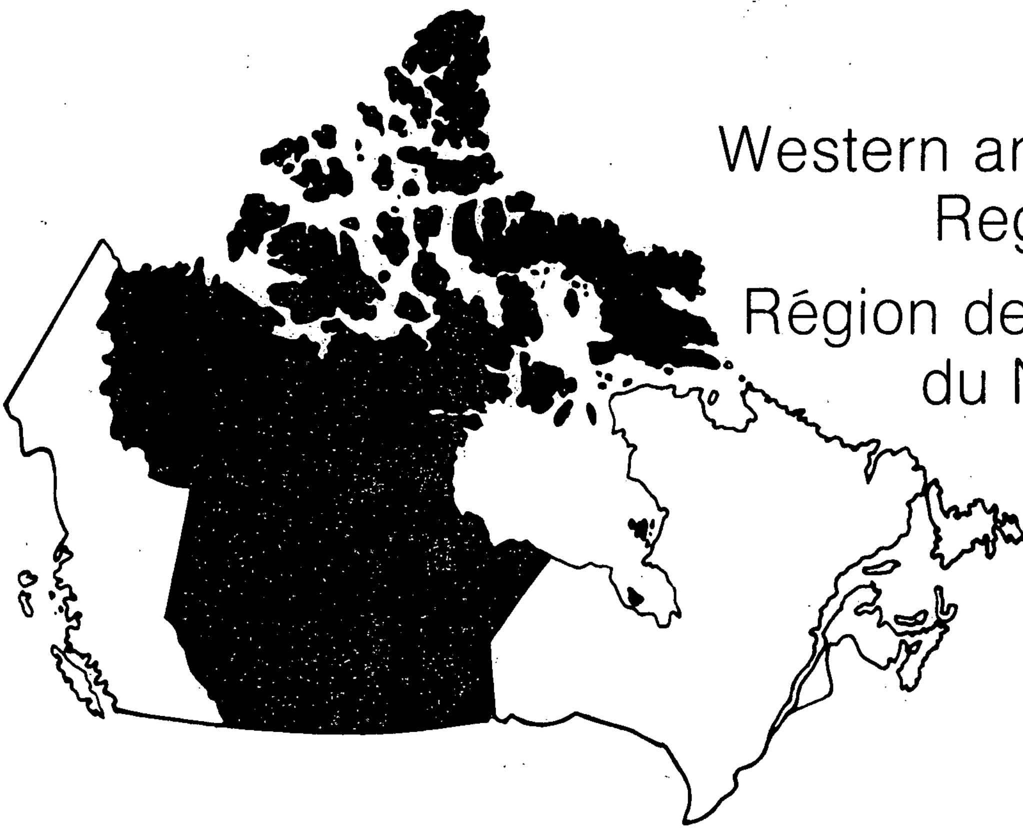
Environment Canada   Environnement Canada



Western and Northern Region

Région de l'Ouest et du Nord

SUMMARY OF

NORTHERN SCIENCE SEMINAR

JUNE 8 - 11, 1989

INUVIK, NWT

Office of the Secretariat
Committee of Regional Executives

Bureau du Secrétariat
Comité des cadres régionaux

Canada

SUMMARY OF

NORTHERN SCIENCE SEMINAR

JUNE 8 - 11, 1989

INUVIK, NWT

COMPILED BY

VINOD MARWAHA

CORE SECRETARIAT

JULY, 1989

SUMMARY OF NORTHERN

SCIENCE SEMINAR

HELD AT

FINTO MOTOR INN
INUVIK, N.W.T.

ON

June 8-11, 1989

SPONSORED BY

COMMITTEE OF REGIONAL EXECUTIVES (CORE)
WESTERN AND NORTHERN REGION
ENVIRONMENT CANADA
EDMONTON

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SUMMARY

Introduction

The observations which follow are representative of various presentations, discussions and comments made during a two day seminar on northern science. The seminar was sponsored by the Committee of Regional Executives (CORE) for the Western and Northern Region of Environment Canada. Participants included representatives from the federal Departments of Environment, Energy Mines and Resources, Fisheries and Oceans, Indian Affairs and Northern Development, and the Government of the Northwest Territories Department of Renewable Resources and the N.W.T. Science Institute. A complete list of individual participants is attached.

The objectives for the science seminar were:

- to provide an overview of environmental science programs that have been and are being conducted, as these relate to program delivery responsibilities;
- to assess requirements in the context of departmental and governmental objectives;
- to consider strategic intent that would support long-term, sustainable and credible scientific programs.

A two-day field trip was organized, following the seminar, to enable participants to experience first-hand the northern environment and culture. The field trip included the Mackenzie delta and Yukon north slope, CPS 'headquarters' in Northern Yukon National Park, Old Crow flats, Dawson City, and other areas that are subject to development pressures. For details of field trip, see Appendix 3.

Federal Northern Science

The federal government has for many decades provided significant contributions to "northern science" in Canada. A shift is evident, however, with declining budgets and reduced programs, as the level of environmental science in the North has reached a point where continuity of experience and expertise should be a concern.

A solid science-support, physical infastructure exists through the Polar Continental Shelf Project and the Government of the Northwest Territories Science Council, and via other government installations such as AES weather stations in the High Arctic Islands. Nonetheless, vast distances and short field seasons in combination with excessively high operating costs restrict the extent of scientific programs.

Federal inventory and data base programs over several decades have added significantly to the foundation for northern science. More recently, a sustained level of scientific work by universities and intermittent efforts financed by the private sector have assumed much more importance in terms of the overall level of northern science.

An increase in the level of extramural science has changed the complextion of northern scientific activity. However, consultants must move from project to project as dictated by the market. Their expertise may not be accessible after a contract is finished. Universities, on the otherhand, are in the business of educating and training largely transient students although faculty expertise may remain in place over many years.

Science in the Canadian North is characteristically a feast-or-famine phenomenon as the level of effort and resources fluctuates between crash programs and a dearth of effort. This pattern is felt to lessen the effectiveness of scientific effort and mitigates against the sustained development of scientific products.

A much greater proportion of scientific work in the future must be directed towards achieving a better awareness and understanding about physical and biological processes and their interactions. These initiatives represent a long term commitment and will require sustained financial support.

The role of new technology must be fully exploited in the North. Cost, safety and operating logistics make the adoption of more technologically advanced methods a bright prospect for the future. Satellite based remote sensing has an important role in northern environmental science but concern was expressed over the research and development lead times required to bring this to fruition.

Increasing levels of political, social and industrial development in the North will mean that the interests of northern residents must have a more influential role regarding the direction and content of northern science. The value of "traditional knowledge", ie. indigenous people's knowledge of the natural environment, remains an untapped scientific resource. The requirement to address the needs and interests of indigenous peoples and to involve them in scientific programs is seen as a fact-of-life for all environmental science now and in the future.

Northern residents will continue to have an increasingly influential role in the direction of environmental science. This will be the result of further devolution of responsibility to the territorial governments and from land claims settlements. Joint management regimes between government and aboriginal groups, similar to caribou management boards involving CWS and CPS park management plans, are an emerging source of funding for northern science.

Environment Canada Science

Environment Canada is only a part of the total northern environmental science effort that is supported by the federal and the territorial governments. Other centres of significant contribution to environmental sciences include

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the federal Departments of Energy Mines and Resources, Fisheries and Oceans, Indian Affairs and Northern Development and the territorial Departments of Renewable Resources.

Within Environment Canada, significant differences characterize northern scientific programs in AES, C&P, and CPS. These differences in program content, purpose and clientele make generalizations difficult. Atmoshperic sciences are highly sophisticated, deal with complex systems, employ sophisticated instrumentation and are part of a global network of air, sea and ice sciences. On the whole, atmospheric sciences serve a wide audience of industrial, commercial and public interests. Science within CPS is tightly focussed on national park/reserve sites and operational program requirements. A full spectrum of physical, biological and social scientific talents may be used as appropriate to meet CPS planning and management needs. Much of the science that is undertaken by C&P has direct application to resource management and regulatory decisions affecting directly the interests of local people and communities in the North. These highly operational programs are supported in part by national research institutes which could play an even more prominent role in the North.

Environmental Science Perspectives

Major program issues linked specifically with the need for scientific support include atmospheric change; ecosystem contamination and long-range transport; water quality and toxic pathways in aquatic ecosystems; hydrometric and sediment data programs in remote regions; habitat and population dynamics for wildlife particularly rare, endangered and migratory species; and the management of conservation areas (park reserves, migratory bird sanctuaries and national wildlife areas) for sustained use.

Establishing and maintaining closer ties between scientific disciplines will become increasingly necessary as northern science moves forward to address complex interactions within and between the physical and biological environment. Better intergration of scientific initiatives within Environment Canada and with other scientific organizations is seen as a valuable tool for the future.

International Science

A decidedly circumpolar theme is emerging amongst polar nations. Transboundary issues and the close proximity of international boundaries in northern polar regions will add impetus for international cooperation and a sharing of scientific knowledge and expertise.

Canada is seen to have a distinctive position with respect to polar science on the international level. An area of significant concern is that a few specific individuals are primarily responsible for existing informal networks and that these arrangements may dissolve as key senior scientists retire or change employment.

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The international agenda for Canadian polar environmental science deserves greater formal attention. Qualified young scientists should be given the opportunity to benefit from the experience of joint and/or exchange programs and should be encouraged to participate in international fora. Current activities to energize more formal arrangements (eg. ICAS, IGBP, UNESCO, MAB, and Finnish Polar Conference) are encouraging.

Environment Canada and the federal government should actively support the creation of a Canadian Polar Research Commission, and other worthwhile recommendations in the report "Canada and Polar Science" (March 1987).

Conclusions

- Science is recognized as an important tool for promoting sustained environmental quality and sustained economic development in the Canadian North.

- Sufficient lead times to conduct appropriate scientific investigations; stable and adequate resource regimes; and the infusion of younger scientists, will help to determine the productivity and value received from scientifically based programs over coming years.

- More so than ever before, close coordination and the better integration of scientific interests to include government, industry, universities and consultants, within Canada and internationally, has a vital contribution to make to meeting Canada's needs for polar environmental science in the future.

- The participants encouraged the sponsors to continue their initiative to provide a focus on northern environmental science using various venues on a periodic, multi-year basis.

- A modest but sustained $5 million per year, for example, for northern environmental science, would lever considerably more and result in new partnerships, international credibility, and improved synergy and coordination. It would signal a commitment to environmentally sustainable development of our polar regions.

AGENDA PRESENTATIONS

1. **Welcome and Opening Remarks:** see Appendix 1

Mr. M. Balshaw, as chairman, welcomed all the participants and provided a brief background of seminar objectives and rationale. Mr. Balshaw suggested this would be a "five-I" seminar as it was structured to inform, integrate, institutionalize and initiate at Inuvik.

Mr. Mel Smith, representing the Territorial government, similarly welcomed participants, outlining some of the developmental projects and other perplexing problems.

2. **DOE Science Programs and Activities**

A) Conservation and Protection

i) K. McCormick: - see Appendix 2

- Presentation focussed on knowledge and the process of acquiring it, as the foundation of CWS actions.

- CWS mandate followed from the Migratory Birds Convention Act (1917) and Canada Wildlife Act (1973).

- The role of CWS was several fold ie. manager, advisor, regulator, auditor, negotiator, advocate, researcher, and finally as an indicator of environmental health. This role was further enhanced by a large degree of co-operation required in wildlife management. An agreement signed with Mexico on snow geese was a prime example.

- An important area of strategic concern was the issue of land claims settlements. Government was acting both as a negotiator and consultant to native groups. The issue of land claims will clearly influence how we do business in the North in the future.

DISCUSSION

In maintaining international obligations, while acting as "consultant" to native groups, one must work with and convince the groups as to the broad nature of obligations. There is also shifting of programs, to respond to these developments.

ii) A. Redshaw:

- Presented a brief overview of NWT activities conducted by IWD.

- One could not consider northern science in the NWT, unless one also considered what was going on politically, eg. land claims settlement, devolution.

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- IWD's activities are co-ordinated jointly with GNWT and DIAND. NWT branch of IWD was established in 1981 with three offices. About 85% of the budget is spent on data collection, such as water quantity and quality; sediment data and hydrometric surveys. Some of the typical activities of the NWT office are:

  ... five year federal/GNWT program to update/upgrade water quantity data.

  ... 109 data collection "platforms" in NWT (Monitor operations from Yellowknife thereby reducing monitoring costs).

  ... only 23 water quality monitoring stations in N.W.T. DIAND, GNWT, DOE have drafted water quality agreement, awaiting approval.

  ... 19 stations for sediment data on Mackenzie River and tributaries only.

  ... develop a comprehensive planning based on Yellowknife River Basin monitoring.

iii) E. Collins: see Appendix 4

- People no longer see north as a waste land.
- Federal initiatives in the north are dew lines, AES initiatives.
- Industrial development will be limited to mining, oil and gas, tourism.
- Major EP activities are rehabilitation of abandoned mines, spill cleanup capability, prevention of spills, and enforcement of regulations.

