or blasting startle them, and they temporarily react in fear or alarm. Loud pulsating noises which appear suddenly,

such as the sound of a close-flying helicopter having two long rotor blades, can have the same effect.

Caribou condition to sounds as they condition to other non-irritating stimuli. "Most caribou herds have become accustomed to fixed wing aircraft flying overhead. As long as the aircraft fly at 1000 feet or more - (so the noise is reduced) - the caribou are not disturbed and do not change their direction of travel or even rise from their beds" (Banfield, 1971, p. 802). As with most other types of stimuli, caribou learn that certain sound stimuli are associated with danger. Where caribou are often hunted from snowmobiles, they are disturbed by the noise of snowmobiles and flee from it, according to hunters. For this reason, caribou may at first flee from the sound of road vehicles travelling near the mine site. However, personnel working on seismic testing on Bathurst and Melville Islands informed us that caribou in test locations quickly learned to differentiate between the sight and sound of snowmobiles, and that of large all-terrain vehicles; and soon adapted to the latter, which they did not associate with danger.

Generally, a strange new sound unaccompanied by other sensory stimuli, initiates alert-investigative behaviour, but not alarm, unless it is very loud. Our observations near DEW line stations indicate that the sounds which will probably be produced at the mine-site will not disturb caribou unless they sound like gunfire (i.e. blasting) or snowmobile engines (which caribou associate with danger) and that any caribou in the area will soon adapt to them. Blasting will occur at the minesite and should not be done on the few occasions when caribou are known to be near the minesite.

3. Visual stimuli: "Caribou are adapted to perceive motion, but have difficulty detecting motionless objects" (Bergerud, 1971, p. 578). Like most mammals, they see different colours only as different shades of grey. The intentions of another animal toward them are perceived mainly from its movements. Herds of caribou sometimes tolerate the class approach of wolves, and flight is commonly not released until the intention movements of the predators are visually recognized (Bergerud, 1971, p. 579).

Our observations near DEW line stations indicate that caribou learn that people and vehicles are not a danger (at least in that location), and probably determine this by seeing that their movements are never directed toward the caribou in an aggressive way.

If the attention and especially the movements of people or machinery are not directed toward any caribou that come near the minesite, no visual stimuli from the minesite should be significantly disturbing to them, unless they visually recognize people and small fast vehicles as being dangerous because of hunting elsewhere.

GENERAL RESPONSE OF CARIBOU TO HUMAN PRESENCE AND ENVIRONMENTAL ALTERATIONS

Possible negative effects on caribou ecology that might result from human intrusion into the northern environment have been a major concern of several northern projects. As a result, the effects of many aspects of northern development have been investigated in different seasons and environmental situations. Investigations of caribou adaptability to many new stimuli resulting from human industrial intrusions, and adaptability to other possibly disturbing phenomena, have been discussed in many studies (Banfield, 1971; Bergerud, 1971; Child, 1971; Miller and Gunn, 1979; McCourt et al. 1974; Geist, 1970; etc.). All workers conclude that caribou are very adaptable, and that they can and do accept or adapt to the presence of men and all types of vehicles, machines, and activities in their environment, as long as these things are not directly associated with something that harms or harasses them. "Phylogenetically, there appears little aversion to man - caribou can live near man if we permit it" (Bergerud, 1971, p. 580). Obvious examples of this are the reindeer (caribou) of Eurasia, domesticated hundreds of years ago when man found that if he didn't present himself as an obvious danger to them, they would tolerate his close presence and he could train some of them to pull his sleds, and to carry him or his belongings on their backs. In North America also, when we permit it, "Caribou can live close to civilization. The Avalon herd in Newfoundland uses ranges within a mile of a well-travelled highway. The Humber herd winters on ranges where cars and trains are heard daily" (Bergerud, 1971, p. 580). Many caribou are found near some DEW line stations where there has been no hunting for several years, confidently moving around, grazing, etc. within twenty metres of people, moving vehicles, large machines in operation, etc.

The following examples, with commentary, will illustrate how caribou can, and possibly will react or adapt to the minesite.

One of the main factors of the mining or construction process will be the presence of many people moving around in a small area, as in most arctic settlements. Caribou will probably tend to avoid in the beginning the minesite as they avoid most settlements, because the people at most settlements hunt them whenever possible. However, if they are not hunted or harassed at or near the minesite, they may learn that people at that location are no danger to them, and become quite "tame" as caribou do near some DEW line stations.

However, the negative factor concerning caribou adapting to humans near Roche Bay is the fact that Roche Bay is one of the main bases or starting points for caribou hunts in that area. Caribou appearing near Roche Bay are frequently hunted, and caribou have probably learned that people near Roche Bay are dangerous. If hunting continues, as it probably will, the caribou perception of humans as dangerous will be maintained, and most caribou will avoid the site.

Caribou reaction to motor vehicles around the minesite initially may be one of fear, because most vehicles seen in that area now are those used by hunters. However, caribou on Bathurst Island quickly learned to distinguish between snowmobiles and the larger, but "non-dangerous" Nodwell tracked vehicles, which never harassed them, according to Pan-arctic seismic personnel. Thus caribou near Roche Bay may learn to distinguish between hunters' snowmobiles, and the larger mine vehicles operating mainly on roadways.

Roads, pipelines, powerlines, buildings, stationary machinery (including rock crushers), and objects like tents and large windsocks which flap in the breeze, will not disturb caribou, or will be quickly adapted to, as indicated by the situation we observed near two DEW line stations.

The main criterion or basis for every relationship between man and any species of wildlife is the way man behaves toward it, whether he harasses or hunts that species, is oblivious to it, or actively helps it. Because caribou have been and will be hunted through much of that area, they will perceive some manifestations of man as being signs of danger, wherever they encounter them.

However if hunting is ceased, the probable result is illustrated by many caribou which calve and summer near Longstaff Bluff, a radar station on western Baffin Island where hunting is no longer allowed. Even though the caribou summering there pass through and/or winter in areas where they are hunted by humans every year, they quickly learn that they are not in danger at this location, and quickly condition to the humans, vehicles etc., at this site. In 1980, several caribou (including cows and calves, yearlings and bulls) were frequently seen travelling or grazing within 100 yards of a gravel crusher in operation. We observed cases such as a large diesel dump truck stopping within 20 yards of a bull caribou which had conditioned to such trucks driving between the gravel crusher and the airstrip, and showed no fear of them except to move if they got closer than about 10 feet (3 m). This caribou did not cease grazing until the driver gave a blast on the air horn. The caribou then lifted its head for a few seconds, looked at the truck and resumed grazing. The truck drove off and the caribou did not react visibly, but continued grazing.

Also at this site, when we were hand pumping fuel from a drum into an aircraft, about 200 yards (metres) from where any aircraft had taxied in over a year, a caribou walked up to within 15 yards (metres) of us, stopped to watch us for more than a minute, then continued walking past in its original direction.

Caribou near this site (including cows with calves) did not show any reaction to the noise of large aircraft taking off or the noise produced by trucks or gravel crushers.

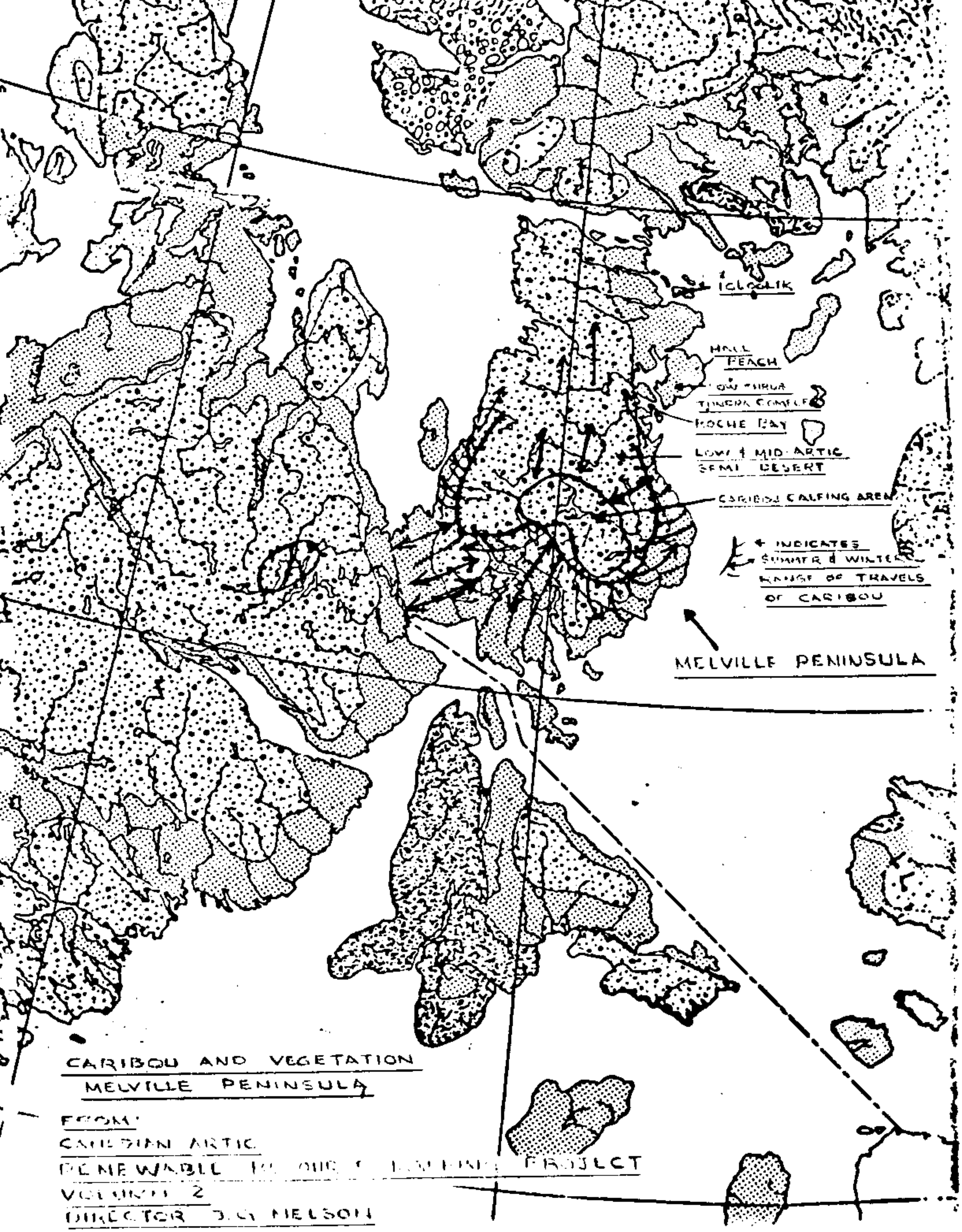
Another example of the adaptability of caribou to unnatural noise (and to aircraft movement) was the existence of a caribou calving area east of the Central Baffin DEW line station. Dozens of caribou calved one to five miles (1½ to 8 km) from an airstrip where large, very noisy transport aircraft were landing and taking off up to four times per week, often climbing directly over the calving ground (with the noise being very obvious out to five miles (8 km).

Thus the caribou situation near Roche Bay will be a result of previous and future conditioning of those animals by people in that area. "We are educating wild ungulates with every contact we make... The behaviour of ungulates toward human beings is largely a consequence of our behaviour towards them; they are as 'wild' as we teach them to be" (Geist, 1970, pp. 413 and 416). (These statements apply to nearly all animal or bird life found in the Roche Bay area.)

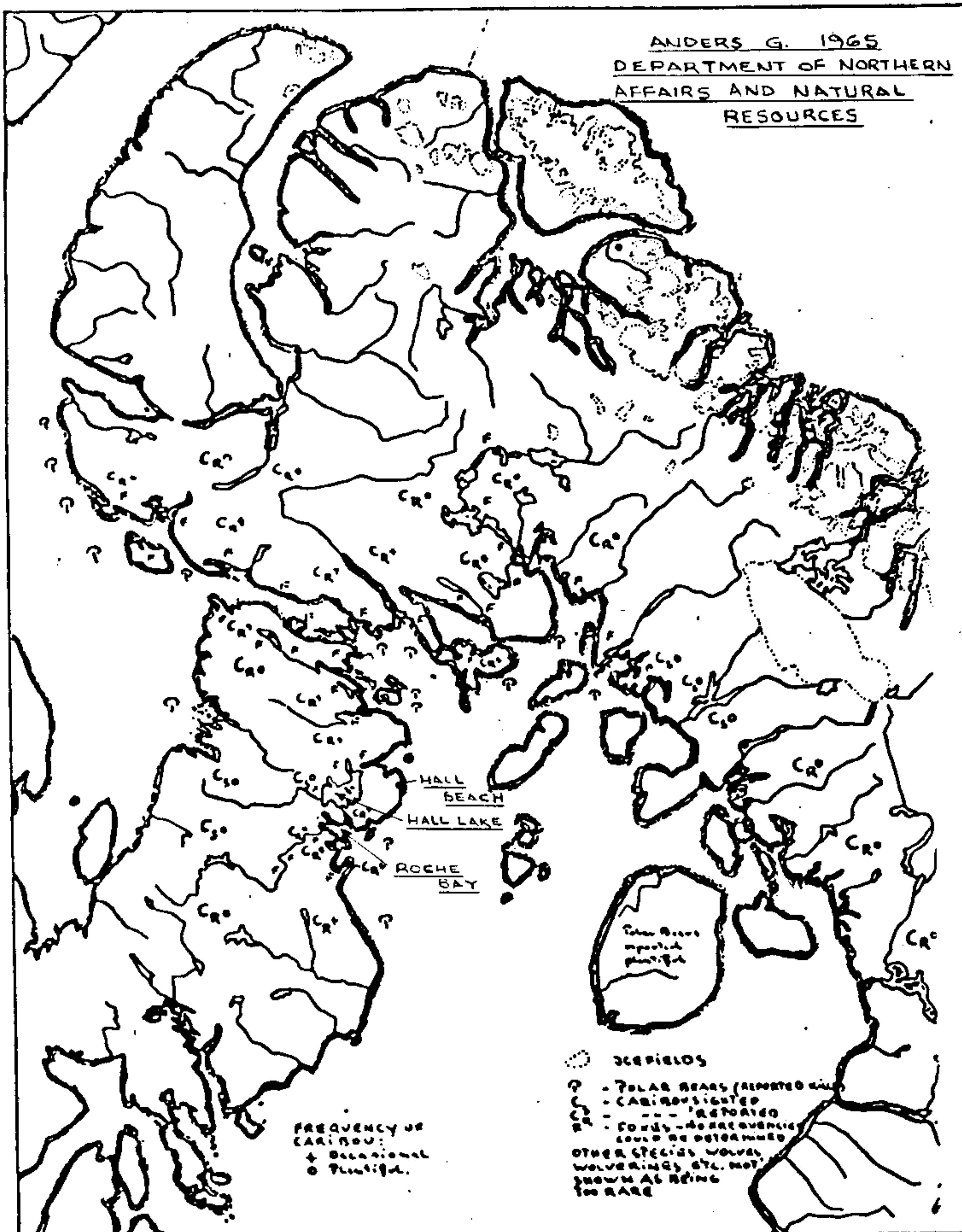
CONCLUSIONS

The effect of the mine on the caribou situation in the Roche Bay area will be insignificant, since the number of caribou occurring in the immediate vicinity of the proposed minesite is very small, and from the above evidence, it appears that the only negative effect of the mine on caribou will be the permanent establishment of human presence near Roche Bay. Since humans hunt caribou in the Roche Bay area, they may be regarded as dangerous, and the permanent presence of humans at the minesite may cause caribou to avoid that site. On the other hand, caribou may adapt to the minesite as they have to some DEW line stations; but this is not likely if frequent caribou hunting continues in that area.

Blasting at the minesite would startle or frighten caribou close to that site, and should not be done if caribou are known to be close.


IGLOOLIK
HALL BEACH
ROCHE BAY
LOW & MID ARTIC SEMI DESERT
CARIBOU CALFING AREA
INDICATES SUMMER & WINTER RANGE OF TRAVELS OF CARIBOU
MELVILLE PENINSULA
CARIBOU AND VEGETATION
MELVILLE PENINSULA
FROM:
PROJECT
VOLUME 2
DIRECTOR J.G. NELSON

(Nelson 1975)



MAP 4: LAND-MAMMAL DISTRIBUTION IN SURVEY AREA
(Including Polar Bear Occurrences)

4.5 SEA MAMMALS

Summary

The main sea mammals occurring in or near Roche Bay are the ringed seal, the bearded seal, the walrus, and the beluga whale.

Of these the ringed seal is the most numerous, the most economically important to the Inuit traditional life-style, and the only one that occurs, in any number in Roche Bay itself. The observations on the number of ringed seals in the area vary considerably, and it is reasonable to assume that part of this variation can be attributed to differing spring ice conditions in Roche Bay. Ringed seals den on land-fast ice in late winter and spring, and Inuit hunters report that considerable numbers of ringed seals den on Roche Bay in years when the ice there is optimal for them. The proposed mining operation itself should not affect these seals, but any major disturbance of this ice from April through June would have a detrimental effect on seal denning, and therefore spring shipping should be avoided.

Bearded seals, walrus, and beluga whale rarely come into the bay. The major threat to these sea mammals, assuming a limited open-water shipping season, would be from water

pollution. The proposed mining operation itself should not cause any water pollution but there is some pollution associated with any sort of shipping. This pollution should be stringently controlled.

SEA ICE AND ITS ECOLOGICAL IMPORTANCE IN THE ROCHE BAY AREA

The condition and distribution of sea ice is of primary importance as the main factor governing sea mammal distribution in the Canadian Arctic. Species such as ringed seals need good land-fast ice for basking and breeding, while other species need or greatly prefer open water (Nelson, 1975, Vol. 2).

Usually the ice in bays is more stable and remains frozen much longer than does ice along a straight open coastline. However rivers can sometimes cause later formation and earlier break-up of sea ice near their mouths, and two rivers, the Ajaqutalik and the Ikerasak or Hall River, flow into Roche Bay.

From information contained in several reports (Project Rand RM 1997 and RM 2706, 1963; Anders, 1965; Nelson, 1975 Vol. 2) and from interviews with several Inuit hunters and wildlife officers living on eastern Melville Peninsula, we conclude that ice conditions from Roche Bay north to Igloolik must be quite variable from year to year. The same conclusion was apparently reached by Project Rand RM 2706, 1963, which states (p.46) "Ice conditions in northern Foxe Basin during the summer navigation season are very variable...". From reports of Inuit hunters, the sea ice in Roche Bay must be stable and long-lasting some years, because often ringed seals den there from April to June to give birth and rear their pups; yet in some years the Roche Bay ice must break up sooner. Roche Bay is apparently on the borderline between two ice zones. "Parry Bay is the southwest termination of the area in northern Foxe Basin that generally remains the most clear of ice in the summer" (Project Rand RM 2706, 1963, p.46). Roche Bay was apparently ice-free by July 30, 1957: "Parry Bay, except for ice-free northwestern part is covered with broken ice" (ibid. p.48), indicating that the beginning of ice break-up must have been early that year, with Roche Bay ice possibly unstable in May or June.

RINGED SEALS (Phoca or Pusa Hispida)
(Inuktitut: Netchuk or Natchek)

The ringed seal is the most common sea mammal in Roche Bay, and the most important sea mammal to the Inuit of that area. Seal meat is a staple of the Inuit diet, and juvenile ringed seals (known as "silver jars") are often hunted on or near Roche Bay in June for their skins, which sell for about twice as much as skins of adult seals (Mansfield, 1967, p.23).

Ringed seals must have stable sea ice with a certain amount of snow cover in late winter and spring, to construct "pupping lairs". Only when ice is stable are pups safe from being separated from their parents before weaning (McLaren, 1958, in Nelson, 1975, Vol. 2, p.50).

Generally, ringed seal pups are born in April in a den or lair (nunarjak) hollowed out of snow over a breathing hole in stable land-fast ice (Mansfield. 1967, p.21). The pups are usually weaned before breakup of the land-fast ice.

Therefore, while ice conditions are important to all sea mammals, they are especially important to the ringed seal. "Where local wind conditions and river outflow clear ice from bays and fiords before the departure of the heavy offshore ice, (ringed) seals may be correspondingly scarce" (McLaren, 1958, in Nelson 1975, Vol. 2, p.48) because of their dependence on stable land-fast ice. But where land-fast ice is retained long after off-shore ice has broken up, ringed seal populations are large. Where much land-fast ice forms and where ringed seal populations are often plentiful is where the coastline is complex, with bays, islands, etc. (Nelson, 1975, Vol. 2, p.48). Inuit make extensive use of such areas of complex coastline to hunt ringed seals (Brody, in Freeman, 1976, Vol. 1, p.162). Hence Roche Bay is important to the hunters of Hall Beach because its complex coastline makes it a good seal-hunting area relatively close to their home.

The ice conditions on Roche Bay and the abundance of ringed seal in the area vary considerably.

As an example of apparent contradictions in spoken and written evidence and the observations of different people, one wildlife officer said Roche Bay was not a good place for seals, yet another said ringed seals were all over Roche Bay, especially in winter. Anders (1965, p.40) also says ringed seals are numerous in Parry Bay. One Igloolik man said Roche Bay was his favourite seal hunting spot. Another, who spent more time hunting, said that sometimes ringed seals were not found in Roche Bay, but near it, yet other times there were very many seals in Roche Bay, with breathing holes all over the sea ice.

Thus this evidence seems to indicate a highly variable seal situation. Jones and Mackay (1978, p.88) also obtained evidence of ringed seal populations fluctuating in numbers from year to year, probably due to fluctuations of a combination of conditions such as ice, weather, food supplies, etc., plus the fact that ringed seals travel over large distances. Ringed seals could be adversely affected by shipping in the area in two ways. First if this shipping disturbed much of the Roche Bay ice before late June it would disturb their breeding. Second, since the ringed seal feeds on shrimp-like crustaceans and small fish such as polar cod (Mansfield, 1967; Nelson, 1975, Vol. 2.) and probably arctic char, any pollution of the waters which affects these food sources would have a detrimental effect on ringed seals. Therefore spring shipping should be avoided and any sources of pollution associated with shipping should be stringently controlled.

There is some possibility that the very existence of a human settlement, with the concommitant noise and movement in the area, might disturb ringed seals. Opinions on this seem to conflict, but the evidence suggests that in areas near settlements where the seal population has decreased, that decrease is usually caused by an increase in hunting. Where seals have not been over-hunted they have not disappeared in spite of noise and movement in the area. In fact they seem to be attracted by these stimuli, as will be indicated below.

For example, Anders (1965) attributes the disappearance of seals from Turton Bay (adjacent to the settlement of Igloolik), to the high intensity of hunting carried out there. However, Beaubier et al. (1970) apparently support the very different opinion of some Inuit of Igloolik, who in 1968 and 1969 were saying that the scarcity of seals near Igloolik was due to ringed seals reacting to the number of people moving around the area, the strange new sounds of snowmobiles and outboard motors, and the strange sounds and smells of the settlement nearby. There was no mention of the very high intensity of hunters listed by Anders as the principal factor. These apparently contradictory opinions can be reconciled by suggesting that while many seals were killed by hunters, many others were frightened away by the sights and sounds of snowmobiles, boats, etc., which they had learned to associate with hunting, and therefore with danger. This conclusion is based on the following evidence: The same authors (Beaubier et al.) mentioned that seals have not disappeared from the vicinity of some hunting camps in northern Foxe Basin (which would probably produce many sounds and smells similar to Igloolik), but do become uncommon in camp areas when the camps become too large (i.e. when there are too many people hunting seals, and too many seals are being killed). These authors further point out that camp size is determined by seal availability (yet the settlement of Igloolik grew much larger than the hunting camp it replaced.)

Clearly the evidence indicates that seal availability in ecologically suitable locations has a great deal to do with the number of people hunting seals, and how many seals are being killed - that is, whether or not seals are being over-hunted.

There is also evidence in the literature to the effect that ringed seals do not react negatively to strange noises provided that they do not associate them with danger. Mansfield (1967, p.20) talks about Inuit hunters attracting seals to within close shooting range by making strange noises - whistling and banging on the bottom of their boat, etc. Thus, it seems ringed seals are curious enough to investigate strange noises and are not repelled by them.

Like many other animals ringed seals will become conditioned to strange new stimuli in their environment if they do not find these new stimuli to be associated with anything harmful or consistently startling. However, if they frequently hear sounds of certain types of motors and see humans, and these sights and sounds are usually associated with danger and harassment, then they will be disturbed by them and will exhibit escape or avoidance behaviour. Probably seals, like most wildlife, will learn that certain places are safe if they are never harassed there. The specific sights and sounds associated with hunters will probably not result simply from development or operation of a mine. Rapid sea mammal adaptability is confirmed, and reasons for it illustrated, by Schusterman (in Harrison et al., 1968), from experiments which showed "that seals learn how to learn quite rapidly" when compared to most animals, especially in pattern discrimination. Thus, seals can visually distinguish between things quite efficiently on the basis of shape and size, and could therefore distinguish between known enemies and harmless or new stimuli. Seals are not repulsed by new stimuli, but often want to investigate them, as illustrated by above-mentioned Inuit methods of attracting them into closer range.

The intelligence and rapid adaptability of seals (and whales) is also illustrated by their trainability to perform complex tasks in the changing or variable situations in circuses and aquaria. Also, little difference has been found between several species of seals tested (ibid.). Therefore, in the Roche Bay area, probably the only harmful effects on ringed seals which could result from any aspect of mine development or operation, would be spring ice disturbance and water pollution. Spring ice disturbance can be avoided and water pollution greatly minimized.

WALRUS (Odobenus Rosmarus) (Inuktitut: Aivik)

The Walrus may be the next most important sea mammal to the Inuit economy of eastern Melville Peninsula. These animals usually live in ice-free shallow water close to land or ice on which they "haul out" often. They feed mainly on bottom-living animals like molluscs (shellfish), but they are known to eat ringed and bearded seal and young walrus when other food is scarce (Nelson, 1975, Vol. 2).

Walrus are quite numerous near the mouth of Parry Bay (Anders, 1965, p.39), and the wildlife officer and another hunter from Igloolik said that walrus have occasionally entered Roche Bay for feeding, but didn't stay there very long. According to Brody (in Freeman, 1976, Vol. 1, p.164), a major change in Inuit hunting pattern in Foxe Basin occurred recently. "The hunting range shifted out into Foxe Basin away from the coastal areas around Parry Bay, following changes in the animals' seasonal movements - fewer and fewer walrus were coming into the bays and along the coastal areas." Therefore the only way in which the mining operation could affect walrus would be through ship traffic in Foxe Basin. But evidence indicates that walrus will not be disturbed by ship traffic (Brooks, 1954, p. 67). Walrus will allow even known enemies such as polar bear to approach quite close, and will flee only far enough to avoid them if they come too near (Brooks, 1954); so, large ships should not seriously disturb them. In fact, they might benefit from icebreaking in some areas, since they prefer open water.

Shipping long after freeze-up might be dangerous to walrus if their preference for open water causes them to remain in narrow shipping channels and become stranded if the channel quickly freezes over. Whether and to what extent this actually occurs is not precisely known but it should not, in any case, apply to the Borealis project where shipping is not being considered beyond a very limited season.

In addition it might be noted that the conditions in this part of Foxe Basin change from year to year according to above mentioned evidence and the walrus, in the area, are probably fairly well adapted to rapidly changing ice conditions and that shipping channels maintained into early winter would be no real hazard to them.

BEARDED SEAL OR SQUARE FLIPPER (*Erignathus barbatus*)

(Inuktitut: *Udjuk* or *Ugjuk*)

Bearded seals are fairly common in northern Foxe Basin, but far less common than ringed seals (Brody in Freeman, 1976, Vol. 1, p.162). They are less numerous southward toward Roche Bay (Nelson, 1975, Vol. 2, p.56), but they do sometimes occur in Parry Bay. They are solitary and are "found most abundantly in the arctic where shallow banks are free of land-fast ice during the winter" (Mansfield, 1967, p.23). They feed mainly on bottom-living animals including molluscs (shellfish) (ibid.).

Although far less common than ringed seals, they are sometimes next in abundance and importance for Inuit hunters in this region (Jones and Mackay, 1978, p.88). Hunters interviewed said they did not occur in Roche Bay.

Because of their preference for open water near shore, bearded seals might benefit from shipping lanes being kept open somewhat past normal dates of freezing. Possible fear of ship traffic would be the only possible detrimental effect on bearded seals that would result from mine development at Roche Bay, if sources of water pollution are carefully controlled. Available evidence does not indicate that ship traffic will disturb them significantly.

HARBOUR OR RANGER SEALS (<u>Phoca Vitulina</u>)

(Inuktitut: <u>Kasigiak</u>)

Harbour seals are seen occasionally in Foxe Basin, but are very rare in the Parry Bay area (Anders, 1965, p.40). They are usually found in places where the water is kept ice-free all year.

Thus harbour seals rarely if ever enter Roche Bay, and any developments there should have no effect on their ecology.

HARP SEALS (<u>Pagophilus groenlandicus</u>)

(Inuktitut: <u>Kairulik</u>)

Harp seals occur occasionally in northwestern and southern Foxe Basin, but are very rarely found between Igloolik and Foxe Peninsula (southern Baffin Island).

Thus harp seals rarely if ever enter Roche Bay, and any developments there should have no effect on their ecology.

WHALES

Three species of whales occur regularly in Foxe Basin, although none are common there, and all are rare or occasional in the Roche Bay area, according to hunters and wildlife officers.

Beluga or White whales (<u>Delphinapterus leucas</u>) (Inuktitut: <u>Kenalogak</u>)

The beluga is the most common of the three whale species, and is hunted mainly in northern Foxe Basin, in the Igloolik-Jens Munk

Island area (Anders 1965, p.43). Beluga are found only in open water, and appear in Foxe Basin in summer, when the ice breaks up. Their main food items are bottom-living crustaceans, squid, and fish including arctic char; and beluga often concentrate for feeding in shallow estuaries of rivers and streams, where desirable food species occur. Two rivers enter Roche Bay, and an 80-year-old Inuit hunter interviewed in Igloolik, said that beluga used to enter Roche Bay for feeding occasionally, but are not known to do so now. The local wildlife officer said that beluga whales have not been known to enter Roche Bay for many years.

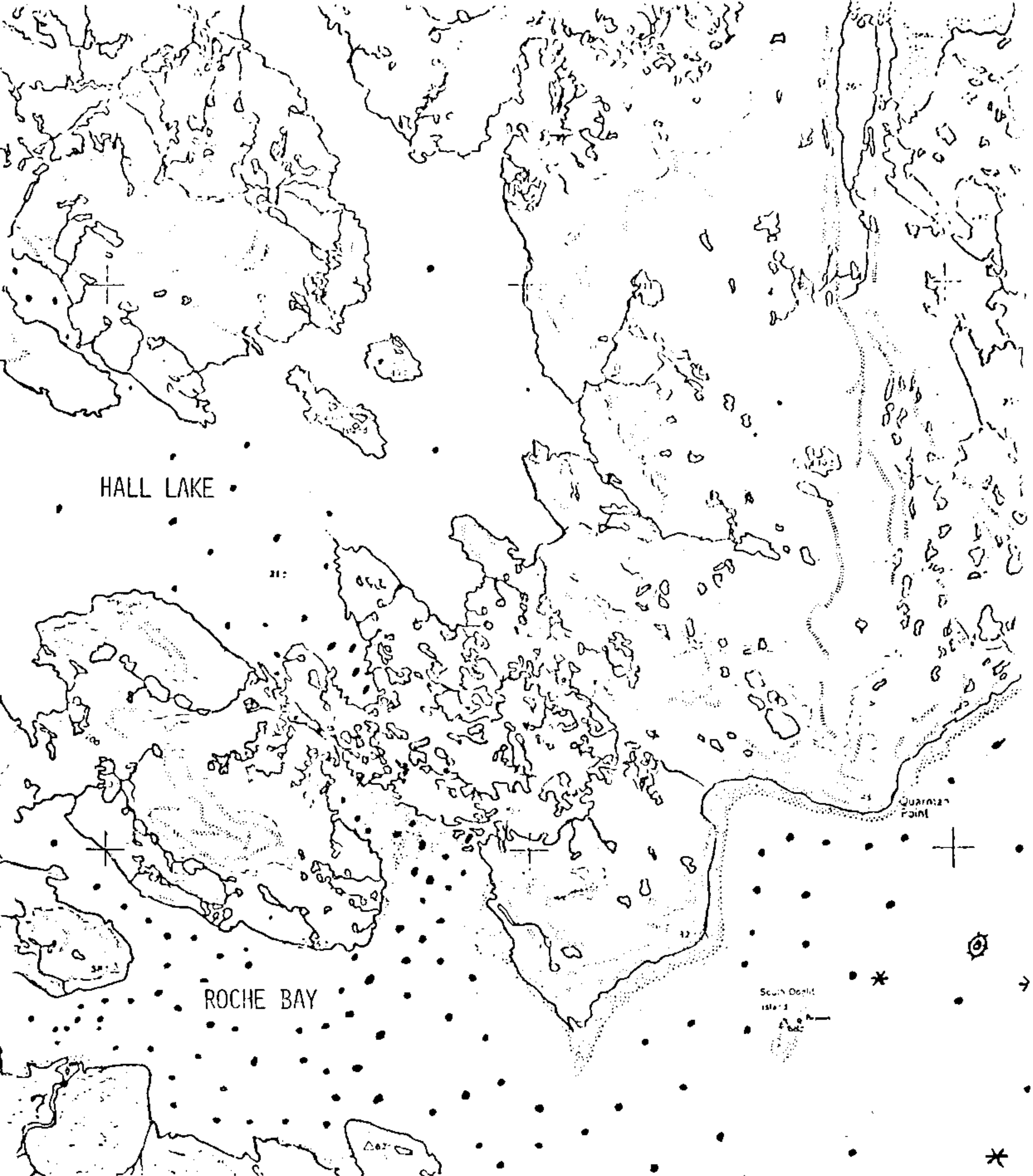
As far as we know at present, the only potential aspect of mine development in the Roche Bay area that could be detrimental to the very few Beluga whales that occasionally come into that area, would be pollution of the bay water, which might possibly result from ship traffic but is unlikely to result from the mining operation itself.

Narwhals (Monodon monoceros) (Inuktitut:)

Narwhals appear in Foxe Basin in summer but are not common there. Their food is mainly shrimp, squid, and small fish like polar cod (Anders 1965, p.42) (and possibly arctic char?). Their range theoretically includes the Parry Bay area. Apparently none were mentioned as occurring in the Hall Beach-Parry Bay area by hunters interviewed there (Brody, in Freeman, 1976, Vol. 1), but several dozen narwhal were seen near Hall Beach in the summer of 1979 (Reed et al., 1980, p.12). Narwhal have not been reported in Roche Bay; hence mining development there should not affect them.

Bowhead or Greenland Whales (*Balaena mysticetus*) (Inuktitut: *sokrark*)

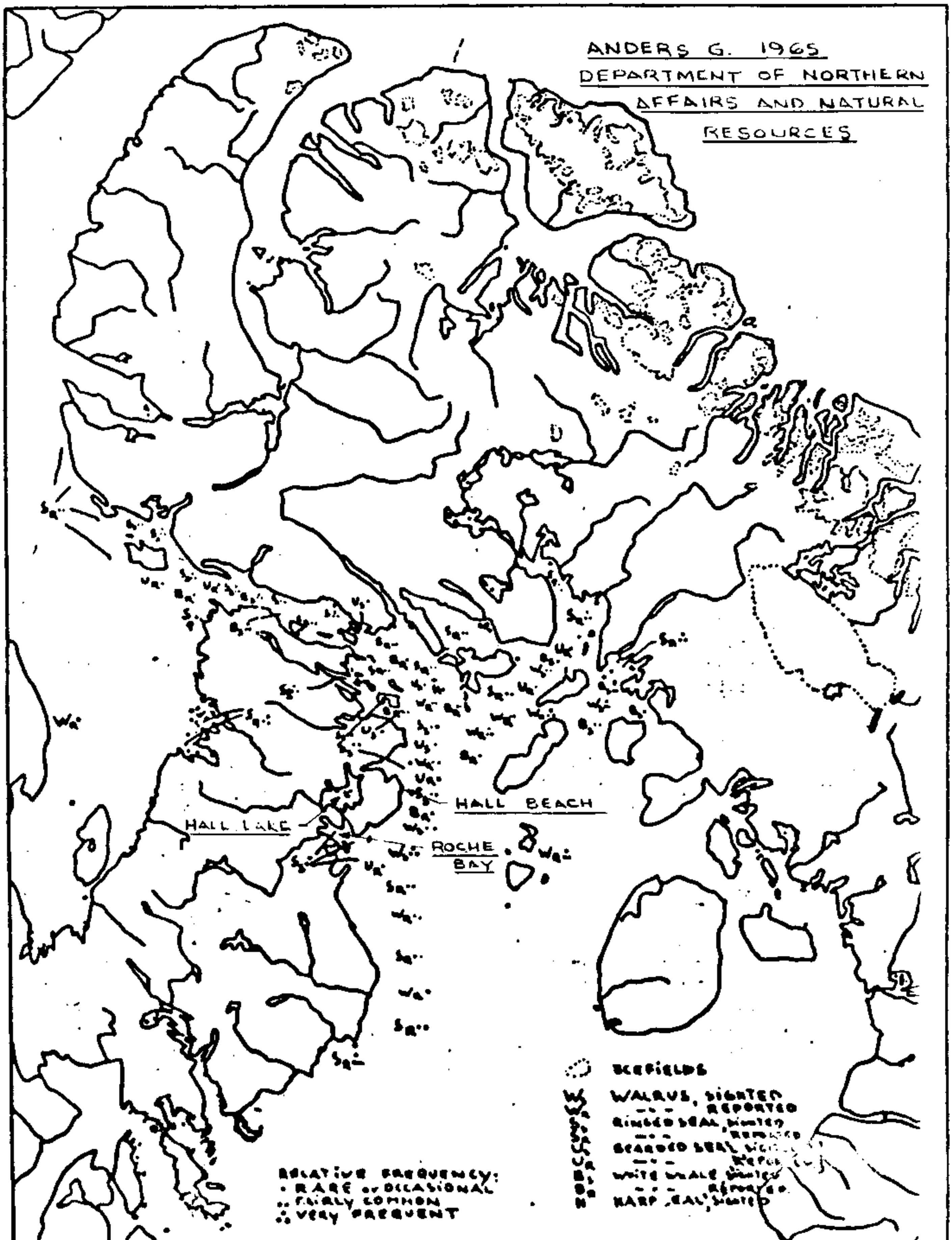
These are the only large whales occurring occasionally in the Parry Bay area. They have never been recorded near Roche Bay. Bowhead whales were quite common in Foxe Basin in the past, but were nearly exterminated by whalers during the nineteenth century. They are now rare or occasional in Foxe Basin, and have recently been placed on the endangered species list. They come into Foxe Basin in summer as the pack-ice melts, and their food there is very small planktonic crustacea known as "krill" (Nelson, 1975, Vol. 2, p.44). From sightings in northern Foxe Basin, it appears that these whales are slowly coming back into the area (Anders, 1965, p. 42). From reports, the present range of the bowhead comes no closer than 50 or more miles (80 km) from Roche Bay, and even if they do actually come closer, development of a mine near Roche Bay, with associated shipping traffic, should have no effect on them.