DISCUSSION

In terms of prevention, DOE's current policy is focussed on the concepts of anticipate and prevent rather than react and cure.

Tourism is not entirely environmentally benign. It might be true for present scale operation in the north, but not in future, as the industrial activity expands.

Other countries are seeking DOE expertise/information on waste management in the Antarctic, based on our experience in the Arctic. Framework of regulations, put up jointly by GNWT, DIAND and DOE here in the NWT, were largely the basis of 32 nation Antarctic treaty. Such initiatives could also be useful for management of tourism.

B) Atmospheric Environment

i) B. O'Donnell: Four program areas were outlined by AES. The first focussed on weather services and was outlined by B. O'Donnell.

- There has been a gradual reduction of manned stations and a trend towards automated stations, due to higher costs involved, especially in the north.

- AES delivers a public weather forecast two to four times a day.

- A number of studies in science have been conducted. Northern Yukon Parks Climatology Study and Eastern Arctic Climate Study are recent examples.

DISCUSSION

Weather stations operating in the 1900's, could provide consolidated data sets for the north; this data could be extremely useful for SOE reporting. Several attempts have been made by D. Harrington (National Museums) to analyze the data. Major initiative is on Arctic Environment Data, in U.S.A.; there is a need for Canadian "holders" to get involved.

Information on water is even more scarce. Whatever data sets exist, they are just begining to surface. Water quantity information is available. Bob Stone of International Programs is a good contact point. Two major concerns about data are sparsity of data; and the fact that a lot of manned stations are shutoff at night.

ii) Nancy Cutler: - see Appendix 5

- Role of general climate program.

- Types of AES networks. Better data, with less resources. Use of satellite technology.

- Climate information.

iii) D. Champ: - see Appendix 6

- Purpose of AES Ice Information Services Program.

- The Nature of Science Involved with the AES Ice Program.

- Ice Information Services.

- Northern Environmental Science Issues.

iv) M. Philips: - see Appendix 7

- Brief background and status of Arctic Air Pollution.

- Major focus on Arctic haze, toxic contaminants, climate change, stratoshperic ozone and methane from wetlands.

DISCUSSION

Suphate quantification is done by modelling, by correlation with USSR/Europe data. CAPMON is archived and is therefore a useable source of data.

C) Canadian Parks Service

i) Doug Stewart: - see Appendix 8

- CPS places emphasis generally on the applied science; environmental science is only one component.

- Northern parks are wilderness areas. Some scientific and management studies are:

  - project specific studies, eg: radar station at Stokes Point;
  - bear management studies;
  - resource description and analysis;
  - park management plan; and
  - park construction plan.

- Five major areas of park management are integration, co-operation, environmental change, traditional knowledge, and park development.

- Intergration of advice from various scientific professionals such as climatologists, biologists, etc.

- Co-operative programs include these with the U.S. National Parks.

- Environmental studies examples include glaciology, whooping crane program, porcupine caribou herd, grizzly bear studies and climatology. Room for increased co-operation.

- Issue of environmental change is expecially noticable in parks. Examples: waste management, toxics in food chain, etc.

- Traditional knowledge is the way in which native people view nature and live in harmony with it. Science has an arrogance, a disrespect for such knowledge. Native people don't see it that way. Partnership with native people in land development is inevitable as land claims are settled.

DISCUSSION

Traditional knowledge and environmental change in the north might provide a good hold on the real affects of global change. A lot of our science and knowledge might not stand up in land claims issues.

Social change may be forcing the disappearance of traditional knowledge input. We need to recast our science so it is useful to the new managers ie. natives? Another factor we are not considering is the aging of the population. Younger natives do not have the interest, opportunity, etc. that the elders have had.

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According to the Brundtland Commission, about 12% of land should be protected. This is not being achieved here; lands set aside are based on eco-region and area of traditional use. In Canada this percentage is 6% considering combined provincial and national parks.

3. Territorial Government's Science Programs and Activities

i) M. Smith: - see Appendix 9

- Science is a basis of supporting business decisions. Crisis response versus basic program needs require different basis.

- Outlined mandate of the department of Renewable Resources.

- Brief description of research activities of the various divisions of the department.

- Reference to the NWT Centre for Remote Sensing expected to be in full operation by 1992.

- Encouraged "involvement", such as through the proposed water quality monitoring workshop.

DISCUSSION

- AES co-operates with GNWT on forestry matters pertaining to operations and research.

- There is a tendency for federal programs which are driven from south to become part of northern operational programs. Such federal programs should be more integrated with NWT programs. Land claim settlements will change the way we operate in the future.

- Intergrated studies should also be done in parks.

- There is a positive value of remote sensing applications in the north. There is a lack of stations in the north. Remote sensing could fill in the gap. GNWT has been surprised at the usefulness of this technology. Mining companies use it more often.

- Determine ways in which transactions can be improved. Transaction costs can sometimes outweigh value of integration.

ii) R. Janes: - see Appendix 10

- The Science Institute of the NWT was created by legislation in 1984. It is directed by a board consisting of 8 people, and has a staff of 17 people. Major activities are research support and advisory services, scientific services, information and education, public information, and technology development. Other important activities are issuing of scientific research licences and the development of a medical research trust fund.

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- Research licencing involves liaison with the public and registration as NWT research. In 1988, 113 projects were licenced.

- Challenges for "resident" science in the north are: lack of policy; lack of advance post secondary institutions; lack of federal government advocates for northern science policy; lack of public awareness of value of science; and delay in the establishment of a Polar Research Commission.

- Prospects/opportunities include contaminants in northern food chain; science outside of the classroom (eg. science camps and fairs); hiring northern residents; collating unpublished literature; climate change; setting northern research priorities; northern research fund and support for resident scientists.

- Multicultural environment for research is a unique opportunity. Today science needs to be linked to traditional knowledge.

- Northern science needs to be forward looking, not responsive to industry pressures.

DISCUSSION

- Reduced resource base has increased the need for co-operation. Canadian Climate Committees are not functioning, and they can be better used. Canadian Climate Research Committee has proposed two northern research priorities workshops to deal with the Arctic issues.

- A substantial part of the Science Institute's support system is university based. About 40% of these universities are foreign. Inuvik Institute in Inuvik, has suffered a major drop in science support provided by federal government departments.

4. <u>Federal Department's Science Programs and Activities</u>

i) <u>B. Ayles</u>: see Appendix 18

- Described the mandate, policies, Arctic programs (stations) and response strategies.

- A series of court rulings pertaining to inland and ocean fisheries have determined that, DFO retain fish protection and that provinces own the resource. Overall responsibility for fish habitat is still with DFO.

- Two main research components of DFO Science are the Institute of Ocean Sciences and the Freshwater Institute. Typical kinds of programs are studies of contaminants and productivity in fresh and marine waters. A major ongoing program in the Beaufort Sea is the Arctic Marine Conservation Strategy. The purpose, principles and implementation strategies of this program were discussed. Science was the guiding force.

- A model for analysing research, in support of northern science management, for decision making, was described. The model takes into consideration analytical aspects such as inventory, monitoring, design analysis, experimental analysis, experimental research, decision making, and fisheries response strategy for the future.

DISCUSSION

- The model for research/science and decision making, needs a feedback loop. This is shown in the fully developed model.

- The allowance for feedback for innovative researchneeds to be improved. DFO has about 100 P.Y.'s dedicated to operations. At least 75% of these P.Y.'s are for surveys and monitoring purposes.

- Climate change aspect of fisheries needs to be looked at. Some work is being done through the joint Global Flux Program and Freshwater Arctic Program.

ii) B. Hrycyk:

- Provided a historical perspective of PCSP since its origin in 1958.

- The PCSP support extends over a large area of the Arctic. Trend is toward more environmental research. Support is provided to more than 1000 scientists in the field each year. Major clients are federal/provincial/ territorial governments, universities. Some of the main research programs are on ice structure and ice mechanics.

- About a year ago, Resolute Base Camp could accommodate 35 to 40 people. New accommodation facilities, lab's, computer room etc., can now accommodate 50 people. It is planned to increase the infrastructure and accommodation at Base Camp for an additional 35 people.

- Ice island of 1982 has been drifting southwards. A camp for 25 people and an air strip has been built.

- Land claim settlements and devolution are affecting PCSP.

DISCUSSION

- International participation is very limited. Some interest is being shown by universities of Japan, France, Germany, USSR etc.

- There is potential that those involved with land claims, devolution etc., act as ambassadors for science.

- Camp managers/personnel provide weather observation data at the island camp.

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- PCSP and the Science Institute share information on research programs. A list of licences is being developed. Steps are being taken to hire Inuit, four or five are already on the team.

- PCSP has no plans to expand to Iqualuit on the Eastern Arctic.

iii) B. Stephen:

- DIAND has a responsibility for both northern development and environment. Two things underline the northern working environment:

  ... the politics of the north; and
  ... DIAND is the rich brother. Strong trend towards collective management.

iv) David Stone: - see Appendix 11

- Most significant issue is contaminants in the food chain in the north.

- Research needs to be focussed on transport pathways, temporal trends, basic toxicity (eco-system effects) and human toxicity (risk management, lactation).

DISCUSSION

- Eureka has had high DDT content in snow.

- AES will start to investigate Organochlorides in the air.

v) A. Heginbottom: - see Appendix 12

- Outlined EMR interests in Northern environmental science.

DISCUSSION

- The ice core from Mount Logan, dating back 4000 years has some non-conformities (gaps).

- Permafrost melting impact on fisheries can be significant.

- Attemps have been made to correlate data from permafrost cores with climate change. EMR has thermal data bank, and correlations have been attempted eg. have "climate hole" at Wrigley, and have been working with AES.

- We should be cautious with climate change predictions because of effects of cloud cover. Should deal with it as climate "variability", not "change".

- Environmental processes are integrated, environmental expertise is compartmentalized. Decision making must also be integrated.

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5. Federal Research Institute

i) M. Dick (NHRI): - see Appendix 13

- Outlined historical background and current programs. Most of these programs are very descriptive with no hard science. In 1986, as a result of reduced resources, strategic partnerships were developed intergrating biological, meterological and hydrological programs wherever possible. The reality, that climate averages may not remain the same, has brought hydrology into prominence.

- NHRI Research Studies, Program No. 3, Northern Water Systems: Some special hydrological problems, due to unusual terrain. Active partners in Program 3 are NASA, CORE of US Army Engineers, DIAND, and OFGD's.

- Hydrology of Permafrost: Development of a runoff model involving ground water, snow melt, and evaporation. Two locations considered are Cornwallis Island 75° N and Inuvik 65° N. AES and NASA are involved in the study, along with the University of Waterloo. Other aspects of the study are behaviour of thaw front during spring break-up, ice break up, and loss of strength of ice.

- Studies in the Mackenzie Delta involve prediction of environmental changes in the delta. Active participants are Freshwater Institute, AECL, and U.S. Department of Agriculture. Mackenzie River Delta, is a unique place for waterfowl. River brings in a lot of sediments. Hydrology in this area is the most complex and least understood. There are 2500 lakes in this delta. Goals of the program are to understand and develop a model for these lakes. Key elements of the model are:

  ... material balance at the delta;
  ... ice jamming;
  ... surface runoff;
  ... energy balance - evaporation versus delivery by precipitation;
  ... water level as a function of probability; and - changes in the Mackenzie river regime;
  ... knowledge of the above processes, could predict the water level of the lakes.

- Major implications of the model are:

  ... results of hydro-dams built in the south can be predicted. Peace-Athabasca Delta is a prime example;
  ... make a stronger connection between nutrients in the lake and hydrology; and
  ... long term changes in the Mackenzie River.

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ii) Dave Egar: - see Appendix 14

- Outlined NWRI northern initiatives and prospects.

- Reference to collaboration with industry, trend to working with partners.

- Emerging focus on toxic chemicals problems.

DISCUSSION

- Reliance on soft money opportunities (PERD, NOGAP, etc.) provides a unique opportunity to carry on A-Base activities but has inherent weakness or vulnerability.

  ... Long term monitoring cannot be done this way since "projects" come with a defined time frame.

  ... Long term program needs to be established, especially in the north.

  ... A lot of science is "transferrable" from the south, but does not work in the north.

- The on and off funding can be better managed by provision of long term direction to the scientific community.

- Institutional memory is important. We must talk more to others who have ownership (need) of the problem. Soft money cannot result in continuous, long term data often necessary for prediction.

- A useful output from this meeting would be a map and directory of northern support facilities to help "intergration" of circumpolar science. It was learned that DIAND already has such a directory.

- We must not accept the change to soft funding if it is harmful. All soft funding seems to come from perceived crisis situations, but agencies do not build this into A-Base. Often soft money is the result of "entrepreneur promotors", not from line efforts. This process increases vulnerability. When new needs arise, we should pressure senior management for more A-Base, not special, money.