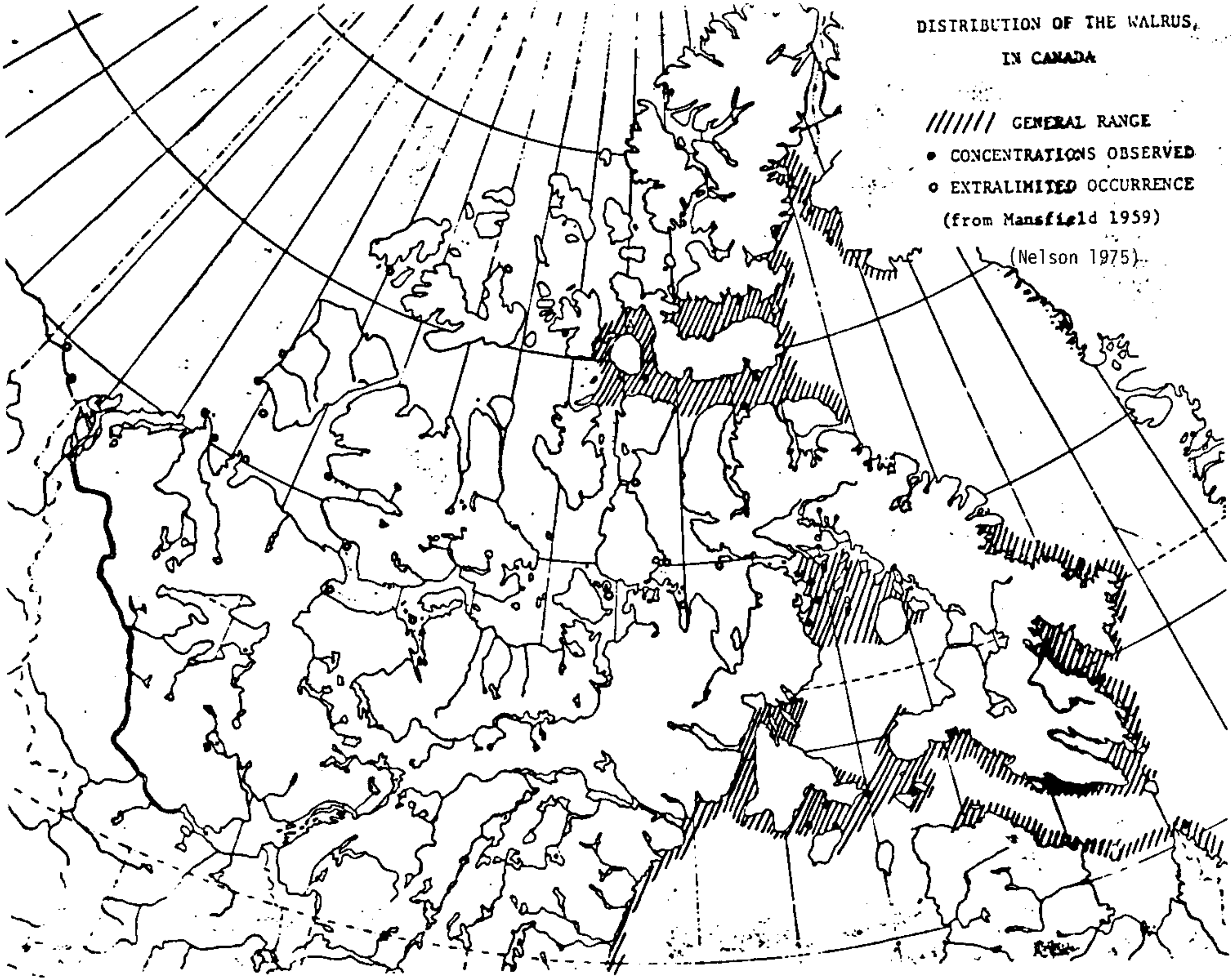
WILDLIFE DISTRIBUTION - ROCHE BAY AREA

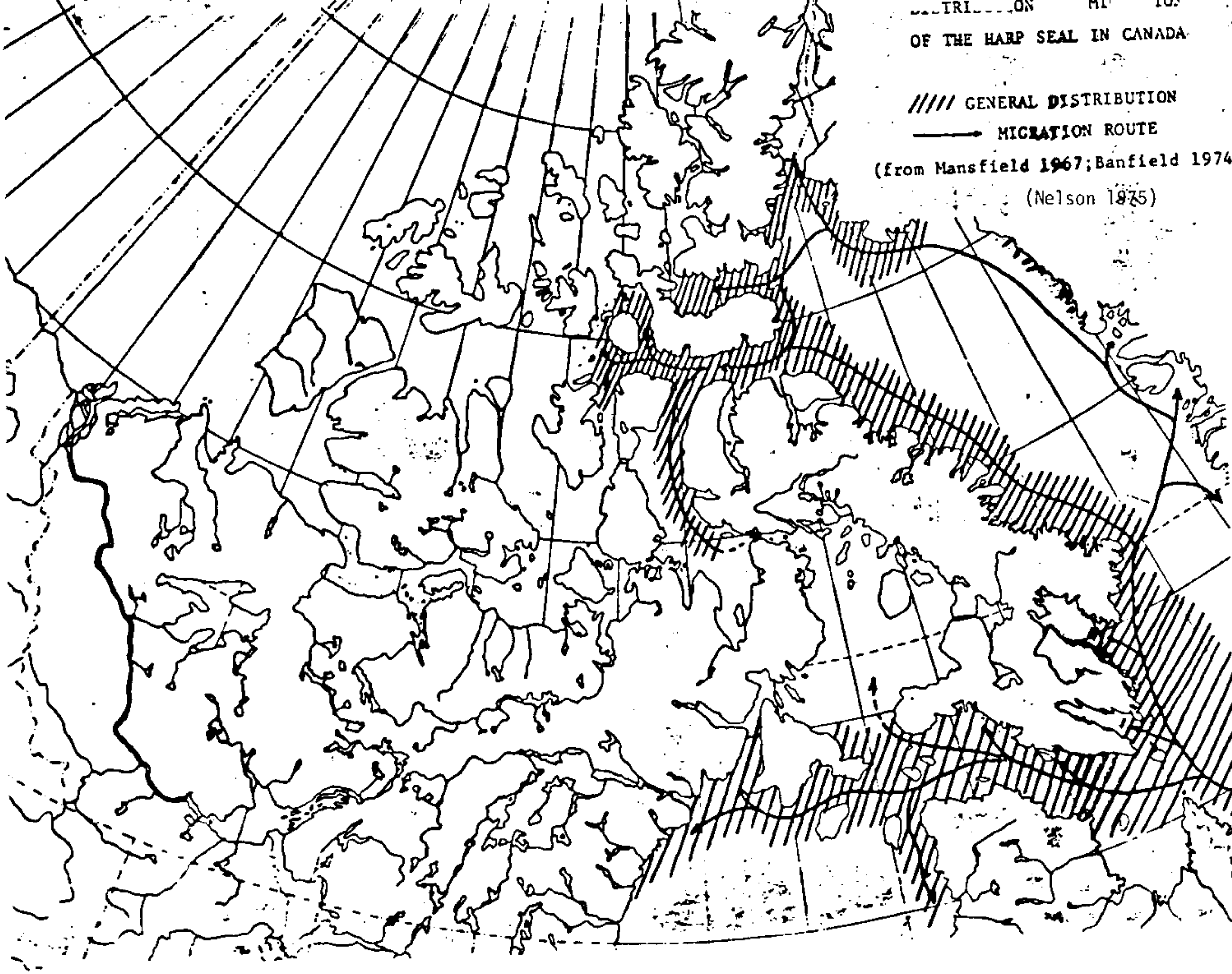
SYMBOLS INDICATE APPROXIMATE RANGE AND ABUNDANCE

- RINGED SEAL (PHOCAHISPIDA) - PROBABLE DISTRIBUTION
- BEARDED SEAL (ERIGNATHUS BARBATUS) - PROBABLE DISTRIBUTION



MAP 5: SEA-MAMMAL DISTRIBUTION IN SURVEY AREA.


DISTRIBUTION OF THE WALRUS, IN CANADA
////// GENERAL RANGE
• CONCENTRATIONS OBSERVED
o EXTRALIMITED OCCURRENCE
(from Mansfield 1959)
(Nelson 1975)



...TRI...ON ...
OF THE HARP SEAL IN CANADA

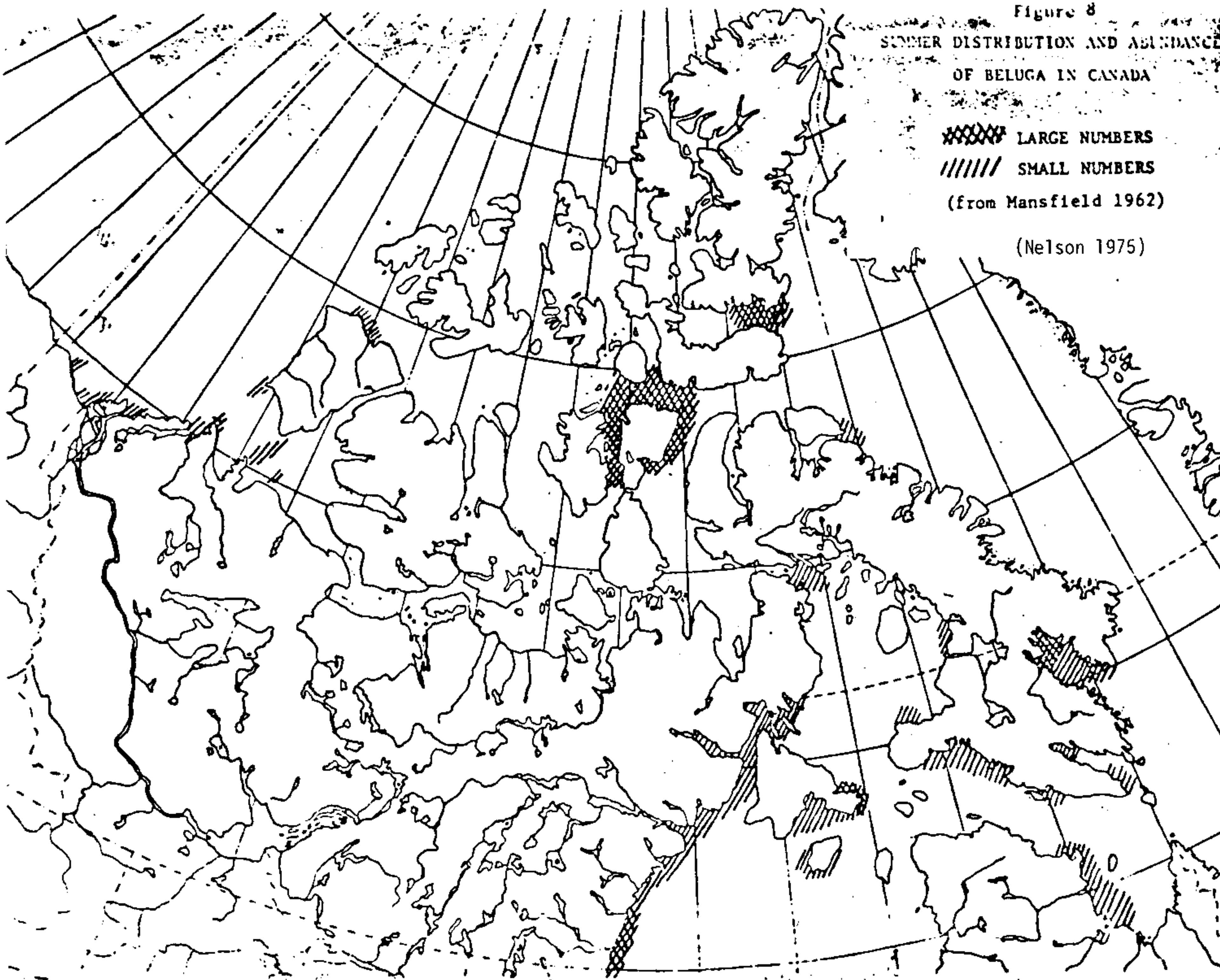


Figure 8
SUMMER DISTRIBUTION AND ABUNDANCE OF BELUGA IN CANADA

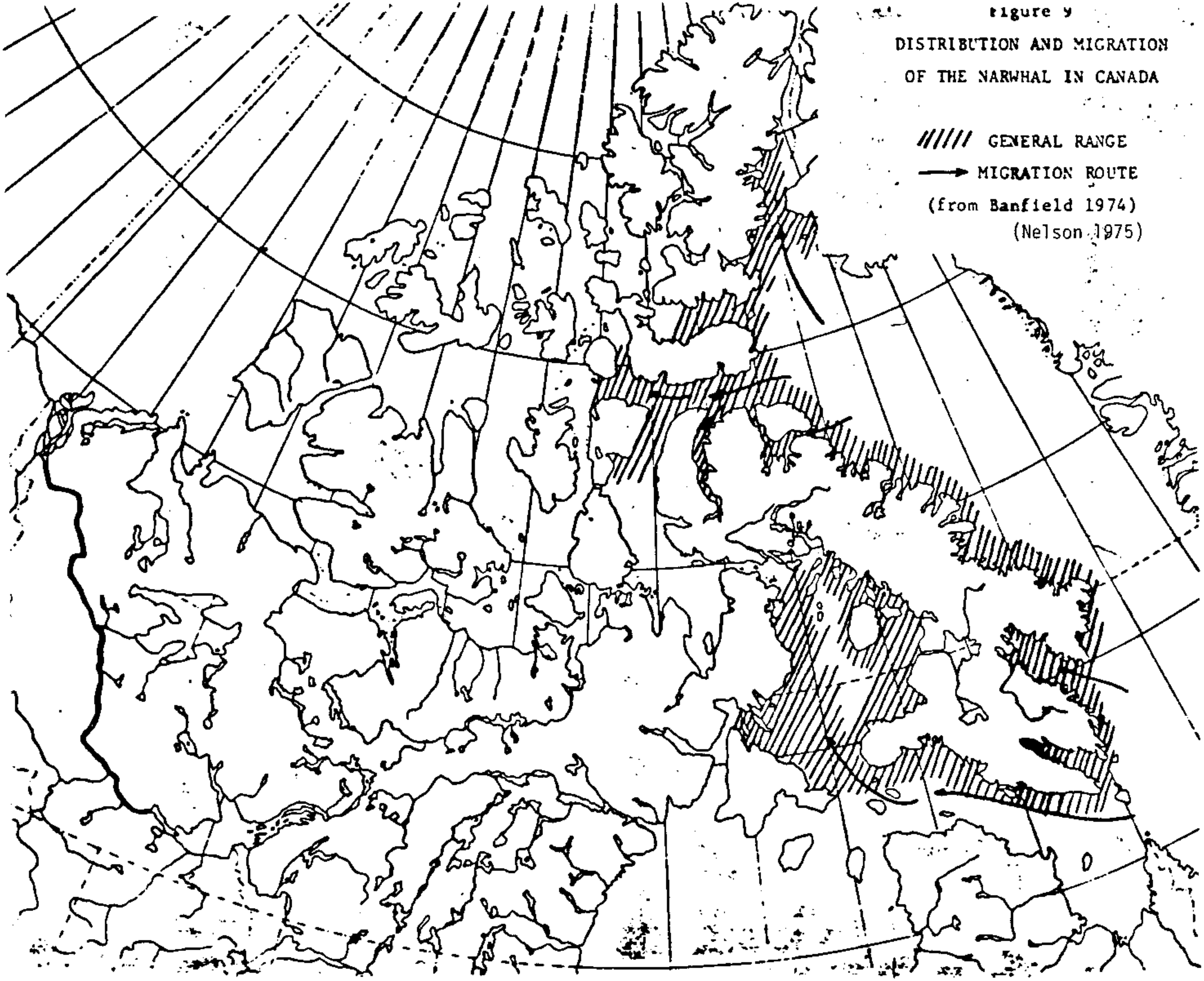


Figure 9
DISTRIBUTION AND MIGRATION OF THE NARWHAL IN CANADA

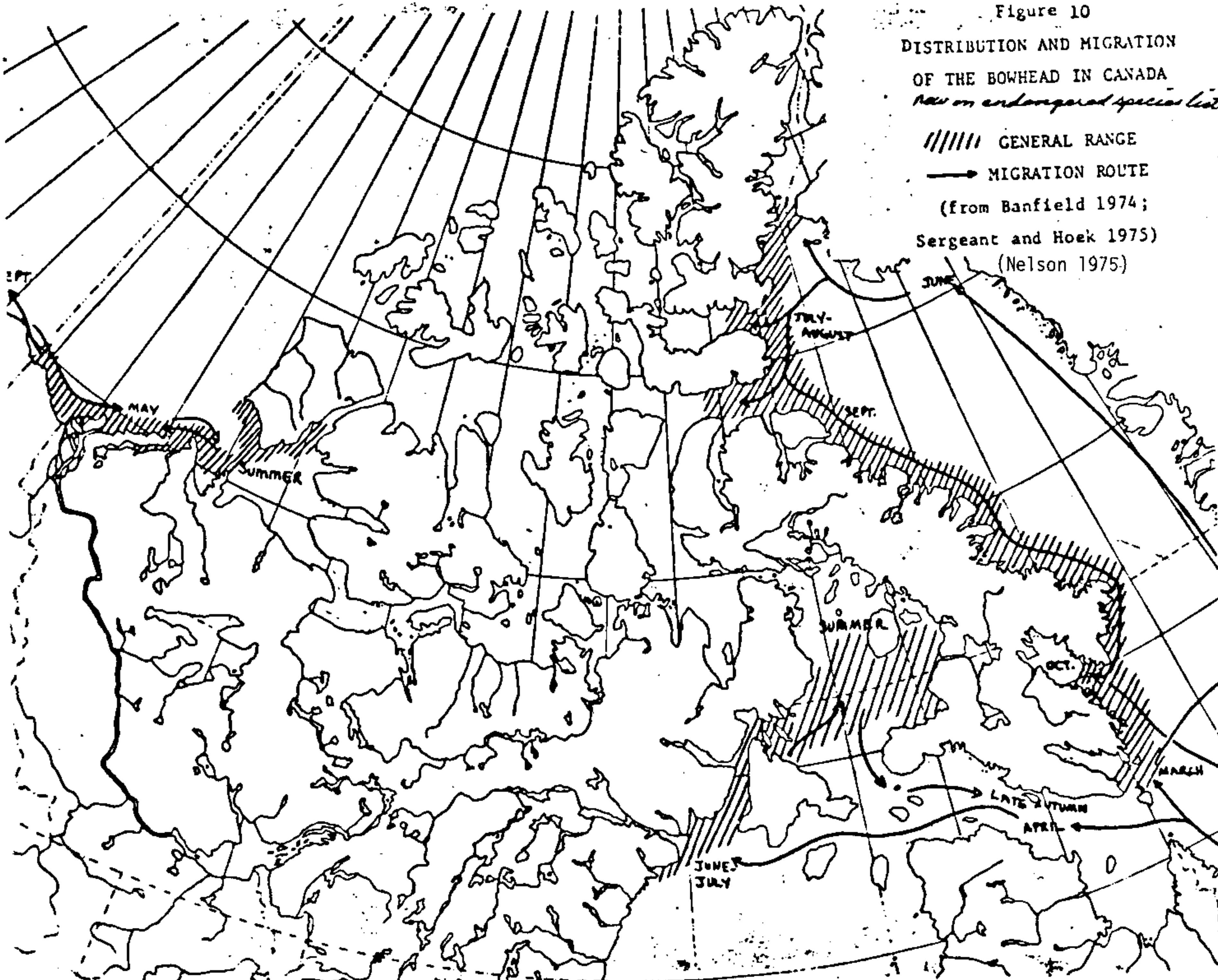


Figure 10

DISTRIBUTION AND MIGRATION OF THE BOWHEAD IN CANADA

now on endangered species list

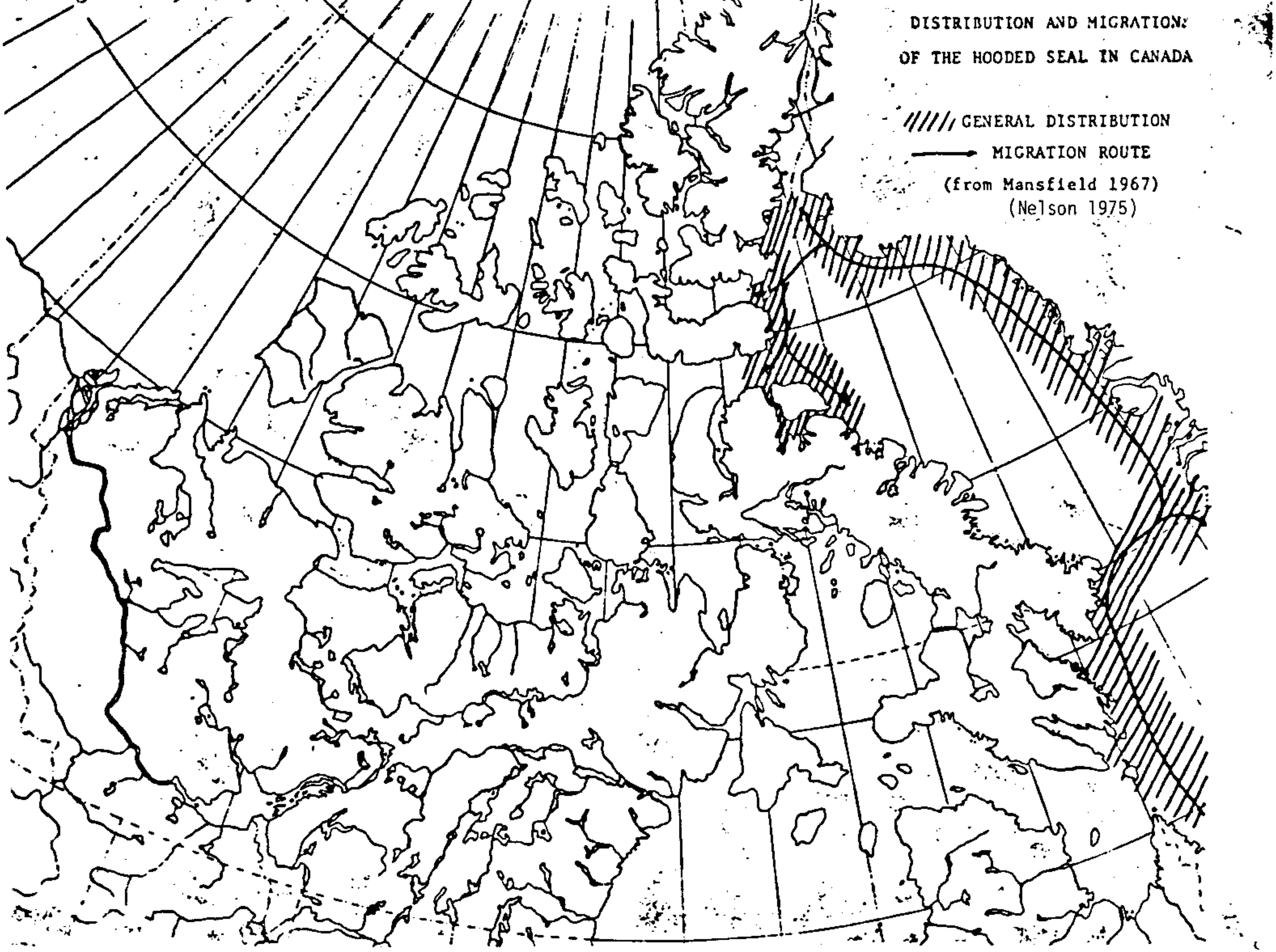
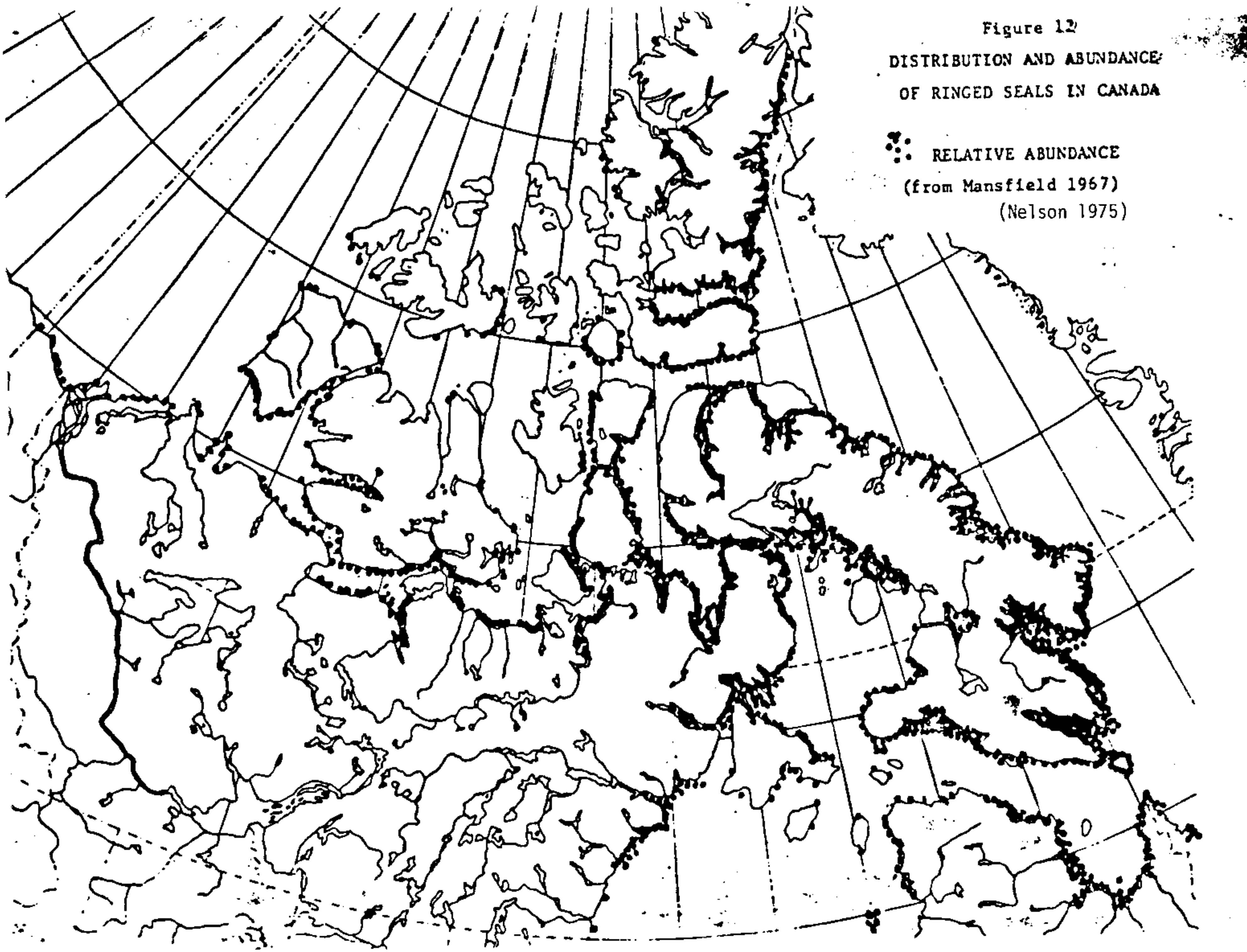

DISTRIBUTION AND MIGRATION:
OF THE HOODED SEAL IN CANADA
GENERAL DISTRIBUTION
MIGRATION ROUTE
(from Mansfield 1967)
(Nelson 1975)

Figure 12

DISTRIBUTION AND ABUNDANCE OF RINGED SEALS IN CANADA



(from Mansfield 1967)

(Nelson 1975)

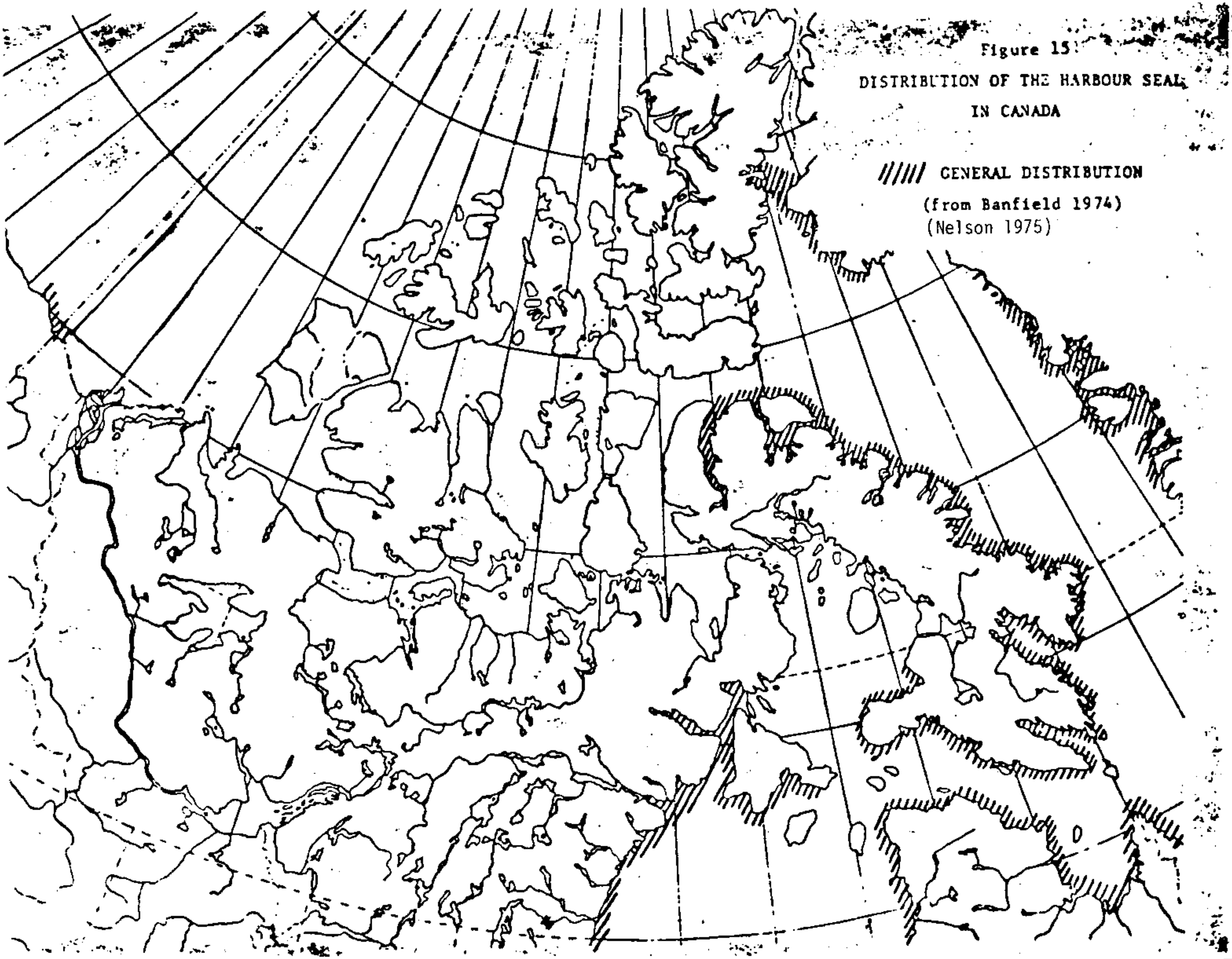


Figure 15
DISTRIBUTION OF THE HARBOUR SEAL
IN CANADA
////// GENERAL DISTRIBUTION
(from Banfield 1974)
(Nelson 1975)

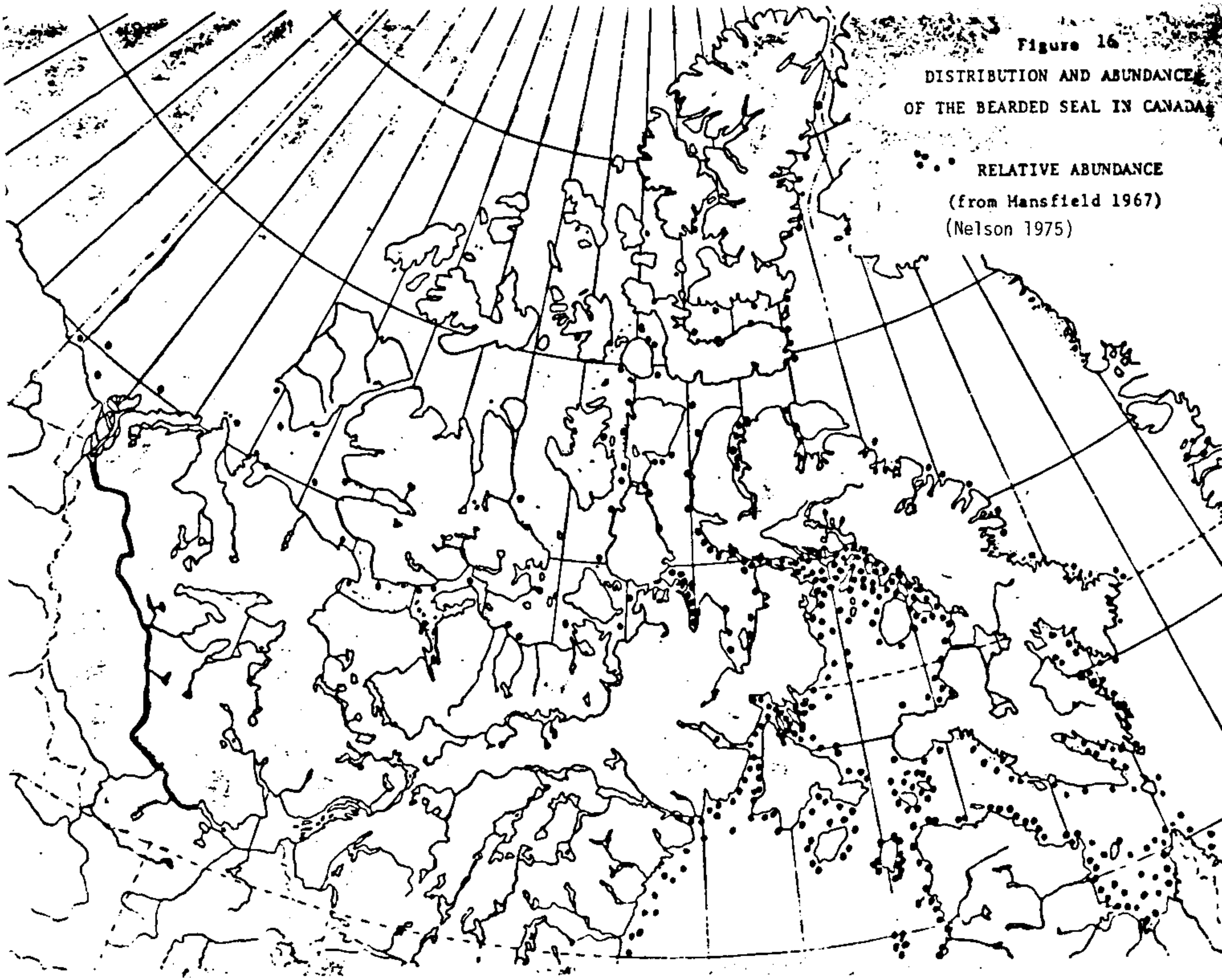


Figure 16

DISTRIBUTION AND ABUNDANCE OF THE BEARDED SEAL IN CANADA

(from Mansfield 1967)

(Nelson 1975)

CONCLUSIONS

If water pollution is prevented during development and operation of a mine near Roche Bay, and disturbance of Roche Bay is avoided between January and July, detrimental effects of mine operation here would occur only if sea mammals were disturbed by human activity on shore, or by ship, aircraft, and vehicle traffic to and from the mine site. However, all evidence presented, when fully examined, indicates that sea mammals known to occur close to the minesite are very adaptable to new stimuli or intrusions into their environment, when these are not associated with danger or harassment, because they are adept at distinguishing between threatening and non-threatening disturbances.

In summary, if water pollution is guarded against during development and operation of a mine near Roche Bay, and if the ice of Roche Bay is not disturbed before July, the sea mammals and, in particular the ringed seals, should not be detrimentally affected by the project.

ARCTIC CHAR (*Salvelinus alpinus*)

(Inuktituk: *Ilkaluk* or *Irkaluk*)

Summary

Arctic char are anadromous fish, which spend most of the year in fresh water, but migrate to the sea for the short arctic summer. None are known to spend the winter at sea.

They generally move from fresh water into the ocean when the ice breaks up around the mouth of their streams. This usually occurs between early June and early July. They spend the summer actively feeding.

They leave the marine environment and go back into streams to their spawning grounds between late July and early September. Peak spawning occurs in September and October in gravel in the upper regions of streams. Fry emerge from the gravel the following May, and remain in fresh water for several years before going to sea.

Char are opportunistic feeders, eating most small marine animal life, but mainly crustaceans, fish and insects.

When they go to sea during summer, they usually remain close to shore.

Most arctic char return to the stream of their origin for spawning, in spite of the great variation in the volume of flow and sediment load in some arctic streams from year to year.

Generally, char are a very adaptable fish.

Two significant streams flow into Roche Bay, the Ajaqutalik and the Ikerasak or Hall Rivers. The Hall River is very important for a large arctic char population; but the value of the Ajaqutalik River for char productivity was considered low by Anders (1965) and by hunters interviewed in this area. Char are common in Roche Bay during the summer.

Water pollution, an abnormal sediment load in the Hall River, and a dam on the Ajaqutalik River, are potentially detrimental factors that could result from mine development and operation beside Roche Bay. Present plans indicate that the first two are unlikely, but, in any event, are controllable. The third potentially detrimental factor - a dam on the Ajaqutalik River - could be harmless, or even a benefit to char, if it is constructed properly.

Thus, if constructed and managed properly, the proposed mine at Roche Bay should not be detrimental to the arctic char population in that area.

LIFE HISTORY

Most arctic char are anadromous fish (i.e. they breed in fresh water but spend some time in sea water), spending most of the year in fresh water. In fact some char spend their entire lives in fresh water (some males, and char in landlocked situations), but "no char are known to overwinter in the ocean" (Griffiths et al., 1975, p.76).

Large numbers of char move from freshwater lakes and rivers into ocean water each year, usually from early June through early July (Griffiths et al., 1975, p.77). This movement is usually coordinated with ocean ice breakup near the mouths of the rivers they are in, although "larger char may enter the sea in spring before the breakup of ice about the river mouth" (Grainger, 1952, p.355).

Char spend their summer actively feeding and growing, whether they are in fresh or salt water.

Between late July and early September arctic char leave the marine environment and move up the rivers and onto the spawning grounds (Griffiths et al., 1975, p.75 and 77).

"Spawning occurs through the fall and early winter with peak spawning occurring in September and October" (Griffiths et al., 1975, p.75). Eggs are usually laid in the upper regions of streams, in gravel.

"The fry emerge from the gravel the following May. After emergence, juvenile char remain in fresh water for a variable number of years" (ibid. p.75). Many of them go to sea several times before reaching sexual maturity, which occurs usually between 4 and 12 years of age (Grainger, 1952; Glova and McCart, 1974; Griffiths et al., 1977).

"Char grow very slowly, and reach an age of more than 24 winters" (Grainger, 1953, p.326). Many char are known to spawn approximately every second year after maturity.

FOOD HABITS

"Arctic char appear to be opportunistic feeders, using most of the available food items" (Griffiths et al., 1977, p.68). Generally, char seem to eat any small animal that moves, but their main foods are crustaceans, small fish, and insects (Grainger, 1953; Glova and McCart, 1974; Griffiths et al., 1977).

RANGE, HABITAT, AND ADAPTABILITY

Data from all studies indicate widespread coastal movements by char during the short arctic summer. Younger char generally stay close to the mouth of their spawning stream, but as they get older, they travel farther from it, and char are known to travel a coastal distance of 250 km (156 mi.; Griffiths et al., 1975, p.77). "Once in marine waters, arctic char apparently remain near shore" (ibid.).

However, arctic char have reached almost all islands or land masses in the arctic and subarctic zones; so they are not confined to shallow or coastal waters.

For spawning, arctic char normally return to the stream where they originated, but the wide distribution of char indicates that this is not always the case. Griffiths et al. (1975, p.77) showed that "while 'the degree of reproductive homing is thought to be high' (Glova and McCart, 1974), there is at least a small degree of interdrainage exchange of non-spawners between the rivers flowing into the Beaufort".

An indication of changing environment, which might influence reproductive homing, and which is often observed in the arctic, is the great variation in the amount and rate of water flow, and in the sediment load carried by some streams from year to year. Does this sometimes cause improper selection of streams for spawning, or the deliberate selection of streams other than the one of their origin? This is not known. However many char have shown that they can adapt to the great variation in some environmental conditions by returning to the stream of their origin year after year, in spite of occasional major changes in one or more of its characteristics.

For a stream to be suitable for habitation and spawning by arctic char, among other characteristics, parts of its upper regions must be accessible to them. There can be no significant waterfalls, extreme rapids, or subterranean flow through gravel or boulder fields, in the lower regions of the stream to block access to lakes or upper parts of the stream-bed. The Ajaqutalik River has rapids near its mouth and its lakes are far upstream. For these reasons, Anders (1965, p.17) felt that this river was not very suitable for char spawning.

The easier it is to reach the upper levels of a stream and lakes on the stream course, the greater the probability that that stream will be suitable for char - as in the case for Hall Lake and River. However, it should be noted that char are occasionally very abundant in streams that appear to be marginal in terms of accessibility, such as the Sylvia Grinnel River running into Frobisher Bay, Baffin Island. "The conditions at the mouth of the Sylvia Grinnell are perhaps different from most char streams in that there is the necessity for the char to ascend a waterfall to gain access to the fresh water above" (Grainger, 1953, p.355).

In general, arctic char appear to be a very adaptable species of fish, as indicated by their very wide geographic range in the northern hemisphere, their occurrence in a wide variety of habitats (some with quite stable and some with fluctuating conditions), the great variety of foods they readily eat, and their long life span.

ARCTIC CHAR ECOLOGY IN THE ROCHE BAY AREA, AND THE POSSIBLE EFFECTS OF THE PROPOSED MINING OPERATION

Two significant streams flow into Roche Bay, the Ajaqutalik River into the south arm, and Ikerasak or Hall River into the north arm. These river mouths, and probably the north and south shores of Roche Bay, are rich in arctic char for much of the summer, according to hunters interviewed. From what we learned from hunters and wildlife officers, the Ikerasak or Hall River from Hall Lake to Roche Bay is the main source of the Roche Bay char population. All evidence indicates that the Hall River/Hall Lake population is the largest in this region, and is important to many people of Hall Beach and Igloolik.