- Soft money drives science in the direction that society wants. Science totally funded by the state is not as vibrant as soft money science. Continuity is perhaps lost. In the long term, it may have a net higher cost. We need a "model" which will balance this effect. A Canadian Environmental Science Trust Fund has previously been suggested, but not implemented. It would have to be large enough for mission oriented and basic sciences.

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- There is no public commitment to "intellectual activity" - they want results. If you do research faster, that will not work either. You need to create an environment in which you can get results, you cannot direct results.

- It is a false myth that more money is good for science and research. What is important is the need for capable people to carry out credible scientific research. The main difficulty is whether the department should or should not fund a particular activity. Management wants results. If no results, funds can be cut.

- Major problem is committtment to sustain intelligent people, who understand and produce credible science. Are people addressing the right problems, and/or, are those working at the middle or lower level being directed properly?

- Government A-Base, company trust fund and public trust fund, might be combined to form a better overall mechanism for funding northern science.

6. External Environmental Science

i) C.A. Lewis: - see Appendix 16

- Discussed the DOE Science Committee, University Strategy, Industry Sector, etc.

DISCUSSION

- Science strategy progress/purpose: Cabinet document is being developed. Some details were outlined reinstating NOGAP, etc. The need is to make the strategy deliverable ie. politically attractive to a southern audience (toxic chemicals, etc). Suggestion was that the theme should be environment, with arctic as the background.

7. International Polar Science

i) E.F. Roots: - see Appendix 17

- Outlined the current situation regarding international cooperation in arctic science, including developments in the south polar regions.

- At the top of the agenda is a decision as to whether or not there will be an International Arctic Sciences Committee (IASC). IASC would attempt to coordinate/plan science/policy similar to SCAR (Scientific Committee on Antarctic Research).

- IGBP (International Geosphere-Biosphere Program): research themes (7) overlap and must be integrated among the agencies and disciplines. Descriptive/modelling/high tech science aspects are integrated in this synthesis rather than usual analytic approach being used.

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- Arctic Oceans Sciences Board has one program well underway at the planning stage.

- UNESCO MAB (Man and Biosphere) has again been invigorated with four main themes:

  ... looking at ecosystem response to different human impacts;

  ... recovery and restoration of damaged ecosystems;

  ... human investment and natural resource use; and

  ... human response to environmental stress.

- Finish Initiative: Innuit Circumpolar Conference has issued a similar challenge (to develop a science and environmental protection policy).

- Arctic arms control: an overriding concern is the increased militarization of the arctic and the impact this may create. One Canadian response to this has been to ask PCO to look into the question of what Canada can do to deal with this. Confidence building measures are proposed; these have a strong environmental and scientific component. A strong research program in the arctic would be a "drop in the bucket" compared to planned expenditures. Arctic science is one of the roles Canada can play extremely well.

8. Panel Session: Opportunities, Strategies and Actions for Future

Chairperson: E.F. Roots
Panel Members: B. Janes
B. Hrycyk
B. Stephen
J. Reid

Dr. Roots opened the discussion by posing the following question to the panel: "What is it that is constructive, that we should do next?"

A. Panel Members Brief

i) J. Reid:

- Integration and action required. Canada and Polar Science, The March, 1987, publication of DOE, proposed solutions that need to be read again. There are seven main recommendations suggested in this report. These are as valid today as in 1987. Why has the report sat on the shelf for so long? We can re-endorse these, come up with a one page recommendation - declaration.

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- LRTAP, ozone layer depletion, toxics in food chain, climate change are significant factors.

- We must look at the north in the global context.

- Need sustainable science as much as sustainable development.

- SOE and Arctic reports are tremendous tools. SOE reporting has been disappointing in DOE to date. Need integration, to show interactions. Do SOE reporting in schools and universities. We want people to understand it, not just scientists.

ii) B. Hrycyk:

- PCSP "Arctic Awareness" program: Trying to get artists and writers to come to the north. Fifteen individuals and/or groups are to submit proposals. Also, have had 4 or 5 television firms filming in the Arctic.

- PCSP called on as advisor to other countries on Polar Science.

- Well placed logistically, will act as logistic link for IASC (International Arctic Science Committee) if/when it forms.

- Communication is an important part of the "awareness" program.

iii) W. Stephen:

- Increasingly northern problems are not uni-dimensional. They have social, political, economic and international dimensions. The era for doing science for sciences sake is probably passed. Marketing of science has to be on a much broader front. Marketing is very much "part of the game".

- Need for education is important. We can do a great deal to bolster northern colleges by providing our expertise, 2 or 3 weeks at a time without charging the college.

- On regulatory responsibilities, we should get industry to buy in better to environmental commitment. Security bonds is one way to do this (eg. Territorial Lands Act).

iv) R. Janes:

- 14 opportunities for action were outlined earlier in the presentation.

- Canada Polar Commission: we need to go ahead with it, to allow Canada to deal effectively with Polar research, and to integrate it with complex issues. Recommended that DOE assume leadership role to get this going.

- On local level, government agencies should develop policies to hire northern residents for the science effort.

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- On national level, DOE should take lead role to organize a northern research priorities forum on a mulitdisciplinary basis (government, universities, native, industry, all the sciences).

- Need to review the organizational alternatives. ACND, National Academy of Sciences, etc. must be integrated (networked) organizationally.

- On publicizing work: this is a matter of course.

B. General Discussion

- Some unique things have been said today. Some excellent attempts have been made in the past to organize science forums in the north. Prime example is the 1978 blue book of science in the north. It sought re-definition of what DIAND and/or Coast Guard should be doing in the north. This was a one time affair. However, when the time for action came, the government changed. Another attempt was made at the liberal caucus meeting in Montebello. While this has been continuing, our drawback may have been in being too ambitious in the past.

- One alternative is to start modestly. For example, PCSP Advisory Committee may be able to overview expectations a few years forward.

- An option may be the continuation of Northern Science Seminar, perhaps, at the invitation of the Science Institute of the N.W.T.

- In 1992, there will be an international symposium proposed for Saskatoon. This may be a useful point of continuity.

- "Urgency" items or "forcing functions" to which we have to react may serve as useful stimuli. For example, global rate of change of climate can be most striking in the northern latitudes. Responses to the phenomena are going to be environmental, social and political. Responsible agencies must be aware that they are getting into science traditionally not handled by them. We need more flexibility in time and space in programs.

- On line data gathering and data systems are becoming more intergrated, but lead time for planning is increasing, ie., platform package for next generation of satellites (1994-95). NASA has now put out a request for proposals aimed at observing the earth in 1995. We need to know what kind of things DOE should be doing in reference to these platform observations. What kind of experiments are to be performed and what type of data we will need? What kind of sensor package should be put on the platforms? Fifty-four programs are being funded now to develop details of sensors for 1995 - 2005 decade; only three programs have good Canadian content.

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- Other forcing functions: the speed of devolution to Territorial governments where experience in science may be small, high interest rates affecting developments, etc. We should change the process: "we only make progress by accident", ie. response to crisis.

- We have lived in the myth of economy of scale. Now we realize we need the flexibility to change to local needs. In CWS, native groups are involved on management boards - this is the ideal that GNWT aspires for.

- Must break away from linear thinking; eg., the study of effects of nuclear war led to the study of the greenhouse effect.

- Need to understand who is benefiting from our science work; federal and territiorial scientists should be able to share infrastructure, information etc., more than today.

- The north is part of a national and international system (eg. weather forecast in south needs information from the north). We need to establish a forum to see if we can be mutually helpful in filling in our respective gaps/needs.

- Also need to make some common themes brought to the attention of seniors, through opportunity events (eg. PM's visit to USSR).

- We are not ready to talk about national strategy. We need better priority setting, better understanding of the many activities (listing, analysis, synthesis of things already in the work plan) before starting new things all over again. How can we improve our knowledge and participation in these activities to do better, and to be better placed to do things in the future?

- In the end, science provides information to someone for better decision-making. We should involve more people in the delivery of our end product, because they will be the ones using it.

- How do we overcome barriers of language, thought process differences, multi-parameter modelling, incentive systems, and eliminate reactive bureaucracy?

- Need to understand client needs (MOT, DND, etc.).

- Need to have a northern strategy, identity, direction, communications/awareness plan.

- How can we make Arctic research more responsive to local needs? Local needs arrise from:

  ... land claims, settlements and devolution;

  ... developments, ie. new initiatives; ongoing operations; abandonment/decommissioning of mining, forestry, oil and gas, and power plants; concerns arising from global issues such as climate change. NWT and Yukon Science Institutes would make good

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coordinating points, finding out local needs from public, industry, non-government and local/regional government, and feed these needs into national research systems/initiatives (government, university).

- Need to ensure our service is relevant. We need some mechanisms/ processes (eg. Parks Planning Process).
- In CORE, two underlying themes are value added and synergy. Value added becomes substance for program delivery. Contribution to synergy is to help various units to work together. These concepts apply equally to science - the efforts should lead to improved decision-making.
- Things are quite good in the North. We are in the process of making them even better through co-operation.
- Suggestion was made that the Prime Minister could announce a $5M annual fund - jointly administered between DOE and the Science Institute of the NWT, which would require an annual conference and would focus on science, health and education.
- New institutional arrangements (land claims, etc.) need to be reviewed. How have things changed and how do we need to adjust for future land claims and other changes?
- On the memorandum to Cabinet (MTC), we will need to define what we're doing, what will be produced in the next few years and a few carefully selected suggestions as to what might be put in place (eg. "the good record at home").
- A suggestion was made that the federal government should establish a $25 Million Northern Environmental Health Fund ($5 Million/year for five years). The fund would be jointly managed by DOE and Science Institute of NWT and would include an annual forum (involving community and scientists) to review progress and new directions

C. <u>**Chairperson's Summary Remarks**</u>

- The evolution of what is happening and our ability to deal with it, brings out an increased need for flexibility and adaptability. We need to identify some essential threads that became policy.
- It is not the time to develop grand pragmatic goals, overall actions that we can talk about, but small practical strategies with value added and through linkages with other partners.
- Increasingly we need to build into our middle managers decision-making the need for co-operation with other agencies. This will make our work more effective and contribute to synergy.
- We need to give concerted attention in setting up our programs in ways that others see they own them and are part of them through better marketing.

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- Even during declining resources, we must put increased effort into communication, including within our management board.

- Management should not be the obstacle for science but should be involved in communicating it's values.

- DOE as an agency is positioned to take the lead on some of the northern environmental issues (not in a competitive way).

- DOE can take more effort to stand behind bilateral efforts, eg., in organizing to help the Minister in the Finnish initiative.

- We need a concerted effort to get the right persons at various fora where communications opportunities exist.

9. Closing and Adjournment

M. Balshaw:

- It is CORE's practice to bring together senior officers of DOE, once or twice a year, to brainstorm specific issues.

- The five I's, inform, integrate, institutionalize and initiate at Inuvik, have been all covered during the course of this seminar. The discussion here will be helpful for input to policy.

- This seminar has helped exchange information and broaden our respective understanding, leading to making us all better policy advisors for the future diverse and highly integrated "northern agenda".

- Thanks for your participation.

OPENING REMARKS

1.. Brief background of the rational for holding the seminar:

- Review of some of the points of January 16, outline attached.
- Events since then have shown that interest in the Arctic has increased, eg:
  - Arctic Environment Strategy for Canada;
  - DOE's Action Plan for the Arctic;
  - new international initiatives;
  - changing institutional arrangements, such as progress in land claims; and
  - proposed Prime Minister's trip to USSR.

2. Support for the seminar came from two DOE Regions: Western and Northern, and Pacific and Yukon.

3. Objectives:

- Overview of environmental science programs that have been and are being conducted, as these relate to program delivery responsibilities.
- Assess requirements in context of departmental and governmental objectives.
- Consider strategic intent that would support long-term, sustainable and credible scientific programs.

Science was left undefined, but was to consider a range of "scientific" activities/data collection, monitoring, regulation support, applied science and pure research, the emphasis being on relevance to program delivery.

4. Presentations:

- The tentative program outline sent out with your invitations provided the general guidance for the presentations--some structure was felt to be important, and our experience shows there would be some variations to this request in any event.
- The intent is to establish a 'basic' understanding of mandate and rational for current science programs, science issues and priorities, plans, co-operative initiatives and any strategic directions.
- Discussion should seek to obtain any clarifications, and provide suggestions for strategic intent, separating questions of resources and jurisdictions, instead of focussing on what science is needed for supporting the delivery of governmental objectives.

5. Products:

- A familiarization with the north (for at least some participants), Inuvik being the reason for the seminar.
- A familiarization with the broad range of northern environmental science as it relates to program needs.
- An assembly of items of presentation, discussion summaries, and 'strategic intent' identified.

The bottom line: what environmental science do we need in the long term to ensure that the many and varied government objectives are effectively and efficiently achieved? This product would become the basis for our individual agencies for any subsequent strategic and operational planning required within our administrations to move in the directions of the strategic intent.

RATIONALE FOR

NORTHERN SCIENCE SEMINAR

1. **Recent Government Initiatives:**

- Minister's office has asked the department to identify a "northern initiative".

- DOE has recently provided suggestions for research opportunities to be provided by the Polar 8 ice-breaker.

- The Science Council is undertaking a review of what is happening in the North, and will be holding a series of it's own workshops in the near future. Technology development and the application of science are viewed as the most urgent requirements.

- MOSST is in the process of developing a 'policy' on Northern Science and Technology, to establish Canada as a leader in key areas of northern science and technology.

- Other federal policies are being developed:

  - Northern Policital and Economic Framework
  - Joint Action Plan for Achieving Northern Conservation Strategy
  - Arctic Marine Conservation Strategy
  - Canadian Polar Research Commission Report
  - Canadian Climate Program

- External Affairs is developing comprehensive international protocols for Canadian participation in basic and applied sciences, commercial contracts and trade initiatives directed at Canada's own North.

- There are new, recent, international initiatives (eg. USSR) aimed at rationalizing and promoting exchange on a wide range of S&T-related activity in circumpolar regions.

2. **Background:**

- Preliminary workshop design - October 1988:
  - changing policical and economic environment;
  - scientific issues-local, circumpolar, global; and
  - operational issues.

- Review by WNR and PY COREs - December 1988, and January 1989:
  - general support;
  - better focus;
  - largely internal to DOE; and
  - tie in to national CORE meeting.

- Current proposal focusses on DOE need in a rapidly changing 'environment', and is intended to facilitate DOE in repsonding to (perhaps leading in) the external activities of which we are an important part.

NORTHERN SCIENCE SEMINAR

CANADIAN WILDLIFE SERVICE PROGRAMS

INTRODUCTION:

THE TERM "NORTHERN SCIENCE" IS RATHER BROAD. THEREFORE, BEFORE LAUNCHING INTO A DISCUSSION OF CWS PROGRAMS, I SHOULD BRIEFLY DEFINE THESE TERMS FOR THE PURPOSE OF THIS PRESENTATION. "NORTHERN" IS A RELATIVE TERM WHICH IS OFTEN INFLUENCED BY ONES BASE OF OPERATIONS. IN THIS INSTANCE, "NORTHERN" WILL REFER TO THE GEOGRAPHIC EXTENT OF BOTH YUKON AND NWT. HOWEVER, MY COMMENTS WILL SHOW A DISTINCT BIAS TOWARD NWT FOR IT IS THE AREA WHICH I AM MOST FAMILIAR WITH. "SCIENCE" REFERS TO KNOWLEDGE AND THE SYSTEMATIC PROCESS OF ACQUIRING KNOWLEDGE. THE ULTIMATE GOAL OF THIS PROCESS IS THE FORMULATION OF RULES OR LAWS WHICH EXPLAIN THE FUNCTIONING OF OUR NATURAL WORLD. THE PROCESS IMPLIES A PROGRESSION FROM INFORMATION GATHERING TO INFORMATION ANALYSIS AND, ULTIMATELY, TO AN UNDERSTANDING OF THE BIOLOGICAL FORCES WHICH IMPINGE THE SPECIES WHICH WE MANAGE. "SCENCE", FOR THIS PRESENTATION, WILL BE CONSIDERED TO BE "KNOWLEDGE" - IN THE BROADEST SENSE.

ACCORDING TO THE BACKGROUND INFORMATION, I'M SUPPOSED TO DISCUSS CWS'S MANDATE, NORTHERN SCIENCE PROGRAMS, OUR RESOURCES, COOPERATIVE INITIATIVES, STRATEGIC DIRECTIONS AND SCIENCE ISSUES AND PRIORITIES. I PROPOSE TO TOUCH ON ALL OF THE ABOVE, EXCEPT FOR THE LAST ITEM WHICH I BELIEVE WILL BE DISCUSSED ELSEWHERE IN THE SEMINAR.

CANADIAN WILDLIFE SERVICE MANDATE:

AS THE FEDERAL AGENCY RESPONSIBLE FOR WILDLIFE MANAGEMENT IN CANADA, CWS MANDATE IS DERIVED FROM TWO PIECES OF LEGISLATION:

THE MIGRATORY BIRDS CONVENTION ACT (1917) STEMS FROM A TREATY WHICH WAS SIGNED WITH THE UNITED STATES A YEAR EARLIER. THE ACT, WAS PROBABLY THE FIRST TO RECOGNIZE THE INTERNATIONAL NATURE OF MIGRATORY BIRD MANAGEMENT. CONVERSELY, IT IGNORED THE ISSUE OF NORTHERN SPRING HUNTING WITH WHICH WE ARE STILL GRAPPLING 70 YEARS LATER. PURSUANT TO THIS ACT, CWS ADMINISTERS TWO SETS OF REGULATIONS:

MIGRATORY BIRD REGULATIONS ADDRESS THE HARVEST AND POSSESSION OF MIGRATORY BIRDS WHEREAS,

MIGRATORY BIRD SANCTUARY REGULATIONS PROVIDE FOR THE ESTABLISHMENT AND MANAGEMENT OF BIRD SANCTUARIES.

THE CANADA WILDLIFE ACT WAS APPROVED IN 1973. UNDER THIS ACT, CWS MAY TAKE MEASURES FOR THE PROTECTION OF ANY SPECIES OF NON-DOMESTICATED ANIMAL IN DANGER OF EXTINCTION OR ACQUIRE LANDS FOR THE PURPOSES OF WILDLIFE RESEARCH, CONSERVATION, OR INTERPRETATION. THE ADMINISTRATION OF SUCH LANDS IS GOVERNED BY THE WILDLIFE AREA REGULATIONS.

CWS PERFORMS A NUMBER OF ROLES IN THE PROCESS OF FULFILLING ITS MANADATE. THEY ARE WORTH CONSIDERING IN THE CONTEXT OF NORTHERN SCIENCE.

CANADIAN WILDLIFE SERVICE ROLES:

MANAGER: CWS MANAGES MIGRATORY BIRD POPULATIONS, WITHIN A NATIONAL CONTEXT, BY MONITORING POPULATION LEVELS, AND SETTING HUNTING SEASONS AND BAG LIMITS AS REQUIRED. WE ALSO MANAGE KEY WILDIFE HABITAT WHICH IN THE NORTH INCLUDES 16 SANCTUARIES AND ONE NATIONAL WILDLIFE AREA (APPROXIMATELY 170,000 SQUARE KILOMETRES).

ADVISOR: CWS PROVIDES ADVICE, ON WILDLIFE MATTERS, TO OTHER FEDERAL OR TERRITORIAL DEPARTMENTS AND AGENCIES. EXAMPLES WOULD INCLUDE THE CARIBOU MANAGMENT BOARDS, INUVIALUIT WILDLIFE MANAGEMENT ADVISORY COUNCIL, CANADA/GNWT ECONOMIC DEVELOPMENT AGREEMENT (REN. RES. SUBSIDIARY AGREEMENT), AND EARP HEARINGS.

REGULATOR: CWS ADMINISTERS THE REGULATIONS WHICH HAVE BEEN ALREADY MENTIONED. THIS INCLUDES THE ESTABLISHMENT OF ANNUAL BAG LIMITS FOR VARIOUS GAME SPECIES AND THE ISSUANCE OF PERMITS RELATING TO PROTECTED AREAS AND THE POSSESSION OF WILDLIFE.

ENVIRONMENTAL AUDITOR: AS A RESULT OF A RECENT DEPARTMENTAL REORGANIZATION, CWS IS REPSONSIBLE FOR PRODUCING "STATE OF THE ENVIRONMEMT" REPORTS WHICH COLLATES INFORMATION, FROM A VARIETY OF

SOURCES, ON THE HEALTH OF OUR ENVIRONMENT. A NORTHERN EDITION OF THIS REPORT HAS NOT YET BEEN COMPLETED BUT I UNDERSTAND THAT IT IS BEING CONSIDERED.

NEGOTIATOR: CWS IS RESPONSIBLE FOR NEGOTIATING INTERNATIONAL AND TRANSBOUNDARY AGREEMENTS REGARDING WILDLIFE. EXAMPLES WOULD INCLUDE PORCUPINE CARIBOU MANAGEMENT AGREEMENT, INTERNATIONAL POLAR BEAR AGREEMENT, TWINNING OF CERTAIN PROTECTED AREAS SUCH AS POLAR BEAR PASS NWA.

ADVOCATE: CWS PROMOTES WILDLIFE CONSERVATION THROUGH NATIONAL WILDLIFE WEEK, ENVIRONMENT WEEK AND OTHER RELATED ACTIVITIES.

RESEARCHER: CWS HAS SEVERAL ONGOING RESERACH PROGRAMS RELATING TO A VARIETY OF MAMMALS (CARIBOU, POLAR BEARS), WATERFOWL, SHOREBIRDS AND SEABIRDS. I WILL ELABORATE ON THESE PROGRAMS AT A LATER POINT.

YOU WILL NOTE THAT THE ROLE OF RESEARCHER HAS COME LAST IN THE LIST. THIS HAS BEEN DONE, INTENTIONALLY, TO EMPHASIZE ITS IMPORTANCE RELATIVE TO ALL THE OTHER ROLES WHICH CWS FULFILLS. IT SHOULD BE APPARENT THAT ALL THESE ROLES ARE DEPENDENT UPON KNOWLEDGE. CWS'S ABILITY TO FULFILL THESE ROLES IS ENTIRELY DEPENDENT UPON THE QUALITY OF INFORMATION OR KNOWLEDGE AT OUR DISPOSAL. SCIENCE, THEREFORE, IS FUNDAMENTAL TO CWS'S ABILITY TO FULFILL ITS MANDATE.

IN THIS CONTEXT, I WISH TO BRIEFLY DISCUSS CWS NORTHERN PROGRAMS WHICH GENERATE MUCH OF OUR KNOWLEDGE.

CANADIAN WILDLIFE SERVICE NORTHERN PROGRAMS:

CWS HAS ABOUT 25-30 PYS, SCATTERED ACCROSS THE COUNTRY, WHICH ARE INVOLVED IN NORTHERN PROGRAMS. ALTHOUGH, THE NUMBER OF PYS PROBABLY REMAINS RELATIVELY CONSTANT, ACTUAL INDIVIDUALS WILL VARY ACCORDING TO THE PROJECTS AND PRIORITIES AT ANY GIVEN TIME. ABOUT 2/3 OF THESE PYS ARE WITHIN THE WESTERN AND NORTHERN REGION AND FIVE OF THE WNR PYS ARE BASED IN YELLOWKNIFE.

AS THERE IS NO SIMPLE WAY TO DEMONSTRATE THE EXTENT OF OUR NORTHERN PROGRAMS, I HAVE JUST LISTED THE NORTHERN PROJECT TITLES AS PRESENTED IN OUR ANNUAL PLANNING DOCUMENTS (SEE APPENDIX 1). THIS LIST DOES NOT INCLUDE ALL CWS PROJECTS BUT IT WILL PROVIDE SOME INDICATION OF THE EXTENT OF OUR ACTIVITIES. THE MAJOR THRUSTS OF OUR NORTHERN PROGRAMS ARE PRESENTED BELOW.

MIGRATORY BIRDS:

THE MAJORITY OF OUR MIGRATORY BIRDS STUDIES FOCUS ON GAME SPECIES PARTICULARLY GEESE AND DUCKS. SEVERAL OF THESE PROJECTS, PARTICULARLY THE GOOSE WORK REFLECTS PRIORITIES THAT ARE RECOGNIZED WITHIN A CONTINENTAL CONTEXT. FOR THE LAST COUPLE OF YEARS, SNOW GEESE HAVE BEEN BANDED AND COLLARED AT A NUMBER OF THE WESTERN ARCTIC COLONIES AND A NETWORK OF OBSERVERS, SCATTERED THROUGHOUT

THE US AND MEXICO HAVE BEEN MONITORING THE MOVEMENTS OF THESE BIRDS DURING MIGRATION AND ON THEIR WINTERING GROUNDS. THE STUDY SHOULD ULTIMATELY DEFINE THE WINTERING AREAS OF THE VARIOUS COLONIES WHICH BREED IN ARCTIC CANADA AND PROVIDE SOME MEASURE OF THE HUNTING PRESSURE WHICH EACH POPULATION IS EXPERIENCING. THIS YEAR, THE COLLARING EFFORT WILL BE EXTENDED TO INCLUDE THE CENTRAL ARCTIC BIRDS WHICH BREED IN THE QUEEN MAUD GULF BIRD SANCTUARY. THE RUSSIANS ARE ALSO IN ON THE ACT FOR GEESE WHICH BREED ON WRANGLE ISLAND WINTER IN SOUTHERN BRITISH COLUMBIA. ONE OF OUR STAFF IS PRESENTLY IN RUSSIA AND WILL BE COOPERATING WITH THE LOCALS ON SOME WORK AT WRANGLE ISLAND.