The minesite and associated facilities (except for the road from Hall Beach) will be eight miles or more from the arm of Roche Bay into which the Hall River flows. Therefore, the only foreseeable dangers to char in the vicinty of this river mouth are from pollution from the minesite or from ship traffic, and sedimentation resulting from any land disturbance associated with construction of a Hall Beach - Roche Bay road. Pollution from both sources can be controlled, and sedimentation from road construction will depend largely on what type of river crossing is built. Current plans are for a river crossing that requires relatively little surface movement, such as a float bridge. In this regard, char often adapt to very variable sediment loads in some streams, as mentioned above, and if any construction near the river was done in winter, spring, or early summer, any sediment loosened should have settled before mid summer, when char are returning to Hall Lake through this stream.

We have received conflicting information about the Ajaqutalik River as a possible char spawning stream. Hunters and wildlife officers interviewed said that char fishing was "average to good" around the mouth of this river in summer (when char from other streams are travelling along coastlines and attracted to places of stream outflow). Some people say that char do go up the Ajaqutalik River (at least a short distance), yet others say the Ajaqutalik is not a spawning stream because char cannot get past the rapids in that river (i.e. Anders, 1965, p.17). The first significant lake appears to be about 90 miles (144 km) upstream from the coast on the Ajaqutalik (although some maps indicate a large lake about 60 miles (96 km) upstream), and there are several sets of rapids between the coast and this lake, so it might be unsuitable for char. However, as mentioned, the Sylvia Grinnell River on Baffin

Island appears to be almost inaccessible to char, yet it used to be a very productive river for char spawning. Possibly the Ajaqutalik is used by spawning char only in some years, or used by variable numbers of char from year to year as its conditions change, etc. This is not presently known.

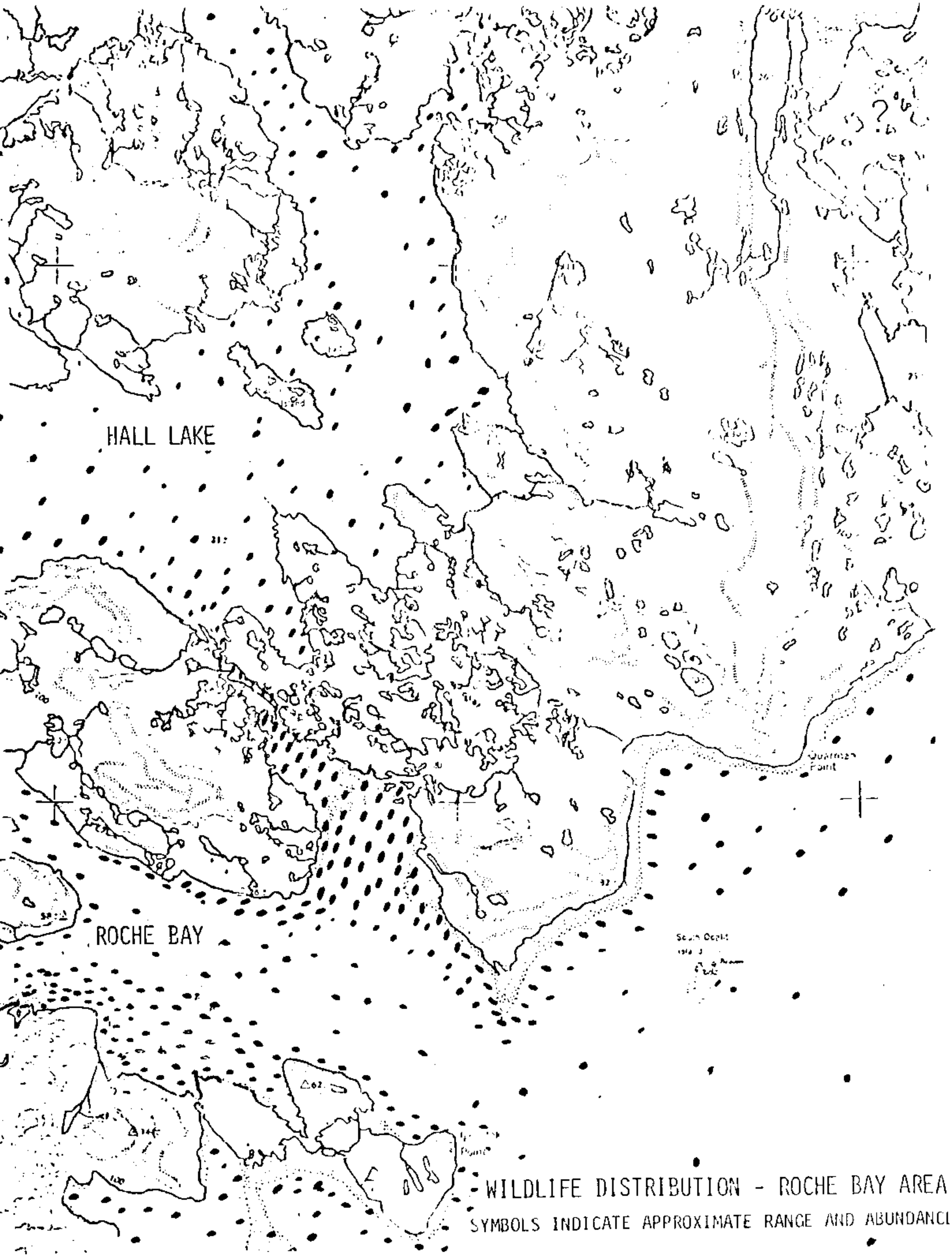
However, no matter what the char situation in that river, the only possible danger to fish near the river mouth is pollution from the mine or related shipping, both of which can be prevented.

A hydro-electric dam, proposed to power the mining operation, can influence the suitability of the Ajaqutalik River as a spawning stream for arctic char. If char do travel up the Ajaqutalik River past the rapids, the dam could be a negative influence, preventing travel beyond that point. On the other hand, with structures included to facilitate passage of fish and to prevent their entering the turbine drive channel, and the elimination of any impassable rapids between the dam and the sea, the hydro-electric power plant could be a significant benefit to char, making the river much more favourable for spawning and wintering.

Arctic char are probably common to abundant in Roche Bay for much of the summer and early fall, because of the rivers entering Roche Bay. Shore structures such as the cellular dock now being planned should be no hindrance to char as they can pass between the cells and moreover, they do reach many areas by crossing deep water, far from shorelines, and rock deposits projecting into deep water along many arctic shorelines do not appear to inhibit their summer travels.

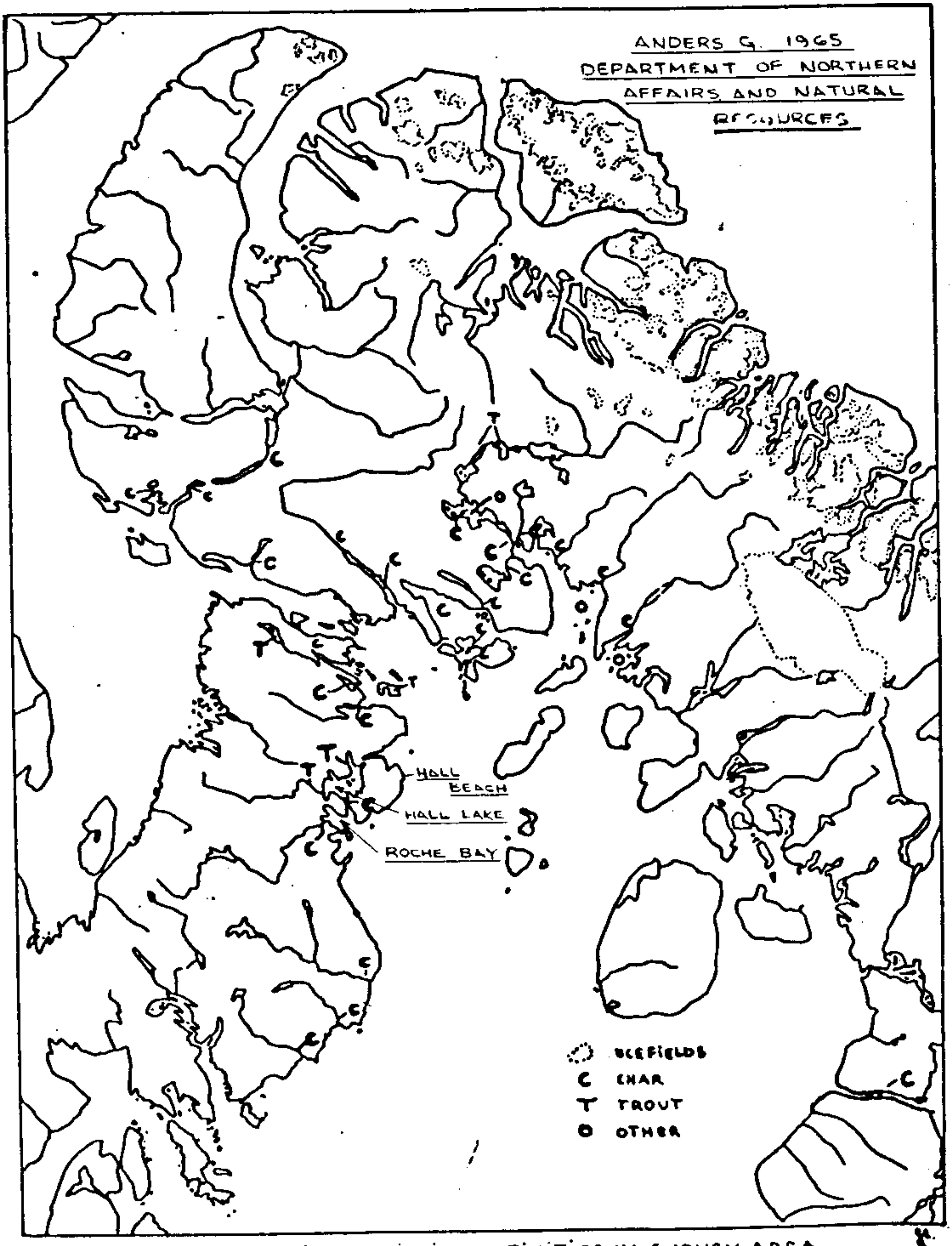
It appears that if systems for fish passage are built into the dam proposed for the Ajaqutalik River, the only possible danger from the mine near Roche Bay to char in this area is water pollution. Because this mining venture will be extremely "clean", with its main power supply being electricity from hydro-electric generators, and by-products from the ore being relatively non-reactive compounds like silica-quartzite (see 10 year leach test), there will be very small quantities of potential water pollutants produced, and pollution should be easily controlled. Ship traffic can be another source of pollution, through improper fuel handling, dumping of wastes or ballast water, etc. Again, such pollution is something that can be controlled.

In summary it appears that the proposed mining operation at Roche Bay, if managed properly, will pose no significant threat to arctic char.



WILDLIFE DISTRIBUTION - ROCHE BAY AREA

SYMBOLS INDICATE APPROXIMATE RANGE AND ABUNDANCE



MAP 6: LOCATION OF FISHING ACTIVITIES IN SURVEY AREA.

BIRDS*

Of primary concern are those species which are either rare-or-endangered or of utilitarian importance to the human communities in the area. These include, in particular, falcons and migratory waterfowl.

FALCONS

Peregrine falcons are relatively common on Melville Peninsula and there are some gyrfalcons as well. The major nesting areas are on the southwestern coast (Calef and Heard 1980) about 100 miles (160 Km) from Roche Bay. The indications are however that there are no falcons on or near Roche Bay itself. Reed, Dupuis, Fischer, Moser (1979) make no note of seeing falcon in their flight of 1979. Jake Ikeperiar, the Inuit Game Officer from Igloolik has said he has seen peregrine falcons as close to Roche Bay as Cape Jermain which is about 68 miles (108 Km) from the proposed project site. A flight by the Elliots on August 7, 1980 revealed no falcons nesting near the proposed mine site, or any sign of unoccupied falcon nests in this area. Of course to be absolutely certain of the absence of any falcons or falcon nesting places in Roche Bay, the Elliots recommend a more detailed survey in July 1981.

---

*This material is attributed to the Elliots

WATERFOWL

There isn't a great deal of information on the waterfowl in the Roche Bay and Hall Lake regions. To a great extent, the information specific to these areas, in the following discussion, must be based on only three sources: (1) two brief surveys by Reed et al in July 1979 and August 1980, (2) our own (Elliots) flight over the area in August 1980, and (3) reports from the hunters and wildlife officers in Igloolik.

Attached are two maps: One of the Elliots' observations superimposed on the Reed et al (1979) observations and a second of the Elliots' observations alone.

In addition, there are reports from R. Allen, the N.W.T. Wildlife Officer from Igloolik, of hundreds of geese and eider ducks which, have for many years, stopped in the Roche Bay area for a short period in the early spring while on their northward migration. Clearly, some springs many geese stop for a few days in the Roche Bay area. During any given spring the likelihood of geese stopping-over in the area will depend, to some extent, on the presence of open water. There are many such spring stopover points and it is probably the case that no particular place is of vital importance.

Mr. Allen and the hunters from Igloolik report that Roche Bay area is not used as a staging area by waterfowl in the fall.

The situation is more complex and more critical during breeding periods. The Reed et al flights provide some observations on the breeding sites in the Roche Bay area.

Reed et al have mapped likely areas of geese nesting and they have sited nesting geese on the South shore of Roche Bay and north of Roche Bay near and around Hall Lake. They have, as well, shaded in some area of the peninsula on which Borealis plans to mill and ship as a possible goose nesting place but it should be noted that no geese were actually sited on that peninsula. In our opinion, this is the case, at least in part, because geese, all things being equal, will choose the lusher terrain to the south and to the north. The area to the north around Hall Lake seemed in both the Reed et al and our own observations to be a nesting area for many ducks, snow geese, and whistling swans. In that area we sighted 60 pairs of greater snow geese with young and 4 pairs of whistling swan, apparently holding territory.

It should be noted that although these waterfowl were at least 6-8 miles from the development site, they were on one of the proposed Hall Lake - Roche Bay roadways. Because of this concentration of waterfowl near Hall Lake, the road proposed to link Hall Beach and Roche Bay may disturb a few of the many pairs of geese, swan, and ducks which normally nest near Hall Lake,although this disturbance would be greatly minimized by routing the road along the raised limestone beaches rather than through the lowland meadows.

Clearly, there are some concentrations of waterfowl within a few miles of the development site; therefore the probable effects of this development on the waterfowl ecology of this area should be examined. Specifically, how will these waterfowl react to human activity, moving vehicles, and stationary structures that will be part of any program to develop a mine with associated facilities? Will human activity and developments cause abandonment of the area by waterfowl?

The reactions of several species of arctic waterfowl to various stimuli associated with different phases of human occupation and mineral extraction have been tested in several studies (by Davis and Wisely, 1974; Patterson, 1974; Ward and Sharp, 1974; and Wisely, 1974; in Arctic Gas Biological Report Series, Vol. 27 and 29). The results of these studies indicate that arctic waterfowl (including snow geese, oldsquaw ducks, and surf scoters) tend to react to such stimuli in the same way they react to the nearest equivalent "natural" stimuli, that such reactions are usually brief because direct harassment does not accompany these "disturbing" stimuli, and that all species of birds tested showed some sign of conditioning to most of the test stimuli in spite of the short time available for some of these studies.

Many other observations of waterfowl in the arctic, combined with results of the above studies, give a clearer understanding of how these waterfowl (especially the snow geese) will react to human-industrial activity in the arctic.

Patterson (1974, p.30) summed up the behavioral psychology of snow geese by saying: "Geese are traditional birds (Newton and Campbell, 1969; Prevett, 1973). They repeatedly use the same breeding grounds, wintering areas, feeding sites, and routes of migration. Their habitual use of such areas might be difficult to alter (Lieff, 1973), although geese themselves do occasionally change their habits.

The number of years geese require to change longstanding habits is, however, unknown."

Ward and Sharp (1974, p.2) briefly discussed a case of Canada geese in the arctic being subjected to extreme human disturbance (capture and banding), which is considered by some people to be worse than the disturbance geese would suffer by being near a human settlement where hunting or harassment was not allowed; yet these geese continued to use the area in spite of ten consecutive years of this harassment.

R. Kerbes, a biologist with C.W.S. specializing in the ecology and management of wild geese in the arctic, described a situation (personal communication) involving snow geese which relates quite closely to the situation that would probably exist during the development and operation of a mine with associated facilities in the Roche Bay area. In this case, lesser snow geese established a nesting colony in the early 1960's within about 6 miles (9 km) of the existing settlement of Eskimo Point. The main trail going out of Eskimo Point (used mainly by people on three-wheeled all-terrain vehicles) goes through the center of the most densely populated part of this goose colony, and some geese are shot there in the spring. Yet thousands of snow geese continue to nest there. These snow geese have conditioned or adapted to human activities and structures in the area so that they now appear undisturbed by people driving through their nesting colony on small three-wheeled vehicles, - as long as the person and vehicle keep moving. If the vehicle stops, geese on nests within about 100 m (i.e. rifle range) immediately flee. Also, these geese apparently have little fear of the nearby settlement. For example, in 1978 some snow geese walked into Eskimo Point, apparently attracted by vegetation on disturbed or fertilized soil there.

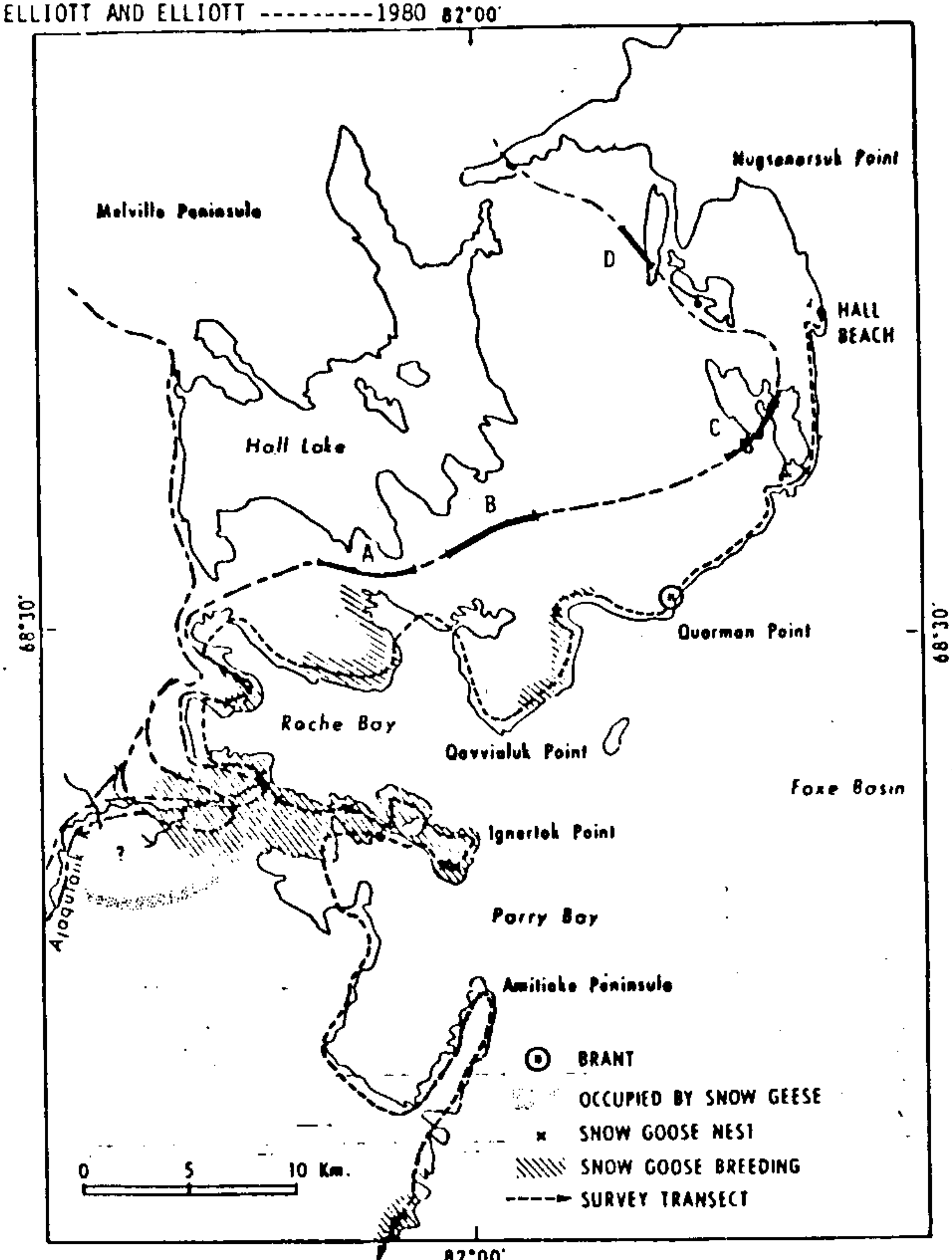
Thus the situation near Eskimo Point is one of snow geese establishing a nesting colony within 6 miles (9 km) of a presently existing human settlement, and accepting frequent human travel through the middle of their colony, even though this is sometimes associated with a small amount of hunting.