TRUMPETER SWANS HAVE CAUGHT OUR ATTENTION FOR THEY HAVE RECENTLY EXPANDED INTO THE NWT (LAST 20 YEARS) IN THE NAHANNI BUTTE AREA AND SEEM TO BE WELL ESTABLISHED THERE. WE HAVE COLLARED QUITE A NUMBER OF BIRDS AND HAVE BEEN GETTING GOOD INFORMATION ON THEIR MIGRATION ROUTES AND WINTERING AREAS. AS WITH MANY NORTHERN SPECIES, THE WEAK LINK IN THE CHAIN OF ANNUAL EVENTS FOR THIS SPECIES LIES OUTSIDE OUR JURISDICTION. DURING THE WINTER, THE SWANS ARE DEPENDENT UPON A COUPLE OF RIVERS IN THE AREA OF YELLOWSTONE NATIONAL PARK WHICH REMAIN OPEN YEAR ROUND. HOWEVER, THE WATER FLOW ON THESE RIVER ARE MANIPULATED BY A LOCAL ELECTRICAL UTILITY WHICH CAN HAVE A SIGNIFICANT IMPACT ON THE BIRDS - IF THE RIVERS FREEZE OVER.

IN GENERAL, THE BREEDING BIOLOGY OF BOREAL FOREST DUCKS IS RATHER POORLY UNDERSTOOD. WE HAVE BEEN INVOLVED IN A STUDY OF THESE

SPECIES, NEAR YELLOWKNIFE, FOR A FEW YEARS NOW WHICH WILL CERTAINLY INCREASE OUR UNDERSTANDING OF THESE SPECIES. AS SIMILAR WORK WAS DONE ON THE SAME STUDY AREA DURING THE 1960S, THIS STUDY SHOULD YIELD GOOD COMPARATIVE RESULTS OVER THE TWENTY-YEAR PERIOD. THIS STUDY AND A NUMBER OF OTHERS WHICH WE ARE UNDERTAKING FROM OUR YELLOWKNIFE OFFICE ARE PRIME EXAMPLES OF THE WORK WHICH CAN BE UNDERTAKEN, AT RELATIVELY LITTLE EXPENSE WHEN STAFF ARE BASED IN THE NORTH.

WILDLIFE HABITAT:

THE NWT HABITAT PROGRAM IS ADMINISTERED FROM OUR YELLOWKNIFE OFFICE. THE PROGRAM INVOLVES THE INDENTIFICATION, EVALUATION AND UTLIMATELY THE DESIGNATION OF KEY MIGRATORY BIRD HABITATS. IN 1984 WE PUBLISHED A LIST OF APPROXIMATELY 60 KEY HABITAT SITES IN NWT. SINCE THAT TIME, WE HAVE REEVALUATED A NUMBER OF SITES AND ARE PRESENTLY UPDATING THAT LIST WHICH SHOULD BE AVAILABLE BY THE END OF THIS FISCAL YEAR. WE ALSO HAVE THREE PROPOSED SANCTUARIES UNDER CONSULTATION OF WHICH PRINCE LEOPOLD ISLAND SHOULD BE DESIGNATED WITHIN A MATTER OF MONTHS. WE HAVE ALSO BEGUN PRELIMINARY DISCUSSION WITH GRISE FIORD REGARDING THE DESIGNATION OF COBURG ISLAND. THIS SITE WAS RECOMMNENDED FOR PROTECTION DURING THE LANCASTER SOUND LAND USE PLANNING EXERCISE. MANAGEMENT PLANS FOR FIVE WESTERN ARCTIC SANCTUARIES WILL ALSO BE AVAILABLE FOR CONSULTATION WITHIN THIS FISCAL YEAR. POLAR BEAR NWA PLAN IS UNDERGOING PUBLIC CONSULTATION AT THE MOMENT AND SHOULD BE FINALIZED WITHIN A COUPLE OF MONTHS.

ENDANGERED SPECIES:

WE ARE ALSO INVOLVED IN RECOVERY EFFORTS FOR FOUR NORTHERN ENDANGERED SPECIES; ALL OF WHICH ARE SHOWING POSITIVE SIGNS OF RECOVERY. THE WHOOPING CRANES WHICH BREED ONLY IN WOOD BUFFALO NATIONAL PARK ARE AT ALL TIME HIGH NUMBERS AND IT IS ANTICIPATED THAT THE POPULATION WILL SOON INCREASE MARKEDLY AS A NUMBER OF SUB ADULTS JOIN THE BREEDING POPULATION.

FOR A NUMBER OF YEARS WE HAVE MAINTAINED A BREEDING FACILITY FOR PEREGRINE FALCONS ON THE WAINWRIGHT MILITARY RESERVE. CHICKS ARE REARED AT THIS FACILITY AND RELEASED IN VARIOUS PARTS OF THE COUNTRY. THE ORIGINAL BREEDING STOCK FOR THIS FACILITY CAME FROM NWT ALTHOUGH MOST OF THE YOUNG BIRD ARE PLACED ELSEWHERE IN CANADA.

THE GOAL OF FIVE FREE-RANGING BISON HERDS HAS NOW BEEN REACHED AND THIS SPECIES WILL SOON BE DOWNGRADED FROM ITS PRESENT "ENDANGERED" STATUS. A NUMBER OF ANIMALS WERE RELEASED IN THE FORT LIARD AREA DURING THE PAST WINTER TO SUPPLEMENT THE ANIMALS WHICH ARE ALREADY THERE FROM AN EARLIER TRANSPLANT.

WE HAVE ALSO BEEN UNDERTAKING SURVEYS OF THE PEARY CARIBOU WHICH OCCUPIES THE HIGH ARCTIC ISLANDS. THERE IS SOME INDICATION THAT THE NUMBERS OF THIS SPECIES IS INCREASING ALTHOUGH IT IS STILL TOO EARLY TO ASSUME THAT THE SPECIES IS OUT OF DANGER.

INTERNATIONAL WATER AND WILDLIFE RESOURCES:

CWS, ON BEHALF OF CANADA IS PARTY TO THE INTERNATIONAL POLAR BEAR AGREEMENT REGARDING THE MANAGEMENT OF THIS SPECIES. WE HAVE HAD A LONG-STANDING PROGRAM ON POLAR BEAR RESEARCH WHICH HAS DONE MUCH TO ADVANCE OUR UNDERSTANDING OF THE POPULATION DYNAMICS SPIECES OF THIS SPECIES. IT IS NOTEWORTHY THAT IAN STIRLING WAS THE ADVISOR TO THE INUVIALUIT WHEN THEY SIGNED THEIR RECENT AGREEMENT WITH THE NUPIAT REGARDING THE SHARING OF THE BEAUFORT SEA POPULATION.

CWS, PY, IS IN THE FINAL STAGES OF A MULTI-YEAR STUDY OF THE PROCUPINE CARIBOU HERD. THE WORK FOCUSED ON THE RANGE QUALITY AND POPULATION DYNAMICS.

NATIONAL/REGIONAL WATER AND WILDLIFE RESOURCES:

NORTHERN OPERATIONS INCLUDES CWS PARTICIPATION IN THE PENDING LAND CLAIMS (DENE/METIS AND TFN) AND THE IMPLEMENTATION OF OUR COMMITMENTS UNDER THE INUVIALUIT FINAL AGREEMENT.

THE REMAINING PROJECTS ARE BEING UNDERTAKEN THROUGH THE IMPLEMENTATION PROGRAM OF TNE INUVIALUIT FINAL AGREEMENT. THESE ARE PROJECTS WHICH HAVE BEEN IDENTIFIED AS PRIORITIES THROUGH THE INUVIALUIT WILDIFE MANAGEMENT ADVISORY COUNCIL WHICH IS A JOINT INUVIALUIT/GOVERNMENT BODY. THE HARVEST STUDY IS UNIQUE IN THAT GOVERNMENT AGENCIES ARE FUNDING A PROJECT WHICH IS ADMINISTERED

ENTIRELY BY A USER GROUP (INUVIALUIT).

ENVIRONMENTAL IMPACTS OF NEW DEVELOPMENTS:

A NUMBER OF PROJECTS ARE BEING UNDERTAKEN TO EVALUATE THE IMPACTS OF INDUSTRIAL DEVELOPMENT ON WILDLIFE. THE CONTAMINATION OF NORTHERN COUNTRY FOODS IS A RECENT ISSUE THAT CWS IS PRESENTLY ADDRESSING.

COOPERATIVE MANAGEMENT:

IT SHOULD BE APPARENT FROM MANY OF THE PROJECTS THAT WE UNDERTAKE THAT THE MANAGEMENT OF MIGRATORY SPECIES INVOLVES A HIGH DEGREE OF COOPERATION AMONG VARIOUS MANAGEMENT AGENCIES, BOTH WITHIN AND OUTSIDE CANADA. THIS COOPERATION WILL BE EXTENDED TO ANOTHER LEVELS THROUGH THE CLAIM SETTLEMENTS WHERE THERE WILL BE JOINT MANAGEMENT BOARDS WHICH INCLUDE MANAGEMENT AGENCIES AND THE LOCAL USERS.

ON AN INTERNATIONAL LEVEL, CWS HAS A LATIN AMERICAN PROGRAM WHEREBY THERE IS AN EXCHANGE OF STAFF FOR TRAINING PURPOSES OR PROJECTS OF INTEREST TO CANADA AND A PARTICULAR LATIN AMERICAN COUNTRY ARE CONDUCTED COOPERATIVELY. PAST STUDIES HAVE INCLUDED WORK ON SNOW GEESE, PEREGRINE FALCONS AND SHOREBIRDS.

IN THE FALL OF 1988, CWS SIGNED AN ACCORD WITH THE MEXICAN WILDLIFE AGENCY REGARDING THE COOPERATIVE STUDY OF MIGRATORY BIRDS AND I

UNDERSTAND THAT A SIMILAR AGREEMENT WITH RUSSIA IS BEING CONTEMPLATED.

CURRENT INITIATIVES:

A COUPLE OF PROJECTS THEY ARE PRESENTLY AT THE DEVELOPMENT RATHER THAN IMPLEMENTATION STAGE.

THE ARCTIC GOOSE JOINT VENTURE IS A COMPONENT OF THE NORTH AMERICAN WATERFOWL MANAGEMENT PLAN WHICH IS PRESENTLY AWAITING FEDERAL FUNDING. IT WILL BE A COOPERATIVE EFFORT AMONG THE VARIOUS CANADIAN AND AMERICAN GOVERNMENT AND NON-GOVERNMENT WILDLIFE AGENCIES. THE FEDERAL GOVERNMENT WILL PROVIDE SEED MONEY WHICH WILL BE SUPPLEMENTED BY OTHER AGENCIES.

CWS IS BEGINNING TO CONSIDER THE IMPLICATIONS OF CLIMATE CHANGE ON MIGRATORY BIRDS. AT THIS STAGE WE ARE TRYING TO DEFINE OR SCOPE THE PROBLEM BEFORE PROCEEDING TO FURTHER STUDY.

CWS IS STILL WORKING ON AN AMENDMENT TO THE MBCA WHICH WILL LEGALIZE SPRING HUNTING. THIS IS AN ISSUE OF IMPORTANCE TO MANY NORTHERN PERSONS AND WE ARE STRIVING TO RESOLVE THIS ISSUE AS SOON AS POSSIBLE.

STRATEGIC DIRECTIONS:

LAND CLAIMS HAVE AND WILL CONTINUE TO HAVE A SIGNIFICANT IMPACT ON HOW WE CONDUCT RESEARCH IN THE NORTH. TO DATE, MANY OF OUR RESEARCH PRIORITIES ARE DEVELOPED WITHIN A CONTINENTAL OR INTERNATIONAL CONTEXT. UNDER THE CLAIM AGREEMENTS, EACH CLAIM AREA WILL HAVE A WILDLIFE MANAGEMENT BOARD (JOINT NATIVE/GOVERNMENT COMPOSITION) WHICH WILL DIRECT WILDLIFE MANAGEMENT WITHIN EACH SETTLEMENT AREA. PRIORITIES WILL BE DEVLOPED BY THE BOARDS AND WE WILL BE EXPECTED TO RESPOND TO THESE REQUESTS. IN A FUNCTIONAL SENSE, WE WILL BE GOVERNMENT CONSULTANTS TO THE CLAIMANT GROUPS. THIS IS NOT AN UNDESIREABLE ARRANGEMENT. HOWEVER, IT WILL IMPOSE CONDSIDERABLE DEMANDS ON OUR SERVICE TO RESPOND TO THESE DEMANDS WHILE, AT THE SAME TIME, ADDRESSING WILDLIFE ISSUES IN A BROADER CONTEXT.

IN CLOSING, I WOULD SUGGEST THAT THIS IS AN OPPORTUNE TIME FOR CWS TO RECONSIDER ITS PRESENT APPROACH TO THE DELIVERY OF ITS NORTHERN PROGRAMS.

APPENDIX 1. SUMMARY OF CWS NORTHERN PROJECTS

PROJECT TITLE	REGION
MIGRATORY BIRDS:	
SNOW AND ROSS GOOSE MANAGEMENT	WNR
USSR/CANADA EXCHANGE (SNOW GEESE)	WNR
SWAN AND GOOSE HABITAT ASSESSMENT (MACKENZIE DELTA)	WNR
TRUMPETER SWAN MANAGMENT	WNR
DUCK PRODUCTIVITY - BOREAL FOREST	WNR
CANADA GOOSE STUDIES - KEEWATIN	WNR
SEABIRD COLONY SURVEYS	HQ
DISTRIBUTION OF MARINE BIRDS AT SEA	HQ, QUE
THICK-BILLED MURRE BREEDING BIOLOGY	HQ
EIDER SURVEYS - HUDSON STRAIT	QUE
WILDLIFE HABITAT:	
PRAIRIE AND NWT SHOREBIRD SURVEYS	WNR
HABITAT MANAGMENT - NWT	WNR
ENDANGERED SPECIES:	
WHOOPING CRANE ECOLOGY	WNR
PEREGRINE FALCON RECOVERY PROGRAM	WNR
WOOD BISON REHABILITATION	WNR
PEARY CARIBOU CONSERVATION	WNR
INTERNATIONAL WATER AND WILDLIFE RESOURCES:	
POLAR BEAR STUDIES	WNR
PORCUPINE CARIBOU STUDIES	PY

NATIONAL/REGIONAL WATER AND WILDLIFE RESOURCES:

NORTHERN OPERATIONS	WNR
WHITE-FRONTED GOOSE POPULATION SURVEYS - WESTERN ARCTIC	WNR
INUVIALUIT HARVEST STUDY	WNR
SNOW GOOSE MANAGEMENT WESTERN ARCTIC	WNR
BRANT POPULATION DYNAMICS	PY
SNOW GOOSE HABITAT STUDIES - NORTH SLOPE	PY
WLDLIFE MANAGEMENT ADVISORY COUNCIL	WNR

ENVIRONMENTAL IMPACTS OF NEW DEVELOPMENTS:

OIL DEVELOPMENT AND BIRDS IN THE BEAUFORT SEA AREA	WNR
ENVIRONMENTAL REVIEWS	WNR
CONTAMINANTS IN WATERFOWL	HQ
CONTAMINANTS IN POLAR BEARS	HQ

FIELD TRIPS

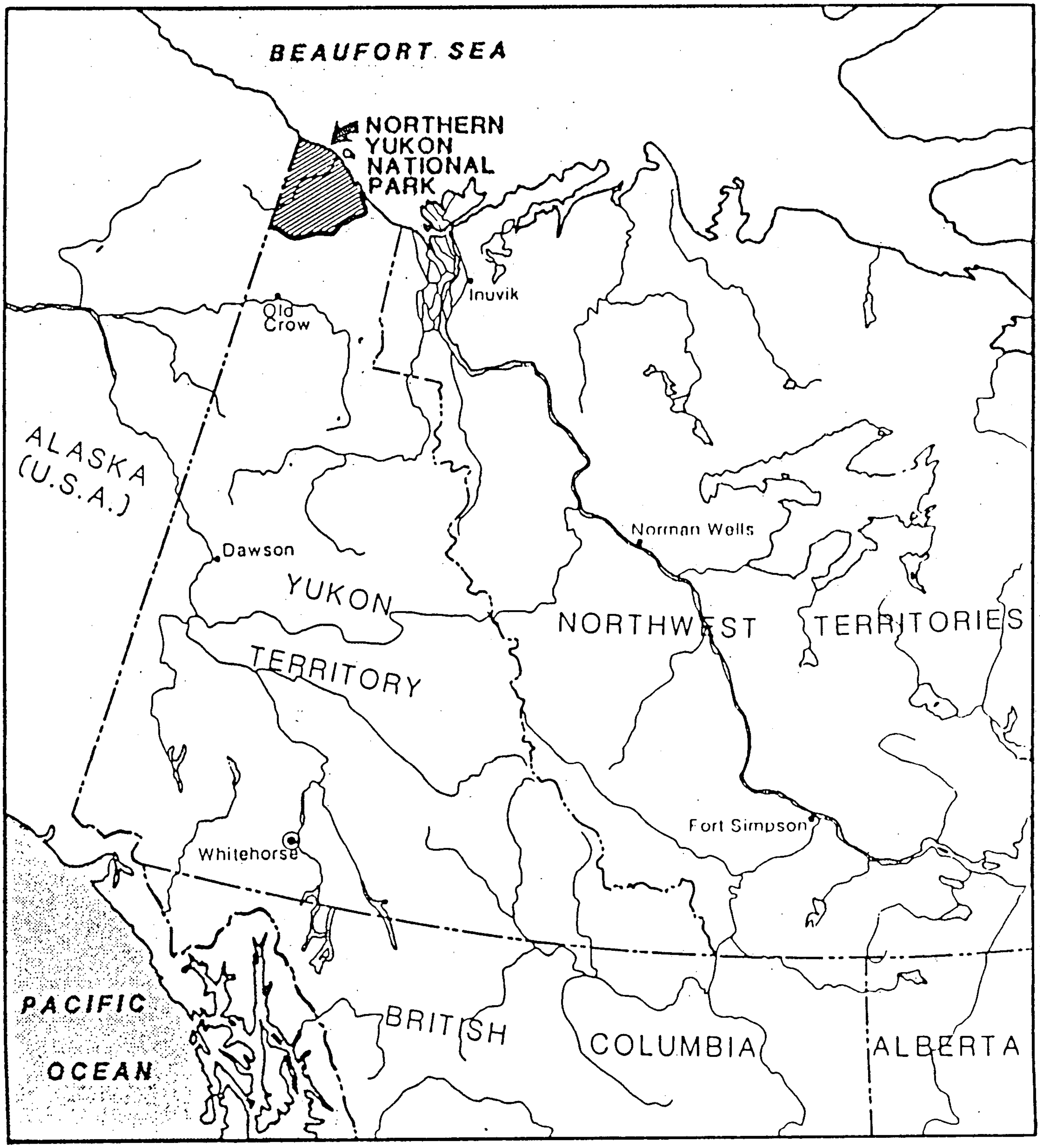
June 10 & 11, 1989

Two aircrafts were chartered, one destined for Whitehorse and the other destined to return to Inuvik. A total of 15 persons took this field trip. The planned routing was: Inuvik - Tuktoyaktuk - Richards Island - Bar Two DEW Line site - King Point - Stokes Point - Herschel Island - Old Crow (brief stop and refuelling) - and overnight at Dawson. The attached map describes the major points of interest covered by the field trip.

The participants of this field trip spent about 2 hours at Tuktoyaktuk and saw an off-shore oil rig, Tuktoyaktuk harbour, and the city. PCSP provided coffee and snacks. Participants also got an opportunity to fly over the Beaufort Sea. They saw the tundra, off-shore oil rigs, and wild life.

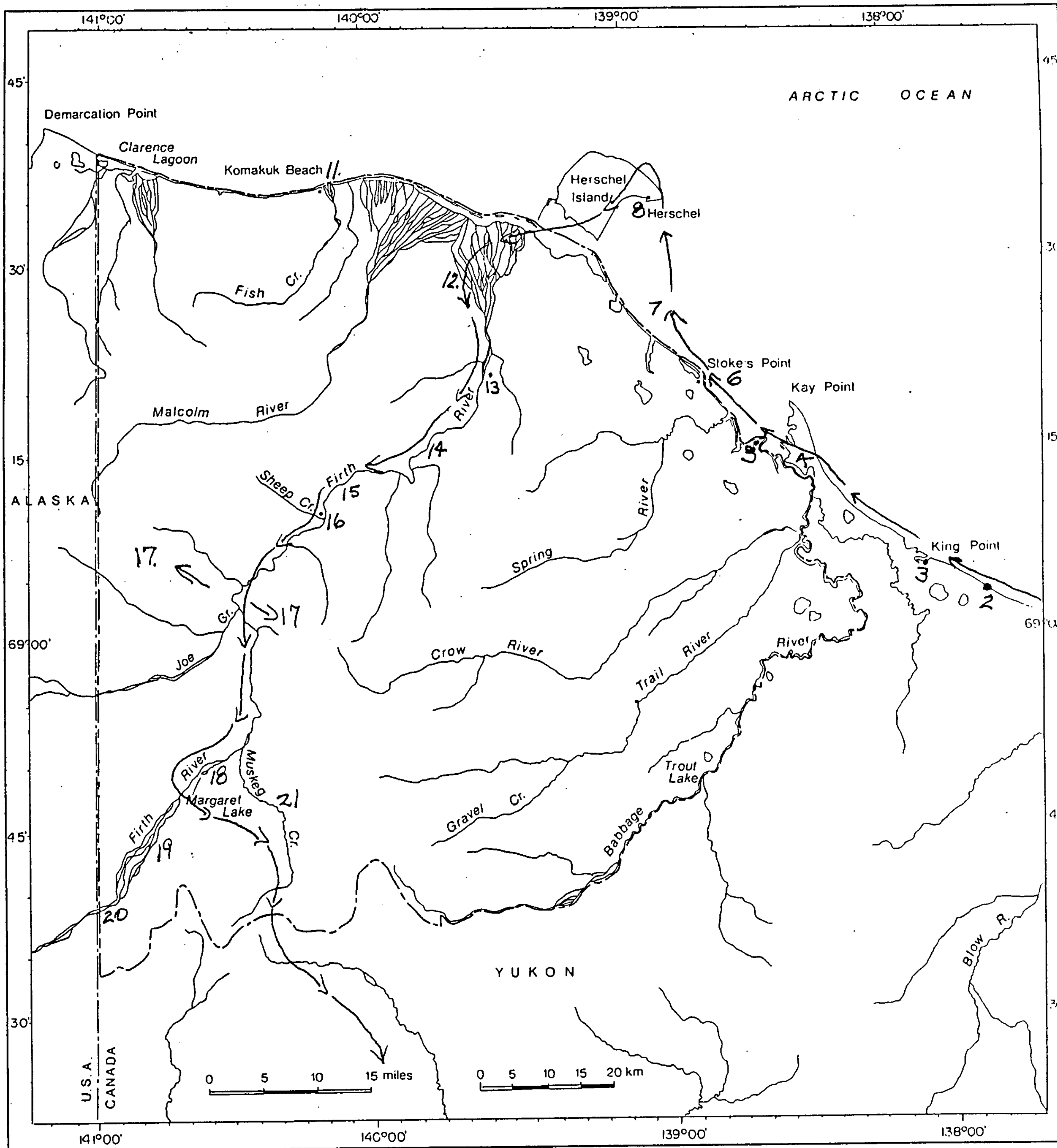
June 8, 1989

A guided walking tour was also provided by Alan Hegginbottom for the evening, following dinner. It was designed to illustrate aspects of the town's history and development, including design and construction, environmental monitoring, utilities, relation to surficial geology, and permafrost.



Map 1: Regional Setting

NORTHERN YUKON NATIONAL PARK



LEGEND

POINTS OF INTEREST - NORTHERN YUKON NATIONAL PARK.

NORTHERN SCIENCE PROGRAMS

ENVIRONMENTAL PROTECTION

Environmental Protection is responsible for ensuring that the environment is protected from pollution and physical disturbances where there is a direct federal interest. This includes the administration and enforcement of federal laws, such as the Canadian Environmental Protection Act and sections of the Fisheries Act.

However, Environmental Protection has roles that extend beyond the enforcement of current regulations. Environmental protection advice and assistance is provided to the territorial government, industry, and the public in the Northwest Territories. This is done through advocacy, consensus-seeking, and consultation. A major responsibility of Environmental Protection is to work closely with federal agencies to ensure that federal facilities and activities meet acceptable environmental standards.

Within the context of its mandate, Environmental Protection is responsible for addressing the following needs:

- prevent, reduce, or eliminate the adverse impacts of new developments

- prevent, reduce, or eliminate releases of pollutants that causes loses

- contain or restrict hazardous or toxic substances that are necessary to society

- ensure the cleanup of spills that cause environmental damage

- provide the public with access to environmental information

- achieve environmental protection objectives in a cost-effective manner

Environmental Protection in the North contains such a variety of clients & environmental challenges that there is a constant need for innovation and close cooperation with the public, industry and the agencies of the territorial government. Initiatives to meet this challenge have included:

- the administration and enforcement of CEPA and sections of the Fisheries Act

- the development of agreements, memoranda of understanding, and other arrangements that improve and delineate working relationships with other parties.

- increased consultation with environmental non-government organizations, and with industry.

- strengthened consultation with the territorial government

- provision of enviromental protection advice and assistance to the territorial government, industry, and the public

- provision of environmental protection advice and assistance to federal agencies

- encouraging the development of cost-effective environmental impact mitigation measures through initiation, and promotion of research and development and technology transfer.