The situation at Roche Bay would be one of human intrusion in the form of a road near the edge of an existing goose colony, with a small townsite near the border of what appears to be another suitable goose breeding area (although about 4½ miles (7¼ km) from the nearest goose nest recorded by Reed et al., 1980). Hopefully no hunting would be allowed in the area.

From the Eskimo Point evidence, and the traditional-habitual nature of geese, it appears that the Borealis Exploration Roche Bay proposal would be acceptable to the geese in that area, or not significant as a disturbance factor to them, particularly since major area of bird concentrations are some distance from the development site.

REED, DUPUIS, FISCHER, MOSER ---1979

ELLIOTT AND ELLIOTT ---------1980

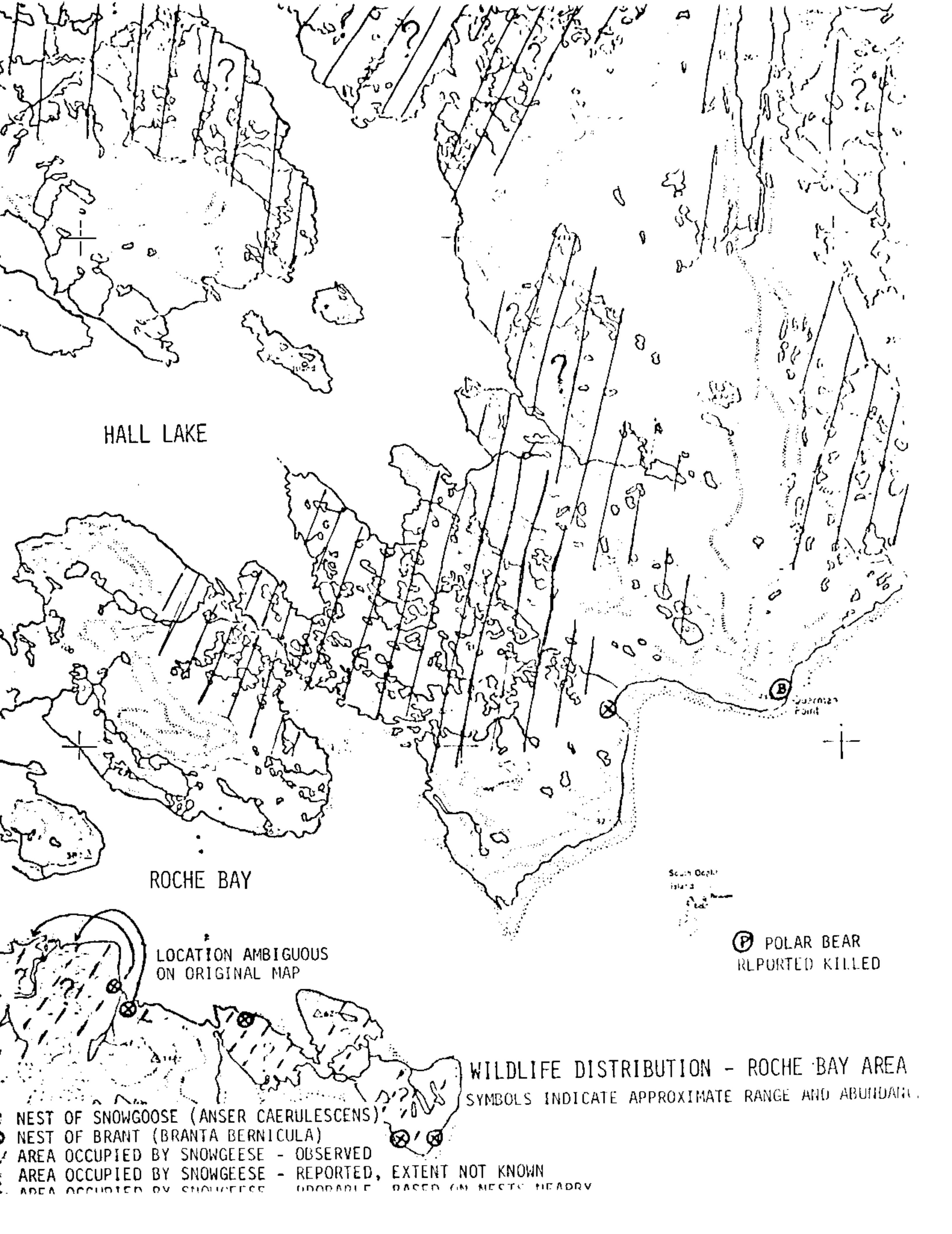


A
WEST OF RIVER:
52 white snow geese with young
5 snow geese + 5 blue geese without young
2 swans without young
EAST OF RIVER:
8 white snow geese with young
2 swans without young
MOUTH OF RIVER:
small building abandoned

B
41 white snow geese with young
2 swans no young
6 ducks

C
18 white snow geese with young
2 swans without young

D
16 white snow geese with young
ducks


HALL LAKE
ROCHE BAY
LOCATION AMBIGUOUS
ON ORIGINAL MAP
POLAR BEAR
REPORTED KILLED
WILDLIFE DISTRIBUTION - ROCHE BAY AREA
SYMBOLS INDICATE APPROXIMATE RANGE AND ABUNDAN
NEST OF SNOWGOOSE (ANSER CAERULESCENS)
NEST OF BRANT (BRANTA BERNICULA)
AREA OCCUPIED BY SNOWGEESE - OBSERVED
AREA OCCUPIED BY SNOWGEESE - REPORTED, EXTENT NOT KNOWN

PROPOSED HYDROELECTRIC GENERATOR ON THE AJAQUTALIK RIVER

Introduction

Although not an intrinsic part of the Borealis Development, current plans for the Borealis mine-site at Roche Bay include a hydroelectric dam on the Ajaqutalik River to generate electricity, which is to be the main energy source for the operation of the mine. The dam will probably be located near 68°17'N, 82°56'W, about 24 km. (15 mi) upstream from the river mouth, (the exact site to be determined after a thorough study of the area). The main environmental effects of such a dam will be the creation of a lake and the alteration of the river flow. Such changes in the arctic environment caused by damming rivers can be beneficial and/or detrimental to different aspects of the flora, fauna, and native people in the area of the dam (Turkheim, 1975).

EFFECTS ON VEGETATION

The above position for the dam was selected because the Ajaqutalik valley upstream from this site is generally quite narrow, steep-walled and barren for about 8 miles (12.8 km). It should be noted that even the valley bottom is quite barren for a long distance, in constrast to the situation downstream from this site. Thus, very little flora will be directly affected by this dam. Because the reservoir will be fairly long, it may cause a slight increase in humidity which could cause slightly more rain and snow to fall in the immediately adjacent parts of the valley, which would tend to be beneficial to plants in this area. (Although on the adjacent valley sides, vegetation is rare because of the lack of soil.)

EFFECTS ON ANIMAL LIFE

Many caribou, pass through the general area twice a year, according to hunters interviewed and Anders (1965); and a few (mostly males) can be found in this immediate area occasionally through the summer. Caribou would not be affected by the dam or reservoir, except for having to walk around it or swim across it in their travels.

Mammals such as arctic hare, arctic ground squirrels and lemmings are probably absent or rare to occasional in this part of the valley, because of the scarcity of soil and vegetation. Correspondingly, predators such as weasels and arctic fox will be rare to occasional in this part of the river valley.

Occasional wolves might follow caribou into this area, but their occurrence in this part of the valley would be very rare and brief.

Bird life should also be quite scarce in this part of the Ajaqutalik valley. The sparse vegetation indicates very little food or cover available for some species, and because few small birds or mammals would occur here, there would be very little food for predatory species. Two low flights through this part of the valley have revealed no bird life (although small birds and ptarmigan are usually not observed from aircraft).

As discussed in the section on arctic char, the Ajaqutalik River is apparently not used by char to a significant degree, probably because of the distance from the river mouth to the first large lake (about 144 km, 90 mi, following the river), and the many sets of rapids between the river mouth and this lake. Damming this river to create a long reservoir could be very beneficial to arctic char, if facilities are included with this structure to allow fish to get past the dam, and prevent fish from being sucked into the turbine drive race; and if any difficult rapids below the dam are opened for better fish passage. Fish may also benefit if the flow rate of this river is kept closer to its annual average, and the dam may reduce the flow variation between seasonal extremes. Aside from the direct fishery improvement that will result from the proposed dam, the developments and stream improvement mentioned above might also make fish access to the large lake far further upstream much easier. Generally, the proposed hydroelectric development could be a great benefit to fish of this area.

EFFECTS ON INUIT LIFE

This proposed dam will have no direct effect on native people, as the nearest settlement is about 75 miles (120 km) away, and there are no camps in the Ajaqutalik valley. Some Inuit do travel through this valley by snowmobile in winter, and if there is some short easy route past the dam, it will be an insignificant delay in their travels. One or more of the shelters built during construction of this facility could be left in a convenient location to serve as a shelter and supply cache for travellers.

The dam and reservoir should have little or no effect on birds or mammals important to the Inuit economy, but may greatly improve the fishery situation, making char available in the reservoir, and in the large lake much farther upstream, and increasing the number of char in Roche Bay, where some Inuit come to fish.

Another possible indirect effect on the Inuit of Hall Beach would be to supply some electricity to that settlement to reduce the need for continuous diesel generator operation. This would depend on the capacity of generators at the dam relative to the needs of the mining operation. Powerlines from the minesite to Hall Beach would also have to be built.

In summary, the proposed hydroelectric development on the Ajaqutalik River should not be detrimental to any aspect of Inuit life, but could be of benefit in several ways.

RECOMMENDATIONS FOR DAM CONSTRUCTION

A hydroelectric dam on an arctic river could cause several environmental and operational problems if it is built without the proper facilities and equipment. These facilities include one or more seaway-type gates at the top of the dam to let out the ice and flood water in spring and early summer (wide upper flood gates). In addition, dams on most arctic rivers should have two turbine spillway gates, one above the other. The reason for two gates is that a dam with a high spillway gate, alone, will be a trap for nutrients carried by the river, but as the trapped water warms from solar radiation, the warm water will rise and flow out maintaining the remaining water at a very cold or near freezing temperature, which is detrimental to plant and fish productivity. A dam with a very low spillway gate, on the other hand, will hold the upper warmer levels of water, maintaining the heat of the reservoir, but will not retain nutrients because of the steady flow at lower levels. A low spillway gate, alone, will also achieve a very low productivity level compared to its potential.

A dam on an arctic river should therefore have wide upper flood gates to let through ice and flood water; a turbine spillway at about half the height of the dam, to retain much of the heat and nutrients of the reservoir and help maintain some water circulation between different temperature layers; and a turbine spillway at a lower level to function at times of lowest flow rate and low reservoir level, when necessary.

The lowest spillway should still be built high enough to maintain a barely adequate reservoir depth, so that there will not be a complete washing away of nutrients and sediments in the bottom of the reservoir.

To plan a dam and reservoir for an arctic river, the seasonal flow pattern and approximate volume and rate should be determined, both for construction and for knowledge of electrical productivity potential.

A dam and reservoir on the Ajaqutalik River should have very little or no effect on the water table or permafrost conditions of this area, because almost all the substrate is igneous or metamorphic bedrock and the small amount of soil in the reservoir area appears to be thin and in scattered deposits.

EFFECTS OF POWERLINE AND ROAD

For construction, maintenance, and operation, a road and powerline will have to be built from the minesite to the dam, (with a powerline running past the mine to Hall Beach if that settlement uses electric power produced by the dam).

A road built in the valley bottom, in places of minimal vegetation, between the mine and the dam should cause very little ecological disturbance, (and the disturbance probably will consist only of damage to a very small amount of vegetation). As discussed under the Hall Beach - Roche Bay road, no wildlife is inherently afraid of roads. Of the species resident in or migratory through affected parts of the Ajaqutalik valley, probably the only species that could be disturbed by vehicle traffic on this road are caribou, which migrate through this general area twice each year. Because caribou are apparently hunted quite often from snowmobiles as they pass through the area, they may be disturbed by a fast moving or noisy motor vehicle. However, if industrial motor vehicle traffic is only occasional on this road, disturbance from it should be insignificant.

Three observation flights along that section of the Ajaqutalik River valley were made on August 7, 8 and 9, 1980, and no caribou were observed in or near that part of the valley that would be affected by the dam or service road. More work and hunter interviews will be done to determine approximately how many caribou move through the area annually, how variable the number of caribou is from year to year, and the times of the year that caribou movements occur through this area. Work on the dam can then be planned so that there will not be a great deal of human activity in the valley during caribou migrations.

In order not to restrict caribou movement electric transmission cables can be placed high enough above ground to allow caribou to pass under, underground, or under a low canopy close to the ground surface. If electric transmission cables are installed between the mine site and

Hall Beach, they should probably be put underground following the raised beaches, or under a low canopy. In this way they will not obstruct either animal movement on the ground surface, or the low altitude flight of birds (mainly waterfowl), many of which pass through the Hall Lake area annually.

CONCLUSIONS

A dam for hydro-electric generation with associated facilities, as planned, should cause minimal ecological or wildlife disturbance. It may, moreover, be of some ecological advantage by providing a habitat in the area for a significant increase in fish and perhaps waterfowl. The hydroelectric project should, of course, produce sufficient electric power to reduce the need for the continuous operation at the Roche Bay site, of diesel-driven generators, with their exhaust fumes and consumption of petroleum resources. In addition the dam may produce some electric power for the settlement of Hall Beach as well.

Unless otherwise noted, the information in this section of the report is based on Turkheim, R.J., 1975, "Biophysical Impacts of Arctic Hydroelectric Developments"; and our observations and interviews of hunters and Wildlife Officers in this area in 1980.

THE HALL BEACH - ROCHE BAY ROAD

Introduction

Borealis Exploration Limited proposes to build a road to transport people and supplies between the settlement of Hall Beach and the proposed mine site at Roche Bay. This road is planned to follow the coastline, along bare gravel raised beach ridges for most of its length, which will be 95 to 105 km (60 to 65 mi.). Stream or small drainage channel crossings will be built using culverts, and a float bridge may be used over the Hall Lake - Roche Bay river channel.

ECOLOGICAL EFFECTS OF ROAD AND ASSOCIATED VEHICLE TRAFFIC

Land and Vegetation

For most of its length this road will be built on raised limestone gravel beach ridges, most of which appear bare, having little or no soil and no vegetation. Road construction here will consist mainly of leveling and compacting the raised beach surface, and should have no detrimental ecological effect. (Testing of beach ridges will be done to determine depth and nature of underlying perma-frost before final planning and construction.)

Raised beach ridges are not continuous for the total distance between Hall Beach and the mine site; so the road will have to cross some vegetated areas, mainly near the river flowing from Hall Lake to Roche Bay. Where the road has to leave the gravel ridges, the highest, dryest, least-vegetated areas will be used whenever possible, as these conditions are best for construction and maintenance of a road, as well as for environmental preservation. Almost all of the route avoids the rich grass-sedge community of this region, which is mainly near Hall Lake and supports most of the wildlife.

Surface Water

To cross seasonal drainage channels or small streams, culverts big enough to accommodate maximum flow will be installed and covered with the surrounding gravel. This should have no detrimental effect on either seasonal or permanent streams.

For crossing the river which flows from Hall Lake into Roche Bay, a floating or "pontoon" bridge is currently planned. Construction in or adjacent to the water would be mainly to form suitable entrance ramps at each end of the bridge, and to establish solid anchors for the bridge. The entry ramps will be relatively close to the original ground surface, and will probably be made using rock and cement with local gravel. The anchors for the floating bridge might be concrete pilings set vertically deep into the gravel substrate. Cables associated with this type of structure should be close to the ground so they are easily crossed by animals and do not obstruct flying birds.

The use of a bridge to cross the Hall Lake - Roche Bay river will probably be seasonal, with the bridge withdrawn in early winter as ice conditions on the river or Roche Bay are becoming suitable for vehicle crossing. The bridge could then remain withdrawn until sufficient ice had cleared from the river in spring. Ice on Roche Bay may remain safe for crossing for some time after the river opens, but this is yet to be determined. (For time periods when safe travel between Hall Beach and

Roche Bay is not possible by land or water, aircraft such as the DeHavilland Twin Otter can land on the large peninsula near the mine site and boat travel from some point on the coastline near the road, to this peninsula or adjacent solid land-fast ice may be possible.

Fish

Arctic char and other aquatic life could be affected by the road, the bridge, or their construction if they resulted in the river being seriously diverted, or dammed for a significant time period, or if large amounts of sediment were disturbed and released into the river from mid to late summer. Construction of the road and bridge as presently planned will probably result in only a small amount of sediment washing into this river. If this work is done at times other than from mid summer to late fall, any loose sediment should have washed away or settled before the next group of char return to that river from the ocean. (Also, as discussed under ARCTIC CHAR, these fish apparently tolerate or adapt to major changes in the sediment load carried by their spawning stream from year to year.)

From several examples in the North, it appears that arctic char are not disturbed by the structures such as bridges in or over the water, so a bridge over the Hall Lake - Roche Bay river should not be an impediment to them, (although possibly a simulation of a low full span floating bridge should be tested unless specific information can be obtained on the effect of such structures on char.) The behavior of their close relatives, the salmon and trout, also indicates that such structures will not significantly influence their behaviour.

On Birds

Wildlife that might be directly affected by the road and associated structures would be ducks and geese which nest on or very near the road route. In this regard, Reed et al. (1980), on a survey flight along the proposed road route in 1979, saw only two snow goose nests.

As examples of the adaptability of snow geese to roads and traffic, in 1980 we observed one pair of snow geese nesting about 30 metres from an infrequently used airstrip in northern Baffin Island, and another pair with newly hatched young feeding about 200 metres from a frequently used airstrip on western Baffin and about 100 metres from a gravel crusher in operation; with large trucks frequently moving between the crusher and the airstrip. These geese were not noticeably disturbed by the noise or movement of these large vehicles (which did not orient their activity toward the geese). Near Eskimo Point N.W.T., where one of the main motor vehicle trails goes through a snow goose nesting colony, geese nesting within 100 metres of the trail tolerate motor vehicles moving along the trail as long as they don't stop. (In 1978, many of these geese walked into that settlement in late summer.) Thus, snow geese can adapt to roads and motor vehicle traffic, as long as they don't learn to associate either one with danger.

On Caribou

The presence of the road itself will have little or no effect on any caribou that might encounter it, and the presence of moving vehicles would cause them significant disturbance only if they associate these vehicles with danger. Caribou have no fear of roads and associated structures as indicated by many test studies associated with arctic resource development, by our observations of caribou crossing and travelling along roads near DEW line stations, by their frequent use of well travelled roads in Scandinavia, and by their use of winter ranges within sight and sound of well-travelled roads in Newfoundland.

Our observations near DEW line stations indicate that where caribou are not hunted, they show little or no fear of moving vehicles travelling on roads and runways near these stations (except to remain about 20 metres away). However, where caribou are hunted from snowmobiles, they learn to associate the sight and sound of these small, fast vehicles with danger. In 1973, seismic workers on Bathurst Island noticed that while caribou were greatly disturbed by snowmobiles, they showed little fear and some curiosity toward the large tracked vehicles used in the same area (which had never been used to harass them).

Other Wildlife

This road should not affect other forms of wildlife because it will be built mainly near the coast (which is mostly bare gravel), and on the driest, most barren terrain along its route.

Sea mammals should not be affected by the road, its construction, or associated vehicle traffic. Boat and snowmobile traffic presently goes much closer to them, and these vehicles are used by hunters to harass them. They could not be easily hunted from the shoreline or road.

EFFECT OF ROAD AND TRAFFIC ON WILDLIFE DISTURBANCE, ACCESSIBILITY, AND HUNTING PRESSURE

Will the Hall Beach - Roche Bay road and associated traffic result in significant disturbance to wildlife, significantly increased wildlife accessibility, or increased hunting pressure by people in this area? We will discuss this in two parts:

Wildlife Disturbance

Observations by Reed et al. in 1979, and by Elliots in 1980; and interviews with hunters and game officers at Igloolik in 1980 indicate that wildlife is not abundant on or near the proposed road route with the possible exception of waterfowl being occasionally abundant near where the road will cross the Hall Lake - Roche Bay (Ikerasak or Hall?) river. Species of wildlife known to be abundant or important in this area are discussed above, or in previous sections of this report, with their probable reactions to any aspect of the developments proposed by Borealis Explorations Limited considered.

In general, available evidence indicates that important species of birds and mammals in this area are very adaptable, and have successfully adapted to similar developments in other locations in the Arctic.