All of the above activities involve northern science issues. The specific science programs that Environmental Protection has been involved in can be divided into three main categories:

Waste Management Programs

Environmental Quality Programs

Environmental Emergency Programs

WASTE MANAGEMENT

1. **Municipal Solid Waste**

- Active and Abandoned Solid Waste Disposal Sites
    - Identification and assessment of 432 sites in 1983/84
    - Additional studies of high priority sites in 1984/85; Yellowknife, Norman Wells, Hay River, Inuvik, Tuktoyaktuk, Iqaluit (Frobisher Bay)
- Solid Waste Management Study 1983/84
    - Examination of 25-year growth scenarios for Beaufort Sea/ Mackenzie Valley based on projected oil and gas activities
    - Cost/benefit analysis of solid waste management options
- Strategy Paper for the Management of Solid Wastes in the NWT 1987

2. **Municipal Wastewater**

- Anaerobic Upflow Filter 1983
    - Operated bench-scale plant to assess capabilities of treating low temperature wastewater
- Water Pollution Control Organization Newsletter
    - Produced newsletter dealing with issues of wastewater treatment and disposal
    - Discontinued in 1986
- Municipal Wastewater Effluent Guidelines
    - Provided advice to NWT Water Board in revisions to the guidelines in 1988

3. Air Pollution

- National Air Pollution Surveillance (NAPS) Station
    - Measure ambient air quality in Yellowknife
    - Transferred to GNWT in 1987

- Incineration Studies 1985/86

    - Examined feasibility of municipal solid waste incineration with recovery and utilization of waste heat in Yellowknife and Norman Wells

4. DEW Line/North Warning System Sites

- Survey of Abandoned DEW Line Sites 1984

    - Visit to 10 sites to inventory environmental conditions, determine the extent of environmental problems, recommend clean-up program for all 21 abandoned sites.

- Clean-up of Abandoned DEW Line Sites 1985

    - Participated with DIAND and DND in the removal of PCB contaminated material at all 21 abandoned sites
    - Material was taken to Alaska for disposal

- North Warning System Site Evaluations 1988

    - Visits to Long Range Radar Sites with DND and DIAND to evaluate plans for environmental protection
    - Concentration on fuel storage, hazardous material management, solid waste management, and wastewater management

- Inventory of Active DEW Line Sites 1989

    - Visits to all active sites in Canada with DND and DIAND to compile complete inventory at each site
    - Will focus on hazardous wastes and recommended disposal methods

5. PCB Programs

- PCB Inventory

    - Environmental Protection maintains a record of all PCB-containing materials located in the Northwest Territories

- PCB Education Training
  - Identification and handling of PCB containing equipment and PCB liquid to various audiences
    - DND clean-up personnel (1985)
    - Government and Industry personnel in Iqaluit (1987)
    - Representatives from government and industry in Yellowknife (1988)
    - Dewline Station Managers in Cambridge Bay (1989)
    - Transport Canada representatives in Yellowknife (1989)

6. Federal Facilities

   - Operational deficiencies and potential environmental problems are identified and recommendations for remedial measures are directed to the operators

   - Approximately 60 facilities have been inspected and information compiled on a computer database

ENVIRONMENTAL QUALITY

FRESHWATER PROGRAMS

1. **Oil and Gas Developments**

- Norman Wells/Mackenzie River Hydrocarbon Monitoring

    - Four year NOGAP contract study of hydrocarbon effects from Norman Wells Refinery on the Mackenzie River (1984-1988)

    - Mackenzie River water, sediment and fish bile, muscle and liver tissues sampled for selected polynuclear aromatic hydrocarbons(PAH) and light aromatics

    - Burbot and grayling caged below refinery outfall and natural seeps to measure accumulation of hydrocarbons

    - Results showed significant uptake of PAH in grayling in 10 day exposures

    - Refinery effects not distinquishable from natural oil seeps with current methods

- Norman Wells Research and Monitoring Working Group

    - Multi-agency, industry and university group conducting research and monitoring of the effects of the Norman Wells pipeline and oilfield expansion project

    - Objectives to test impact pre-development inpact prediction, effectiveness of mitigative measures and to prepare operating guidelines for future northern pipelines

2. **Mining Developments**

- Placer Mining 1982

    - Reviewed known environmental effects of existing placer mining operations in B.C., Yukon, and Alaska
    - Paper summarizing concerns was presented to representatives of industry, government, and public

- Existing and Abandoned Mines

  - Impact monitoring at about 15 locations

  - Studies have progressed from qualitative investigations of relatively obvious effects, such as depletion of fish and benthic invertebrate populations, to quantitative measurement of contamination of water and sediment and changes in species composition and abundance

  - Recent studies (1984- 1986) include evaluation of arsenic depositional trends in Yellowknife Bay sediment relative to waste disposal history at Giant Mine, and initial impact zone delineation at Lupin Mine at Contwoyto Lake

  - Residual impacts of abandoned mines done at Discovery and Thompson-Lundmark gold mines and Rayrock uranium mine by monitoring contaminant mobility

  - Copper and mercury enrichment in accumulated sediment traced to high dissolved concentrations in acidic tailings leachate

- Baseline Data Collection at New Mines

  - Baseline data collected at 10 locations since 1974 to:
    - document sensitivity of aquatic systems to mine impacts(fish, fish habitat and water quality); and

    - establish contaminant baseline in water and sediment and species composition and abundance of biological communities to determine the significance of change.

3. **Special Monitoring Programs**

- Fish Tainting in Hay River 1981

  - Action plan, and a list of techniques and mechanisms available to NWT Water Board for evaluating complaints of fish tainting by petroleum in Hay River Harbour

- Water and Sediment Monitoring Study Guides

  - Guides prepared to provide other regulators and industry with recommeded methods for monitoring contamination of water and sediment

  - Guides emphasize use of systematic approach to collecting and using data in setting effluent limits

  - Guides stress importance of predetermining acceptable data quality, discuss study model options, and provide a list of criteria and design decision points

- Quality Assurance/Quality Control (QA/QC) for Water Sampling 1988

  - Details procedures for obtaining, preparing, handling, storage, and shipping of water samples
  - Reduce opportunities for errors in water quality results

- Lab Protocols Study 1989

  - Internal assessment of lab use of quality assurance and control procedures, and of acceptability of inorganic chemical data, using blind reference materials

- Slave River Monitoring Program

  - Provision of technical advice on the design of a trans-boundary monitoring program on the Slave River in 1989

  - Monitoring of key parameters from pulpmill and tarsands processing plants and pesticide use in northern Alberta and B.C. in water, suspended sediment and fish

4. **Technical Advisory Committee (TAC)**

- As member of the TAC, technical advice is provided to the NWT Water Board in writing and issuing water licenses for activities which involve the use of water or the deposit of a waste into water
- Major industrial activities are mining, oil and gas, and hydroelectric power generation
- Licenses are also issued to municipalities

MARINE PROGRAMS

1. Oil and Gas Developments

- Abandonment of Artificial Islands

  - A project to evaluate potential chemical, physical and biological impacts of abandoning artificial islands in the Beaufort Sea was initiated. Sediment samples from selected abandoned islands were analyzed for priority organic contaminants, and erosion rates at abandoned islands and subsea berms were measured by means of a remote instrument package.

- Subsea Pipelines

  - A project to evaluate current subsea pipeline technology and identify environmental and technical implications of Arctic subsea pipeline construction was undertaken. The resulting report identifies current standards for subsea pipeline construction and environmental factors which will affect construction and operation of those pipelines.

2. Monitoring Programs

- Beaufort Sea Shorebase Monitoring

  - Sediment and benthic samples were collected along the Tuktoyaktuk Peninsula to monitor the impacts of shorebase development on the marine environment. Administration of the program was transferred to INAC, and EP's role was limited to provision of advice regarding monitoring designs and statistical analyses.

- Arctic Marine Methods Guide

  - This project was undertaken to promote consistency in the collection and analysis of chemical and biological data in the Arctic marine benthic environment. The Guide consists of two volumes; the first is a review and evaluation of sampling and analytical methods, while the second is a guide to recommended practices.

- Beaufort Sea Shoreline Drift Waste Surveys
  - Two coastal surveys were undertaken; the first was carried out to determine the extent of shore wastes, while the second assessed the efficacy of industry efforts to clean certain Beaufort shorelines.

- Marine Environmental Quality Program
  - A report on the current status of the Arctic marine environment was produced for inclusion in a national overview. As part of the continuing support of this program, a workshop was held in Yekllowknife to identify priorities for MEQ initiatives.

- Tuktoyaktuk Harbour Point Source Monitoring Program
  - A two-year integrated monitoring program was carried out in the Harbour to assess the effects of contaminant releases from oil and gas shorebases on indigenous benthic fauna.

3. Data Collection Programs

- Ocean Dumpsite Investigations
  - A program to identify the physical and biological characteristics of two potential offshore dumpsites was undertaken. The program include sampling of sediments, benthos, and fish in the vicinity of the proposed dumpsites, as well as side-scan sonar profiling of the dumpsite areas.

- Environmental Assessment of Beaufort Sea Dredging

  A project to document known site-specific impacts of dredging and technologies for reducing these impacts was undertaken, and a process for assessing effects of dredging operations on "valued ecosystem components" was developed. A workshop was held to refine the process and achieve consensus on use of the process.

- Beaufort Sea Data Compilation
  - This project was undertaken to examine the natural variability of chemical and physical parameters in Beaufort Sea sediments. The information can be

used to determine the number of samples required to assess environmental impacts and to identify areas where additional data are required.

4. Future Scientific Programs

- Mackenzie Delta-Beaufort Sea Hydrocarbon Development

  - Conceptual plans for Mackenzie Delta-Beaufort Sea production proposal include a subsea pipeline component. EP will undoubtedly be involved in a public review of the project under EARP; near-term assessment of subsea pipeline technology and environmental effects on and from pipeline construction and operation will depend on Regional EP priorities.

- Marine Environmental Quality

  - The five-year MEQ Action Plan identifies five areas where new actions are required; four of these are scientifically-based and applicable to the Northern region:

    a) Monitoring of the Arctic marine environmental status;

    b) Formulation of guidelines for selected chemical contaminants;

    c) Marine State of the Environment reporting; and

    d) Implementation of marine environmental management plans.

Other MEQ intiatives may include identification of priority chemical pathways selected marine biota, and assessment of ocean dumping practices and effects.

LAND BASED PROGRAMS

1. Terrain Disturbance and Drilling Waste Disposal from Oil and Gas Exploration 1982

   - Provided advice as a steering committee member on a DIAND study to examine the terrain disruption caused by a variety of drillwaste disposal options
   - The use of multi-year sumps was compared with the surface disposal and spread of drillwastes at the Hoodoo wellsite on Ellef Ringes Island in the high arctic.

2. Environmental Audit 1986:

   - Reviewed the processes of internal and external environmental auditting

   - Two discussion papers which examined the usefulness of environmental auditting and how it might be used to improve the delivery of Environmental Protection's mandate in the NWT

3. Historical Pesticide Use 1988

   - Federal operators were canvassed to determine their historical use of pesticides in the NWT

   - This information was summarized to form the basis for future trend analysis of continued use of pesticides by these operators.

   - Review of pesticides proposed for use by federal operators provides proponents with environmental information which can affect their use of pest control products

ENVIRONMENTAL EMERGENCIES

1. Oil Spill Response

- Arctic Marine Oil Spill Program (AMOP)
  - Review of research and development relating to oil spill countermeasures technology
  - Annual seminar to discuss new initiatives produces technical proceedings

- OILSPILS Remote Sensor 1985/86
  - Under PERD, development of a device capable of remotely detecting gaseous products from oil spills
  - Device works, but limited sensitivity will require further development, testing, and evaluation

- Baffin Island Oil Spill (BIOS) Program 1980-83
  - Scientific investigation involving test spills of crude oil into a small bay of Baffin Island
  - Assess short and long term fate of spilled oil, effects on nearshore marine plants and animals, and effectiveness of shoreline cleanup techniques

- Arctic Regions Environmental Emergency Team (AREET)
  - Group of environmental scientists formed to provide environmental advice to responsible agency in the event of an oil spill into the Arctic Ocean
  - Operating procedures for the team have been developed
  - Training/communication exercise is planned for 1989/90

- Environmental Atlas for Beaufort Sea Oil Spill Response 1987
  - Objective to provide a synthesis of environmental information relevant to oil spill countermeasures in the Beaufort Sea
  - Useful in developing site-specific contingency plans, developing more realistic spill training exercises, and as a reference in an actual spill

- Spill Response Exercises
  - Attended about 10 spill response training courses run by third parties
  - Reports outlining problems encountered and suggesting improvements

- Contingency Planning Guidelines 1989/90
    - Objective is to provide guidance in the preparation of contingency plans for the prevention and clean-up of spills
    - Provide operators with specific information requirements for their plans

- Environmental Atlas for Lancaster Sound Oil Spill Response 1989/90
    - Same type of project as Beaufort Sea Atlas but geographic focus is Lancaster Sound region
    - Greater emphasis on spills from oil tankers

2. Bulk Fuel Storage

- Study of Spill and Overflow Prevention Measures at Hydrocarbon Product Storage Facilities in the Yukon and NWT 1984
    - Under PERD, study analyzed spill histories of bulk fuel storage facilities to determine the causes of spills
    - Reviewed existing design features and operating procedures
    - Provided recommended improvements to design, construction, and operation of facilities