The presence of the road itself will not disturb any species in this area as indicated by tests near arctic industrial sites, our observations near several developments in the Arctic, and the observations of others working in the North (as discussed in sections on each species).

The adaptability of the important species of this area to vehicle traffic moving along this road is discussed in previous sections on each species. Generally, the appearance of motor vehicles travelling between the mine site and Hall Beach along the road will not be a completely new stimulus to wildlife in this area, because for several years now, there has been quite a lot of motor vehicle traffic moving on or near that route. According to hunters and wildlife officers interviewed, there is much traffic between Hall Beach and Roche Bay by motorized canoe during open water season, and by snowmobile during ice season. We observed tracks of small all-terrain vehicles near the mine site and road route in 1980, and a wildlife officer from Igloolik informed us that much of the road route is occasionally driven by people from Hall Beach in four-wheel drive trucks.

With the apparent quantity and variety of traffic on or near the road route, wildlife seriously disturbed by resulting stimuli would probably have left this area by now. Wildlife still resident in this area may be conditioned to such traffic (at its present level).

Because of present day traffic on or near the proposed road route, and the adaptability of all or most wildlife species in this area, the addition of the road with associated traffic should be a relatively minor disturbance factor.

Wildlife Accessibility and Hunting Pressure

Will the Hall Beach - Roche Bay road provide faster easier access to wildlife of this area, and thus increase the hunting pressure here? In consideration of this possibility, it first must be recognized that observations by Reed et al. in 1979, and Elliots in 1980 indicated a scarcity of wildlife along the actual road route, while interviews with hunters and wildlife officers indicate occasional short-term concentrations of waterfowl in the area where the river from Hall Lake flows into Roche Bay.

Second, it must be remembered that travel and hunting along or near the road route is already frequent, usually from motorized canoes or snowmobiles, but with some use of all-terrain vehicles and four-wheel drive trucks in parts of this area. (This might be part of the reason why wildlife is quite scarce along this route.)

Thus would any wildlife be more accessible from this proposed road and associated modes of travel than from the present modes of travel through or near this area? Except for the few snow-geese that nest very near the road route, and the waterfowl that may concentrate for short time periods near the Hall Lake to Roche Bay river crossing, most wildlife in this area will not be any more accessible. If hunters are travelling with vehicles suitable only for road travel, then much wildlife in the surrounding area will, in fact, be less accessible to them than if they were travelling with boats, snowmobiles, or all-terrain vehicles during most of the year, as they are doing now. Hunters travelling the road in road vehicles would be forced to leave their vehicles and travel on foot, to pursue any wildlife which was not very close to the road. This is not easy in much of this area, which is flat and open with extensive soft marshy areas. Geese and caribou could see a hunter approaching for a great distance, and caribou cannot be pursued by people on foot. Travelling the same general route by snowmobile in winter, the hunter could leave the general travel route to pursue wildlife seen anywhere in the Hall Lake area. In summer, travel over much of the Hall Lake area is difficult or impossible with most all-terrain vehicles in use in this area, but much more area can be easily reached with them than with road vehicles.

Sea mammals would be inaccessible to road travellers, and can be successfully hunted only in the water by boat in summer, and on the ice or at the flow edge, travelling by snowmobile, dog team (or on foot) in winter.

If the road or presence of friends and relatives at the mine or Hall Beach attracts many people of this area to travel on the road frequently, then the apparently very small amount of wildlife along the road route will be exposed to more hunters. If the road and fast road vehicles are used to quickly haul boats, snowmobiles, or A.T.V.'s to points near temporary wildlife concentrations, then wildlife of this region would be subject to more hunting pressure than at present. However, it is expected that the hunters of this region will continue to use their present modes of travel for hunting in the Hall Lake - Roche Bay area, partly because this is now traditional for them, partly because present travel modes are more efficient for the purpose of hunting (as discussed above), and partly because road vehicles will be generally unavailable and/or extremely costly to use for hunting.

In any event, should the road be built and if it does increase wildlife vulnerability in some way that cannot presently be foreseen, it will be the responsibility of the local Hunters and Trappers Association and the N.W.T. Wildlife Service to regulate the use of the road for purposes related to hunting.

This road is proposed as a benefit to people in this region, as well as to serve a purpose for the mine itself. Strictly speaking, the road does not seem to be necessary to the mine itself and all the factors must be carefully weighed before a final decision is made.

4.5(a) People

There are two Inuit Hamlets - Hall Beach and Igloolik - within 100 miles of the Roche Bay development site.

Hall Beach

Hall Beach, a town of approximately 350 people is located on the East Coast of Melville Peninsula approximately 40 miles northeast of Roche Bay.

Hall Beach was named after Captain C.F. Hall, an 19th century American explorer who spent some years on Melville Peninsula.

The area around Hall Beach is rich in Thule sites and seems to have been inhabited periodically since the 13th century although no Inuit camps were reported to exist near Hall Beach in the more immediate past.

"The present-day site was established in 1953, a direct result of the building of a large DEW Line site. The selections of Hall Beach for this site was due to its latitude, the availability of adequate fresh water supplies and the wide, easily accessible beach. Since that time, the community has grown considerably because of immigration from the outcamps (by 1968 the last families had left the land)."*

There is a nursing station, school, two churches, a transient center, a co-op, and a Hudson's Bay Store in Hall Beach.

*Canada North Almanac, 1977.

The economy is based on Government and DEW Line wage employment, and traditional hunting and fishing activities.

The DEW Line station Foxe Main is located about two miles from the settlement.

There is twice weekly regularly scheduled Nordair service to Hall Beach. Community microwave television receiver.

It is important to note that Hall Beach is one of the northern communities to have voted for prohibition of alcohol.

Igloolik

Igloolik is approximately 120 miles from Roche Bay on an island off the east coast of Melville Peninsula.

"The present village of Igloolik has emerged as a predominant settlement in the region even though the site it occupies is not one which self-supporting Eskimo (sic) hunters would have chosen as the best place to exploit the local resource. The growth of Igloolik is entirely due to the establishment there of the Hudson's Bay Company post and of the Roman Catholic Mission."*

Evidence indicates that the Igloolik area has a "unique record of unbroken habitation."*

Igloolik has a nursing station, school, two churches, a transient center, and a Hudson's Bay Store. The Inuit Co-op in Igloolik is

* Canada North Almanac, 1977

** Canada North Almanac, 1977

quite developed and operates, in addition to the store, a coffee house, a contracting company, garbage and sewage collection etc.

The Government presence in Igloolik is more noticeable than in Hall Beach. There is,among other facilities, a large laboratory facility, a two-man R.C.M.P. office, a social worker, and two Wildlife officers.

Perhaps because of the laboratory facilities there seems to be a significantly more noticeable southern presence in Igloolik,than in Hall Beach.

The economy of Igloolik is based on Government and Co-op wage employment as well as on traditional hunting and fishing activities.

Both Igloolik and Hall Beach represent relatively new communities (at least in their present form) in that they, like many other hamlets in the Arctic, have been formed by the coming-together of a great number of previously migrant people into a single settlement. The recent causes of this growth in settlement size seem to be, in part, the establishment of military stations during and after WW II, (Frobisher) and, in part, the government policy of establishing social services in the North. As a rule the building of schools and nursing stations will lead to greater concentrations of people than is found in a hunting camp.

Whatever the reasons, these towns have been growing rapidly and will, probably continue to grow. In 1966 Hall Beach had a population of just fifty people. In 1980 the population was over 350. In 1977 the population of Igloolik was about 750 people but the projected population for 1990 is about twice that.

Clearly we are witnessing a period of great demographic as well as cultural change in the North. The nature of this change and its relation to the planning of the Borealis project will be treated in a separate socio-economic study now under way.

Attached is a letter addressed to the communities in the north and the Inuit organizations as well as to other informed individuals. The letter addresses planning alternatives with respect to social and cultural factors. The response to this letter, and meetings in the communities this summer will provide the data for a more complete analysis of the social and cultural impacts of the Borealis project, as well as the ways in which the positive impacts of the project can be optimized.

4.5(b) Archeological sites

Several possible archeological sites were sighted by the Elliots of the area in August 1980. Near the Hall River there were one or more Dorset or possibly pre Dorset sites. And farther up the Ajaqutalik River, above the proposed reservoir, there is a semi recent (Thule at oldest) site. The remaining stone walls seem to have been part of a camping shelter or temporary residence.

There may be other sites closer to Hall Lake and there are of course Thule sites quite near the Hamlet of Hall Lake itself.

4.6 Present Land and Resource Use and Status:

"The area of Melville Peninsula where the above development proposal is located, is situated on unpatented Crown Land. No applications or dispositions are in the immediate area. The fishing camp at Hall Lake is the only disposition outside of the Community of Hall Beach."*

At Hall Lake Northeast of the development, the Hall Beach Co-op is attempting to develop its tourist industry. Borealis is in close contact with the Co-op on this development in order to avoid any negative impact on the fishing camp.

Other than the Borealis Development and the tourist camp there are no local or regional plans for the area.

The renewable resources gathered in the area of the mine site, as per our biological sections, have a relatively small present dollar value or food value. These values, need to be protected and will be protected under our proposed development.

The fish camp has been operating for 3 years, provides no income to the Hall Beach Co-op at present. The only direct monetary gain to the Community is the employment of several of the local hunters and guides and their wives for the short season.

The opening of the mine and its production should increase the tourist activities at the fishing camp judging from data for other areas.

*Ganske, A.E., Regional Manager, Land Resources, Indian and Northern Affairs, Canada, Re: Borealis Exploration Limited, Environmental Impact Assessment Guidelines, Section 4.6, Present Land and Resource Use and Status, Yellowknife, April 9, 1981.

5. ENVIRONMENTAL IMPACTS

Note to section 5: It is not at all clear precisely what is required in this section. We have therefore decided to treat the major impacts with regard to which there are significant feasible alternatives in this section and other impacts in the two subsequent sections. It should also be noted that these sections are, to a great extent, summaries of material handled in greater detail in other parts of the I.E.E. - that is, for a detailed discussion of the effect on the project on caribou, for example, it would be more informative to consult the caribou section of the study than the material in section 7.

5.1 Alternative products: Direct Shipping Ores - Concentrate-low silica concentrate - reduced iron crude: In the past Canada has exported most of its iron as Direct Shipping Ores. Fortunately this is no longer the case. The shipment of Direct Shipping ores maximizes shipping costs and minimizes benefits to Canada. Borealis is not considering Direct Shipping crude ore.

Concentrate: Borealis is, at this time, planning to ship a concentrate of 64-66% Fe and about 6-8% silica. (The balance is basically oxygen.) There is a market for magnetite concentrates of this sort and the company's feasibility studies are based on 64-66% concentrates.

Low silica concentrate: It may be possible to ship a 69+% fe concentrate. Such a concentrate could be used for direct reduction and would sell for considerably more on the market. Part of Sidbec Normines production is in low silica concentrates for their direct reduction operation. At this time we do not know if the low silica concentrate of Borealis ores would be feasible using a dry process. We do know that with a wet process and finer grinding the purchaser can readily produce a low-silica concentrate from our concentrate. Whether we can do so on Melville Peninsula will depend on a number of economic and environmental considerations. Clearly any wet process in an arctic environment would involve considerable environmental costs which would probably outweigh the cost advantages of shipping a product with a few percentages less silica.

Reduced iron: It is of course technically feasible to produce reduced iron and even steel on Melville Peninsula. Such a development is not contemplated because of the shortage of energy, in particular, the carbon based energy ordinarily required and because of the shortage of labour in the Roche Bay area. We do not believe that, for the foreseeable future the shipment of reduced iron or steel is feasible.

The alternatives are therefore concentrate or low-silica concentrate. The Borealis position is that, all things being equal, the company will produce the highest concentrations of Fe consistent with the requirement of the dry process.

5.2 Wet or Dry Processing

Traditionally most iron operations have used a wet crushing/grinding operation with flotation and or spiralling and, whenever feasible, magnetic separation. Since our ore does not require either spiralling or flotation there is no reason, in theory, why water should be required although the use of water does increase, to some extent, the efficiency of the grinding operation and of the magnetic separation.

Most recently, because of the energy and environmental costs of moving massive quantities of water, some other iron operations have turned to dry processing. The dry processing eliminates the handling and heating of the water in the arctic. Dry processing also eliminates the need for settling ponds and it minimizes the shipping bulk. The environmental cost of dry processing is twofold: (1) an increase in the cost of grinding which will be minimal because our grinding costs, judging by the Bond Work Index, are relatively low and (2) an increase in the probability of dust pollution. Stringent measures will have to be undertaken to minimize dust pollution. Work is continuing on optimizing methods of dust pollution and recovery.

5.3 Revegetation As Opposed To Chemical Fixing Of The Tailings - Filled Pit

Revegetation would be the ideal solution. There is however no proven means of vegetating mine sites in the arctic particularly areas, such as this one, where there has been no vegetation. If vegetation fails the risk of dust pollution increases considerably over the long term.

The alternative is to chemically or physically fix the top layers of the tailings once the pit is filled. The disadvantage of this method is that, in the long term, it does not have an ameliorating effect on the environment with most of the methods now available the use of a chemical fixant would preclude future vegetation. The advantage of a chemical fixants is that it would, with a greater degree of certainty, prevent long term dust pollution.

5.4 Land Transportation: Conveyor System vs. Trucking

The advantages of trucking are greater flexibility and more employment for semi-skilled labour.

The major disadvantage of trucking is the considerable use of fossil fuels. The regenerative electric conveyor system on the other hand may, in the beginning, be a net producer of power. The conveyor belt will also result in less surface disturbance less noise pollution.

Trucking may still be used within the pit to avoid unnecessary enlargement of the pit but the system, from the pit to the dock site, will probably be a cable belt conveyor.

5.5 Diesel Power vs. Hydro Power

The disadvantages of the use of diesel to generate electricity are obvious and well established. Diesel power results in the depletion of a non renewable resource as well as a worsening of Canadian balance of payments. Diesel power also results in considerable air pollution and, in particular, an increase in sulphur dioxide emissions which will be carried, by the wind, to affect other areas. In addition, insofar, as the system is dependent on diesel powered generators there will be increased shipping and handling of fossil fuels at the dock site and storage sites and increased risk of spills.

The advantages of the building of a hydro electric project on the Ajaqutalik River are not so clear. (See 4.5, p.122) The use of hydro would considerably expand the area of impact of the Borealis project and it may have a negative impact on the fish populations in the area. At the same time the hydro system - if it is properly constructed - may have a positive impact on the fish populations and vegetation patterns along the river. To what extent this will be possible can only be determined after further study and so a firm decision is impossible at this time.

The obvious advantage of a hydro project is that it will greatly lessen dependence on fossil fuels and so minimize those forms of environmental deterioration one associates with the use of fossil fuels.

SECTIONS 6 AND SECTIONS 7: MAJOR ENVIRONMENTAL IMPACTS-MITIGATING AND AMELIORATING FACTORS - RESIDUAL IMPACTS

As in section 5, this is primarily a summary of material handled in more detail earlier in the I.E.E.

6-7(a). Air Strip

Major Impacts: Leveling and filling of limestone beaches. There may be some drainage needed before filling is feasible.

Mitigating and Ameliorating Factors: Provided that vegetated areas are for the most part avoided, there should be very little damage to the terrain. The limestone shale has proven to be an excellant material for road and building sites. Moreover the airstrip should involve only filling in of natural excavations rather than excavating into the material itself.

Residual Impacts: There should be no residual impacts of the air strip.

6-7(b). Air Traffic

Major Impacts: Air traffic will result in fossil fuel emissions and noise. Both of these will have some adverse effect on wildlife and vegetation in the area.

Mitigating and Ameliorating Factors: The airstrip will be located on the peninsula in Roche Bay near the dock site. This location should minimize air and noise pollution because (1) the prevailing winds are away from the land, (2) the major nesting areas for migratory birds are to the North and South of the peninsula, (3) air traffic coming in off the water should have less effect on caribou and other terrestrial mammals.

In addition the increased use of shipping should eventually work to minimize air traffic and emissions. The amount of fuel needed to move a ton of material by air is much greater than the amount of fuel needed to move a ton of material by water -- and the resulting emissions are greater as well.

Finally as the town grows into a more permanent sort of community the amount of "commuter traffic" should decrease significantly.

Residual Impacts: There will be some movement of the bird population away from that part of Roche Bay particularly during the spring stopover periods. The birds will probably move in the direction of Hall Lake where they already appear in greater numbers. It should be noted that no nesting birds were sighted on this peninsula in any of the three survey flights and that only in some years do birds use Roche Bay as a spring stopover point.

In addition there will be some residual effects of any fossil fuel emissions both in the area of Roche Bay and in those areas where wind is likely to carry those emissions.

6-7(c). Port Facilities

Major Impacts: Some obstruction to fish populations. Some possible interference with currents and sedimentation patterns.

Mitigating and Ameliorating Factors: Nanisivek type cellular construction of the dock site should provide ample room for fish to move between the cells and should not have a significant effect on current and sedimentation in the area.

6-7(d). Shipping Traffic

Major Factors:

(i) potential for spills of fossil fuels

(ii) potential for spills of concentrate

(iii) some interference with sea ice

(i) Insofar as diesel generators are being used there is always the potential for spills as the diesel is transported from the ship to land. In addition any time there is shipping of any sort there is a potential for oil spills from the ship itself.

Mitigating and Ameliorating Factors: Borealis will work to lessen dependence on diesel generators as soon as feasible by using alternative sources of energy. Diesel will be off-loaded by pipe with closely monitored couplings and impermeable lined and buried storage facilities. Ships will be carefully monitored to avoid unnecessary spills and water pollution.

Residual Factors: Where there is shipping there will be some added water pollution. The best that can be hoped for is to minimize that pollution by maximizing the efficiency of the shipping and by maximizing the monitoring of the operation.

(ii) When the concentrate is being loaded there is some potential of spills into the bay.

Mitigating and Ameliorating Factors: The concentrate is an iron oxide. The iron will sink in the deep waters surrounding the dock it is not a mobile compound. (For spectrographic analysis refer to Neal February 20, 1970.)

With sophisticated stacker-reclaimer-loader equipment the risk of spills should be greatly minimized.

Residual Effects: There is always the possibility of some small amounts of iron being deposited in the dock site area of Roche Bay. As the water is deep and the iron relatively inert the effect should be minimal.

(iii) There will be some interference with the sea ice if the season is extended to the 103 days which require ice breaker assistance and/or slightly reinforced ore carriers.

Mitigating and Ameliorating Circumstances: There will be no shipping in the spring and no disturbance of land fast ice during the very limited season. Most of the shipping will be done in the 63 days window for non-reinforced conventional ore carriers.

A separate feasibility study of the shipping is now in progress.

6-7(e). Construction of Town, Mill, and Minesite

Major Impacts: Increase in human population and surface disturbance.

Mitigating and Ameliorating Factors: There will be a separate socio-economic study in which ways to mitigate the population factor will be discussed.

Surface disturbance should be minimized by building on limestone raised beaches in the area and on bed rock. The erosion and negative effects on the permafrost by building on such material is small. It should also be noted that if the road and hydro are excluded, the entire operation will, affect a relatively small geographic area adjacent to Roche Bay.

Residual Effects: There will be some surface disturbance and erosion and some disturbance due to increased population in the area.

6-7(f). Tailings Disposal

Major Impacts: The mined out pits and some natural excavations will be filled with fine particled silica. There is some possibility of dust pollution.

Mitigating and Ameliorating Factors: With the dry process there will be no liquid effluents into lakes and rivers. While the pit or excavation is being filled, the surface will be dampened in winter and covered with water in summer to eliminate dust pollution. As the fill is completed, the surface will be fixed and vegetation of the area may be attempted. There is no possibility of acid leach from the tailings.

Residual Impacts: If the vegetation is feasible there will be a considerable increase in vegetation in the area as the areas to be vegetated are bedrock and limestone shale with no or minimal ground cover or vegetation at this time. There is some limited potential for neutralizing the surrounding acidic surface water in the area.

There will be a long term need to monitor the vegetation because in areas where vegetation is not successful the surface must be chemically fixed to avoid dust pollution.

6-7(g) Conveyor Belt System

Major Impacts: Surface disturbance in area of footings. The system itself will provide some obstacles to wild life movement in the area. There will be some noise from the operation of the system.

Mitigating and Ameliorating Factors: The system will be elevated on footings which should minimize the surface the disturbance and present less of an obstacle to animal movement as well as to the movement of water during run-off. The system will be covered to reduce dust pollution and noise. The noise will be a continual hum rather than the more exaggerated and intermittent noise of truck transportation.

Residual Impacts: There will be some erosion around the footings of the system and some noise.

6-7(h). Roads in the Mine Area

Major Impacts: Surface disturbance

Mitigating and Ameliorating Factors: Roads will be built, whenever possible, on bedrock or raised beaches so as to minimize erosion.

Bibliography of Company and Property References

*AMAX Mineral Sales, World Outlook for Crude Steel and Iron Ore Introduction - Revised October 2, 1980.

*Aula, J., Municipality of Hall Beach, Motion Number 136-80-81, December 1, 1980. Re: Road Hall Beach - Roche Bay.

*Biskupski, J., Report of Investigation No. 0-70315 Batch Tests on Iron Ore Sample from Section S Borealis Exploration, Ontario Research Foundation, Sheridan Park, Ontario, June 24, 1970.

Community Planning and Development, NWT Canada, March 1980.

*Cox, C.B., Letter to Hamlet Council, Hall Beach, N.W.T., December 8, 1980. Re: Socio-Economic Planning.

*Cox, R.T. Letter to Eugene Lysy, Re: I.D.C. participation in Borealis Exploration Ltd., Inuit Development Corporation, Ottawa, Canada, January 20, 1981.

*Cox, R.T., Borealis: Questioning Assumptions about Development in the Arctic, paper presented at NWT Chamber of Mines, Mining Days, Yellowknife, April 8, 1981.

Crowe, K.J., Cultural Geography of Northern Foxe Basin, N.W.T., Department of Indian and Northern Affairs, 1969.

*Ganske, A.E., Borealis Exploration Limited, Environmental Impact Assessment Guidelines Section 4.6 Present Land and Resource Use and Status, Yellowknife, April 9, 1981.

Geological Survey of Canada. Some of current (last 10 years) Academic and Government Research done on Borealis Exploration properties. Non-hydrocarbon Mineral Resource Potential of Parts of Northern Canada, by Economic Geology Division, Geological Survey of Canada, Open file 716, published Nov 1980.

Report of Activities, Geological Survey of Canada- Paper 73-1 Part A, April to October 1972 Project 720062 by Mikkel Schau.

Precambrian Geology of the Prince Albert Hills, Western Melville Peninsula, Northwest Territories - Unpublished paper by Dr. Homos Frisch - G.S.C. confidential.

Iron-Formation in Melville Peninsula, N.W.T., MS Thesis by David Watkins, Carlton University 1972.

*Indicates some or all of this material included in appendix.
Appendix listing alphabetical.

Geological Studies in Western Melville Peninsula, District of Franklin, T. Frisch and N. Goulet. Regional and Economic Geology Division, C.G.S. Project Paper 75-1 720070 1975.

Physical work done by G.S.C. and Energy Mines and Resources.

a. June, July, August 1973-1976. Airborne Magnetic Survey of Melville Peninsula by Geotemex Ltd., Survair Ltd., Northern Survey Corporation Ltd., Relevant Maps for BSX done by G.S.C: 8278G Sheet 47A/6; 7938G Sheet 47A; 82946 Sheet 47A/4; 8264G Sheet 47A/15; 8277G Sheet 47 A/11; 8265G Sheet 47 A/10; 8292G Sheet 47A/12; 7939G Sheet 47B 8325G Sheet 47B/7; 8326G Sheet 47B/2.

b. Energy Mines and Resources - Surveys and Mapping Branch. Complete New Series topographical mapping relevant to BSX. #47 A/6 Edition 1; #47 A/11 Edition 1; #47 A/4 Edition 1; #47 B/2 Edition 1; #47 A/12 Edition 1; #47 A/5 Edition 1; #47 B/7 Edition 1; #47 A/15 Edition 1; #47 A/10 Edition 1;

Base Maps: Melville North/Base Map 5th Edition 1975.
Melville South/Base Map 5th Edition 1974.

Heywood, W.W., Geological Notes Northeastern District of Kewatin and Southern Melville Peninsula, District of Franklin, N.W.T., Geological Survey of Canada, Ottawa, 1967.

Lewis, M. Belyea, D., Vegetation of Scarpa Lake, NWT, Biology Department, York University, Toronto, 1977.

*Morgan, R.A., Ten Year Leach Test, Sample #203, 12/17/80. Microbas Laboratories, Inc., January 12, 1981.

*Neal, H.E. Metallurgical Testwork Melville Peninsula Samples for Borealis Exploration Limited, Toronto, Canada January 31, 1969.

*Neal, H.E. Metallurgical Testwork 1969 Field Samples from Melville Peninsula for Borealis Exploration Limited, Toronto, Canada, February 20, 1970.

Northern Power Commission, 1978 Annual Report.

*Peterson, E.B., and Peterson, N.M., Revegetation Information Applicable to Mining Sites in Northern Canada, Department of Indian and Northern Affairs, Environmental Studies #3.

*Ross, M., Feasibility Study of the Beneficiation of Magnetite Bearing Iron Ore for Borealis Exploration, Ltd., RR #80-233, Eriez Magnetics, Erie, Pennsylvania, August 12, 1980.

*Sarbutt, K.W., Bond Ball Mill Closed Circuit Grindability Test, Lakefield Research of Canada Limited, Lakefield Ontario, March 24, 1981.

*Schumacher, P.L. Preliminary Beneficiation and Reduction Tests on Borealis Melville Peninsula Ore, Allis Chalmers, March 1980.

*Scruggs, G.G., Borealis Claims-Melville Peninsula, N.W.T., Calgary, July 21, 1977.

*Swim, M.G., Roche Bay, C.H.S. Field Sheet (Collector) No. 4328, Project #57-11-4 surveyed by Mr. M.G. Swim, assisted by Mr. C.G. Miller, Captain P. Tooke and Officers of the C.C.G.S. Labrador, September 1970.

*Theurkauf, E., Report on the Preliminary Tests to Investigate Dressing of two types of Ore from the Melville Deposit in Canada, Study Group for Iron Ore Dressing, Othfresen, February 20, 1970 (Translation) March 19, 1981 In Indian and Northern Affairs.

*Underhill, D.H., Cox, C.B., Borealis: The Geology and Feasibility of its Magnetite Deposits in the Canadian Arctic, Paper presented Metal Bulletin's Second International Iron Ore Symposium, Frankfurt, West Germany, March 24, 1981.

*Ursel, N.H., Mineral Exploration on Melville Peninsula, District of Franklin, Northwest Territories for Borealis Exploration Limited, Toronto, December 27, 1968.

*Wilson, I., and Underhill, D.H., Discovery and Geology of Major New Iron Deposits, Canadian Mining Journal, July 1971.

BIBLIOGRAPHY OF BIOLOGICAL REFERENCES

1. Anders, G. 1965. Northern Foxe Basin, an area economic survey. Department of Northern Affairs and National Resources, Canada.

2. Babb, T. 1970. (?) High arctic disturbance studies. Probably part of an Arctic Land Use Reconnaissance/Arctic Institute of North America Project. pp. 230-281.

3. Banfield, A.W.F. 1961. A revision of the reindeer and caribou, genus Rangifer. Department of Northern Affairs and National Resources, Canada.

4. ______________, 1971. The relationship of caribou migration behaviour to pipeline construction. Orig. paper No. 45 in Trans. International Symposium on the Behaviour of Ungulates and its Relation to Management. University of Calgary. Also published by the International Union for the Conservation of Nature and Natural Resources. 1974. Morges, Switzerland.

5. ______________, 1974. The Mammals of Canada. University of Toronto Press.

6. Beaubier, P.H., Bradley, M.J. and Vestey, J.G. 1970. Human ecological studies - Igloolik, Northwest Territories. I.B.P. Human Adaptability Project, Department of Geography, McGill University, Montreal.

7. Bergerud, A.T., 1971. The role of the environment in the aggregation, movement and disturbance behaviour of caribou. Orig. Paper No. 29. in Trans. International Symposium on the Behaviour of Ungulates and its Relation to Management. University of Calgary. Also published by the International Union for the Conservation of Nature and Natural Resources, 1974. Morges, Switzerland.

8. Bissett, D. 1967. Northern Baffin Island. An area economic survey. Northern Baffin Island Report, Vol. 1. A.E.S.R. 67/1. Department of Indian Affairs and Northern Development, Ottawa.

9. Brody, H. 1976. Inuit Land Use in North Baffin Island and North Foxe Basin. In M.M.R. Freeman, (ed.) Inuit Land Use and Occupancy Project, Vol. 1. Dept. Indian and Northern Affairs, Ottawa.

10. Brooks, J.W. 1954. A contribution to the life history and ecology of the Pacific walrus. Special report No. 1. Alaska Cooperative Wildlife Research Unit. U.S. Fish and Wildlife Service.

11. Calef, G.W. and Heard, D.C. 1979. The status of three tundra wintering caribou herds in the northeastern mainland Northwest Territories. Orig. Trans. Second International Reindeer/Caribou Symposium. Roros Norway. Also pub. by N.W.T. Wildlife Service, 1980

12. Child, K.N. 1971. Reactions of caribou to various types of simulated pipelines at Prudhoe Bay, Alaska. Orig. Paper No. 46 in Trans. International Symposium on the Behaviour of Ungulates and its Relation to Management. University of Calgary. Also published by the International Union for the Conservation of Nature and Natural Resources, 1974. Morges, Switzerland.

13. Clement, (?). 1978. Caribou critical areas, Baffin Island, Bathurst Inlet, Melville Peninsula, etc. N.W.T. Wildlife Service report.

14. Crowe, K.J. 1969. A cultural geography of northern Foxe Basin, Northwest Territories. Department of Indian Affairs and Northern Development, Ottawa.

15. Davis, R.A. and Wiseley, A.N. 1973. Normal Behaviour of snow geese on the Yukon-Alaska North Slope and the affects of aircraft-induced disturbance on this behaviour. Biological Report Series, Vol. 27, Ch. 2. Canadian Arctic Gas Study Ltd.

16. Donaldson, J.L. Population and Recruitment Estimates for the Wager Bay and Lorillard Caribou Herds in 1977. Unpublished study of the N.W.T. Wildlife Service, Yellowknife.

17. Elliott, Clive and Crystal, Caribou on Melville Peninsula. 1975, unpublished.

18. Elliott, J.L. (ed.) 1971. Minority Canadians, Vol. 1 Native Peoples. Prentice-Hall of Canada Ltd., Scarborough, Ontario.

19. Freeman, M.M.R. (dir. & ed.) 1976. Inuit Land Use and Occupancy Project. 3 Volumes. Inuit Tapirisat of Canada. Department of Indian and Northern Affairs, Ottawa.

20. Garrott, R. 1979. On the trail of the arctic fox. National Wildlife, Vol. 17, No. 4. June-July.

21. Geist, V. 1970. A Behavioral approach to the management of wild ungulates. In Duffey, E. and A.S. Watt (ed.). The Scientific Management of Animal and Plant Communities for Conservation. Blackwell Scientific Publications, Oxford.

22. ________,1975. Harassment of large mammals and birds, with a critique of the research submitted by Arctic Gas Study Ltd. on this subject. Report to the Berger Commission.

23. Glova, C. and McCart, P. 1974. Life history of arctic char (Salvelinus alpinus) in the Firth River, Yukon Territory. Canadian Arctic Gas Study Ltd. Biological Report Series. Vol. 20, Ch. 3.

24. Godfrey, W.E. 1966. The birds of Canada. Nat. Mus. Canada, Bull. No. 203, Biol. Series No. 73. Ottawa.

25. Gollop, M.A., Black, J.E. Felske, B.E. and Davis, R.A. 1974. Disturbance studies of breeding black brant, common eiders, glaucous gulls and arctic terns at Nunaluk Spit and Phillips Bay, Yukon Territory, July 1972. C.A.G.S.L. Biol. Rep. Ser. Vol. 14, Ch. 4.

26. Gollop, M.A. and Davis, R.A. 1974. Gas compressor noise simulator disturbance to snow geese, Komakuk Beach, Yukon Territory, September, 1972. C.A.G.S.L. Biol. Rep. Ser. Vol. 14, Ch. 8.

27. Gollop, M.A., Davis, R.A., Prevett, J.P. and Felske, B.E. 1974. Disturbance studies of terrestrial breeding bird populations: Firth River, Yukon Territory, June, 1972. C.A.G.S.L. Biol. Rep. Ser. Vol. 14, Ch. 2.

28. Gollop, M.A., Goldsberry, J.R. and Davis, R.A. 1974 a. Effects of gas compressor noise simulator disturbance to terrestrial breeding birds, Babbage River, Yukon Territory, June, 1972. C.A.G.S.L. Biol. Rep. Ser. Vol. 14. Ch. 2.

29. _______________, 1974 b. Aircraft disturbance to moulting sea ducks, Herschel Island, Yukon Territory, August 1972. Canadian Arctic Gas Study Ltd. Biological Report Series, Vol. 14, Ch. 5.

30. Grainger, E.H. 1953. On the age, growth, migration, reproductive potential, and feeding habits of the arctic char (Salvelinus alpinus) of Frobisher Bay, Baffin Island. Journal of Fisheries Research Board of Canada, Vol. 10, No. 6, pp 326-370.

31. Griffiths, W.B., Craig, P.C., Walder, G. and Mann, G. 1975. Fisheries investigation in a coastal region of the Beaufort Sea (Nunaluk Lagoon, Yukon Territory). C.A.G.S.L. Biol. Rep. Ser. Vol. 34, Ch. 2.

32. Griffiths, W.B., Den Beste, J.K. and Craig, P.C. 1977. Fisheries investigations in a coastal region of the Beaufort Sea. C.A.G.S.L. Biol. Rep. Ser. Vol. 40, Ch. 2.

33. Harington, C.R. 1968. Denning habits of the polar bear (Ursus maritimus Phipps). Canadian Wildlife Service Report Series - Number 5. Department of Indian Affairs and Northern Development, Ottawa.

34. Honigman, J. and I. 1971. The Eskimo of Frobisher Bay. In Elliott, J.L. (ed.) Minority Canadians, Vol. 1. Native peoples. Prentice-Hall of Canada Ltd. Scarborough, Ontario.

35. Jakimchuk, R.D. (ed.) 1974. The reaction of some mammals to aircraft and compressor station noise disturbance. Arctic Gas Biological Report Series, Vol. 23, prepared by Renewable Resources Consulting Services Ltd.

36. Jones, S. and Mackay, D. (eds.) 1978. Proceedings of the Seventh Arctic Environmental Workshop, April 12-15, 1978. Publication EE8, Institute of Environmental Studies, University of Toronto.

37. Kelsall, J.P. 1968. The migratory barren-ground caribou of Canada. Department of Indian Affairs and Northen Development, Ottawa.

38. Kuc, M. 1972. The response of tundra plants to anthropogenic habitats in the high arctic. Geological Survey of Canada, Ottawa. Paper 72-1, Part B. pp. 105-112.

39. Lewis, M. and Belyea, D. 1977. The Vegetation of Scarpa Lake, N.W.T. (unpub. paper). York University, Toronto.

40. Macpherson, A.H. 1969. The dynamics of Canadian arctic fox populations. Canadian Wildlife Service. Report Series-Number 8. Department of Indian Affairs and Northern Development.

41. Mansfield, A.W. 1967. Seals of arctic and eastern Canada. Bulletin No. 137. Fisheries Research Board of Canada, Ottawa.

42. McCourt, K.H., Feist, J.D., Doll, D. and Russell, H.J. 1974. Disturbance studies of caribou and other mammals in the Yukon and Alaska, 1972. C.A.G.S.L. Biol. Rep. Ser. Vol. 5.

43. McCourt, K.H. and Horstman, L.P. 1974. The reaction of some mammals to aircraft and compressor station noise disturbance. C.A.G.S.L. Biol. Rep. Ser. Vol. 22.

44. McLaren, I.A. 1958. The biology of the ringed seal (Phoca hispida Schreber) in the eastern Canadian arctic. Bulletin of the Fisheries Research Board of Canada, No. 118.

45. Miller, F.L. and Gunn, A. 1979. Caribou and muskoxen response to helicopter harassment, Prince of Wales Island, 1976-77. Canadian Wildlife Service. Escom. No. A1-30.

46. Miller, F.L., Jonkel, C.J. and Tessler, G.D. 1972. Group cohesion and leadership response by barren-ground caribou to man-made barriers. Arctic Vol. 25, No. 3. September.

47. Naysmith, J.K. 1972. The impact of technology upon native people and their traditional pursuits. Dept. of Indian and Northern Affairs.

48. Nelson, J.G. (director), 1975. Canadian Arctic renewable resource mapping project. 12 vol. Renewable Resource Studies, Inuit Tapirisat of Canada, Borial Institute for Northern Studies. University of Alberta, Edmonton.

49. Patterson, L.A. 1974. An assessment of the energetic importance of the North Slope to snow geese (Chen caerulescens caerulescens) during the staging period in September, 1973. C.A.G.S.L. Biol. Rep. Ser. Vol. 27, Ch. 4.

50. Project Rand RM-1997. 1963. A report on the physical environment of the Quoich River Area, Northwest Territories, Canada. Department of Geography, McGill University, Montreal. The Rand Corporation, Santa Monica, California.

51. ________________, RM-2706. 1963. A report on the Physical Environment of northern Baffin Island and adjacent areas, N.W.T. Canada Dept. of Geography, McGill University, Montreal. The Rand Corporation. Santa Monica, California.

52. Reed, A., Dupuis, P., Fischer, K. and Moser, J. 1980. An aerial survey of breeding geese and other wildlife in Foxe Basin and northern Baffin Island, Northwest Territories. July 1979. Progress Notes Canadian Wildlife Service, No. 114.

53. Reed, A., Dupuis, P. November 1980. A Preliminary Report on Greater Snow Goose and Atlantic Brant Investigations Near Foxe Basin and Northern Baffin Island, N.W.T., August 1980.

54. Rippin, B. and Bowden, E. 1972 (?). Melville Peninsula caribou study. May 20 to 22, 1972. Unpublished study of the N.W.T. Wildlife Service.

55. Schusterman, R.J. 1968. Experimental laboratory studies of Pinniped behaviour. In Harrison, Hubbard, Peterson, Rice and Schusterman (eds.). The behaviour and physiology of Pinnipeds, Appleton-Century-Crofts, N.Y.

56. Schweinsburg, R.E. 1974. Disturbance effects of aircraft on waterfowl on North Slope lakes, June 1972. C.A.G.S.L. Biol. Rep. Ser. Vol. 14, Ch. 1.

57. ________________, 1974. Snow geese disturbance by aircraft on the North Slope, September 1972. C.A.G.S.L. Biol, Rep. Ser. Vol. 14, Ch. 5.

58. Synder, L.L. 1957. Arctic birds of Canada. University of Toronto Press.

59. Tener, J.S. 1965. Muskoxen in Canada. Canadian Wildlife Service, Department of Northern Affairs and National Resources, Ottawa.

60. Thompson, D.C. and Fischer, C.A. 1979. Distribution and numbers of the Kaminuriak caribou herd in March and April 1977. Arctic Vol. 32, No. 3, September. pp. 266-274.

61. Treude, E. 1975. Studies in settlement, development and evolution of the economy in the eastern central Canadian Arctic. The Muskox Vol. 16, pp 53-66.

62. Turkheim, R.J. 1975. Biophysical impacts of arctic hydroelectric developments. In Day, J.C. Impact of mining and hydroelectric projects and associated developments on arctic renewable resources and the Inuit. Renewable Resource Studies, Inuit Tapirisat of Canada.

63. Urquhart, D. 1971. The effects of oil exploration activities on the caribou, muskoxen, and arctic foxes on Banks Island. Northwest Territories Wildlife Service report.

64. Usher, P.J. 1975. Historical statistics approximating fur, fish and game harvests within Inuit Lands of the N.W.T. and Yukon, 1915-1974, with text. Inuit Tapirisat of Canada.

65. Vallee, F.G. 1971. Eskimos of Canada as a minority group. In Elliott J.L. (ed.) Minority Canadians I, Native peoples.

66. Van de Velde, F. 1957. Nanuk, king of the arctic beasts. Eskimo Vol. 45: pp. 4-15.

67. van Diepen, P. 1975. The impact of mining on the arctic biological and physical environment. In Nelson, J.G. (dir.) Renewable Resource Studies, Vol. 7. Inuit Tapirisat of Canada.

68. Ward, J. and Sharp, P.L. 1974. Effects of aircraft disturbance on moulting sea ducks at Herschel Island, Yukon Territory, August 8, 1973. C.A.G.S.L. Biol. Rep. Ser. Vol. 29, Ch. 2.

69. Wiseley, A.N. 1974. Disturbance to snow geese and other large waterfowl species by gas-compressor sound simulation. Komakuk, Yukon Territory, August-September 1973. Canadian Arctic Gas Study Ltd. Biological Report Series, Vol. 27, Ch. 3.

70. Wright, J.G. 1944. Economic Wildlife of Canada's Eastern Arctic - Caribou