- Guidelines for Bulk Fuel Storage Facilities in Northern Canada 1988
    - Objective is to provide guidance in the proper design, construction, and operation of bulk fuel storage facilities
    - Based on requirements of National Fire Code

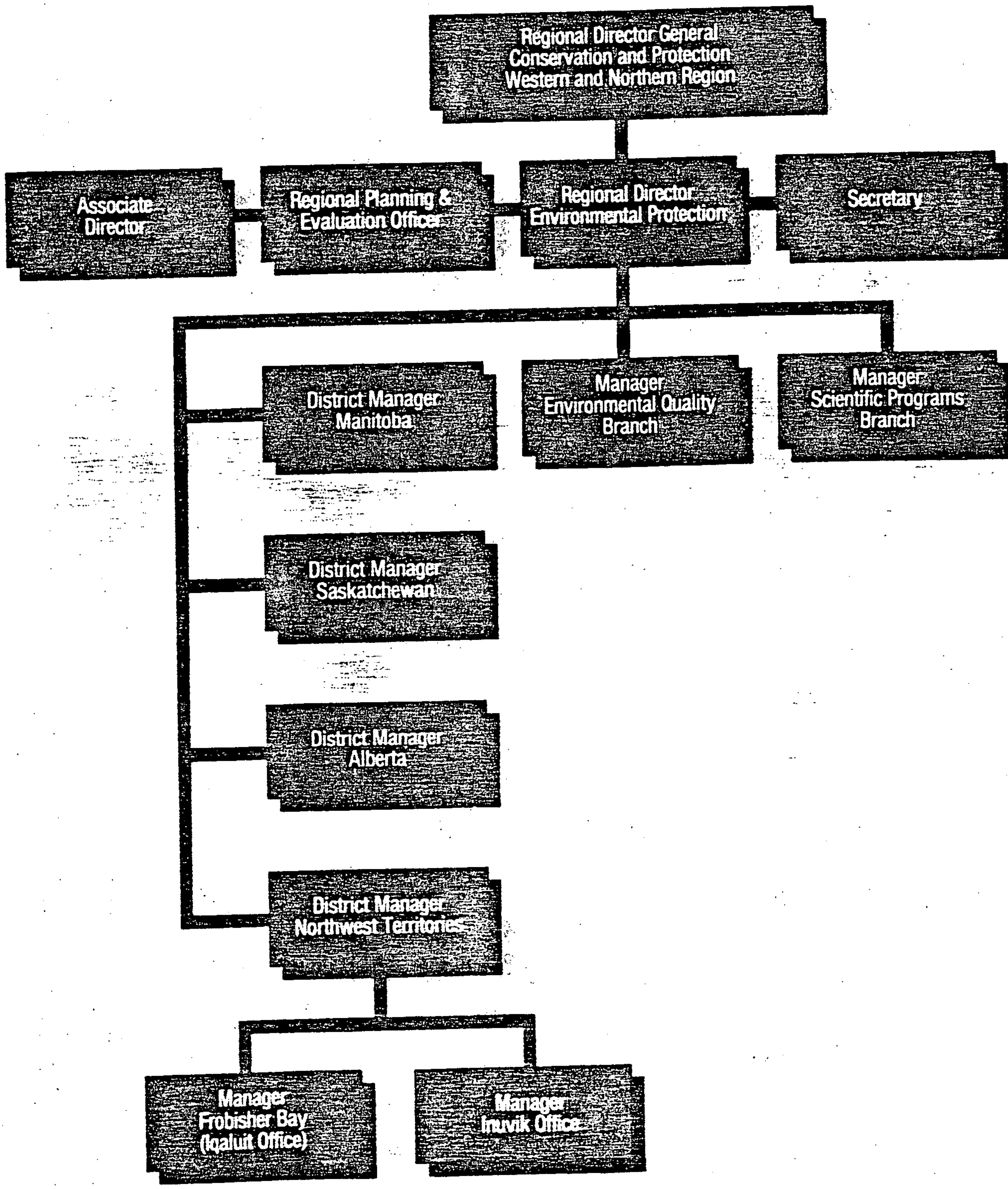
- Bulk Fuel Storage Facility Inspections
    - About 15 facilities have been inspected to assess how well they complied with requirements of the guidelines
    - Recommendations to improve the performance of the facilities were provided to the owners

ENVIRONMENTAL PROTECTION

- ORGANIZATION

- ROLE
  - ADMINISTER CEPA AND FA
  - ENFORCE CEPA AND FA
  - PROVIDE ADVICE TO FEDERAL DEPT'S
  - PROVIDE ADVICE TO GNWT
  - PROVIDE ADVICE TO INDUSTRY AND PUBLIC

- SCIENCE PROGRAMS
  - WASTE MANAGEMENT
  - ENVIRONMENTAL QUALITY
  - ENVIRONMENTAL EMERGENCIES


Regional Director General
Conservation and Protection
Western and Northern Region
Associate Director
Regional Planning & Evaluation Officer
Regional Director Environmental Protection
Secretary
District Manager Manitoba
Manager Environmental Quality Branch
Manager Scientific Programs Branch
District Manager Saskatchewan
District Manager Alberta
District Manager Northwest Territories
Manager Frobisher Bay (Iqaluit Office)
Manager Inuvik Office

WASTE MANAGEMENT

Municipal Solid Waste

Municipal Wastewater

Air Pollution

DEW Line/North Warning System

PCB Programs

Federal Facilities

ENVIRONMENTAL QUALITY
FRESHWATER PROGRAMS

- Oil and Gas Developments
- Mining Developments
- Special Monitoring Programs
- Technical Advisory Committee

ENVIRONMENTAL QUALITY
MARINE PROGRAMS

- Oil and Gas Developments
- Monitoring Programs
- Data Collection Programs
- Future Scientific Programs

ENVIRONMENTAL EMERGENCIES

- Oil Spills

- Bulk Fuel Storage .

ARCTIC CLIMATE-RELATED ACTIVITIES

Presentation to Northern Science Seminar, Inuvik, June 1989

By N. Cutler, Canadian Climate Centre

1. Role

- Management of national climate archive
- Provision of information services
- Monitoring, impacts
- Climate analysis, atmospheric modelling, climate forecasts
- Promotion of use of climate information

2. National Archive

- Contents
  - data from one or several of AES networks, e.g. hourly, synoptic, daily climate, rainfall rate ,sunshine, radiation, soil temperature, evaporation, upper air, freeze-up and break-up, snow surveys.
  - problem with sparse station density and also (e.g. coastal stations) lack of representativness
  - most data digitally stored - hourly to daily values

- Accessibility/Dissemination
  - types of access to national archive
    - publications
    - custom jobs
    - direct access to computer by users
  - software for custom analysis - e.g. GRP's, MAST et. al. (climate), CRISP (sea ice)
  - regional role - they handle most of routine

3. Modelling and Forecasts

- GCM with CO_2 scenario by this Fall
- 30-day climate forecasts

4. Analysis and Impacts

- Three areas of activity (see attach. 1 for more info.)
  - regional climatologies e.g. Climate of Yukon, other reference material re present climate, and also computerized analysis system development
  - design values - mainly for design and operation of offshore petroleum exploration
  - climate variability and change and its impacts

5. Initiatives for Consideration as Future Priorities

- improving coordination and cooperation for research (including data collection) - particularly important on issues like global change where interdisciplinary work is important

- establishing one or more new arctic research centres to encourage research, particularly cooperative, interdisciplinary initiatives in the North; and to help maintain a Canadian presence

- review of available weather and weather-related data, including remotely-sensed data, to identify how gaps could be filled, for example by integrating satellite and surface data; and to ensure an adequate data collection system is in place to monitor changes and serve the needs of planners, environmental assessment, etc.

-development of improved means to interpolate climate data to serve the needs of users requiring information at a distance from sparse observing stations

- exploring feasibility of development of regional-scale models for the Arctic to provide increased definition of climate-change GCM output, and also as an aid to interpolation of current climate (as in previous item)

- cooperative R&D to assess the future impacts of a changing atmosphere on the arctic environment, economy, and society (e.g. native lifestyles)

- monitoring present climate and its influence on the North to identify changes

- reconstruction of past climate of the Arctic using proxy and other data to provide a baseline re future changes, to provide analogs for future change, and to identify the impacts of past variations/changes

- exploration of feasibility of developing indices integrating climate and other environmental/social/economic

Attachment 1

SOME CCC ACTIVITIES IN ARCTIC CLIMATOLOGY

1. Arctic Offshore Development

This activity relates to the use of climatological information for the safe development of arctic offshore energy resources, and of marine transportation in the North. The work involves developing automated information systems, accurate and reliable methodologies, and environmental test data. These are used for engineering design, project planning and regulation, and environmental assessment needs.

1.1 CRISP development

CRISP is an automated information system for analyzing sea-ice data. The system operates on digitized ice data sets including several regional data bases covering Canadian waters as well as a Northern Hemispheric data base. Sophisticated graphical output is a highlight. An operational version of the system is available to address specific requests and has been publicized through the organization of workshops. User has been very favourable, and demand for analyses steady. Duration 1986-89.

1.2 Ice-offshore structure interactions

The usefulness of standard sea-ice information available in the AES ice archive for evaluating loads imposed by sea ice on offshore structures is being evaluated. Depending upon results, a separate module for CRISP may be required. Duration: 1987-89.

1.3 Hudson Bay sea-ice climate relationships

This project affords an opportunity to investigate the feasibility of using sea-ice information derived from microwave data for augmenting the existing ice archive. In addition, by focussing on a closed system such as Hudson Bay, relationships between sea ice and climate can be examined. Duration: 1985-88.

1.4 SPASM development

An automated information system for the movement of surface pressure centres has been developed. The system operates on a 40-year gridded pressure data set and can provide data on storm movement for areas of potential resource exploration and production across Canada. This information is important to assess the nature, frequency and sequence of severe events that can affect a given area. In addition it is useful for climate change monitoring work. An operational system is now available although not widely publicized as yet. Some further enhancements are planned. Initial user response is favourable. Duration: 1985-88.

1.5 Beaufort Sea wind

Through comprehensive reanalysis of past extreme and wave hindcast severe storms in the Beaufort, a definitive extreme wind climatology is being developed. This will then be used as input to wave models to develop needed engineering design criteria. Duration: 1987-89.

1.6 WISP development

As point measurements of surface winds are scarce in the Arctic, particularly in offshore areas, an automated system synthesizing winds from other continuous meteorological fields is being developed. A test version has been completed and output generated by it is currently being evaluated. Results are encouraging. Duration: 1987-88.

1.7 Marine atlas for the Beaufort Sea

Based on data collected at offshore drill sites in the past ten years, a climatology of the Beaufort Sea area was completed. Data on all standard elements pertinent to offshore activity were presented. This was produced to address a specific need of COGLA's to have suitable backup evaluation material on hand in view of Gulf's renewed Beaufort interest. Completed in 1987.

1.8 Combined extreme

While a good understanding of extreme occurrences of environmental climatic elements such as wind speed, low temperature, wave height, etc. is developing, our knowledge of the occurrence of such events in combination is less well advanced. This project addresses this concern. The combined occurrence of extreme winds and sea ice in the Beaufort Sea is the focus of current work. Duration 1987-89.

2. Arctic Climate Relationships and Climate Change

The other major area of activity relating to the Arctic focuses on the relationships between the basic climate variables and elements of the physical and biophysical environments, and the socio-economic sectors. This is being addressed principally in connection with possible future climate change and its impacts in Canada's North.

2.1 Non-AES climate data

Since data coverage in Canada's North is often sparse and non-representative, efforts are being made to identify and evaluate all non-AES climate data sets which may be held elsewhere in Canada or outside the country. Such data can be invaluable for sensitivity studies which are the basis of effective impacts work. Several such data sets have been identified. Duration: 1987-89.

2.2 Permafrost-climate relationships

A network of 4 stations has been set up. Both ground network temperatures and surface climate elements are being measured simultaneously. The intent is to develop permafrost-climate relationships which can be used to evaluate permafrost response under various climate scenarios. The stations also provide a capability for ongoing monitoring of climate. The network is operational with a couple of years' data now accumulated. Duration: ongoing.

2.3 Lake-ice studies

The freeze-up and break-up of lake ice has been identified as a useful indicator of climatic trends by virtue of its good correlation with air temperature. Data from Canadian lakes is being examined in order to determine ones which might be fruitfully monitored for detecting early climate change. Some general statistical analyses have been done and several locations identified for more detailed study. Duration: 1987-89.

2.4 Baffin Island Inland Studies

This area is judged to be likely a sensitive one in regard to climate change. The project involves is a cooperative one between AES and the University of Windsor to study the relationships between climate and climate variation, and other components of the environment. In addition, it affords an excellent opportunity to monitor inland climate: most arctic sites at present are coastal. Two weather stations have been set up and a third will be added this summer. Duration: ongoing monitoring.

2.5 Climate Change Indicators

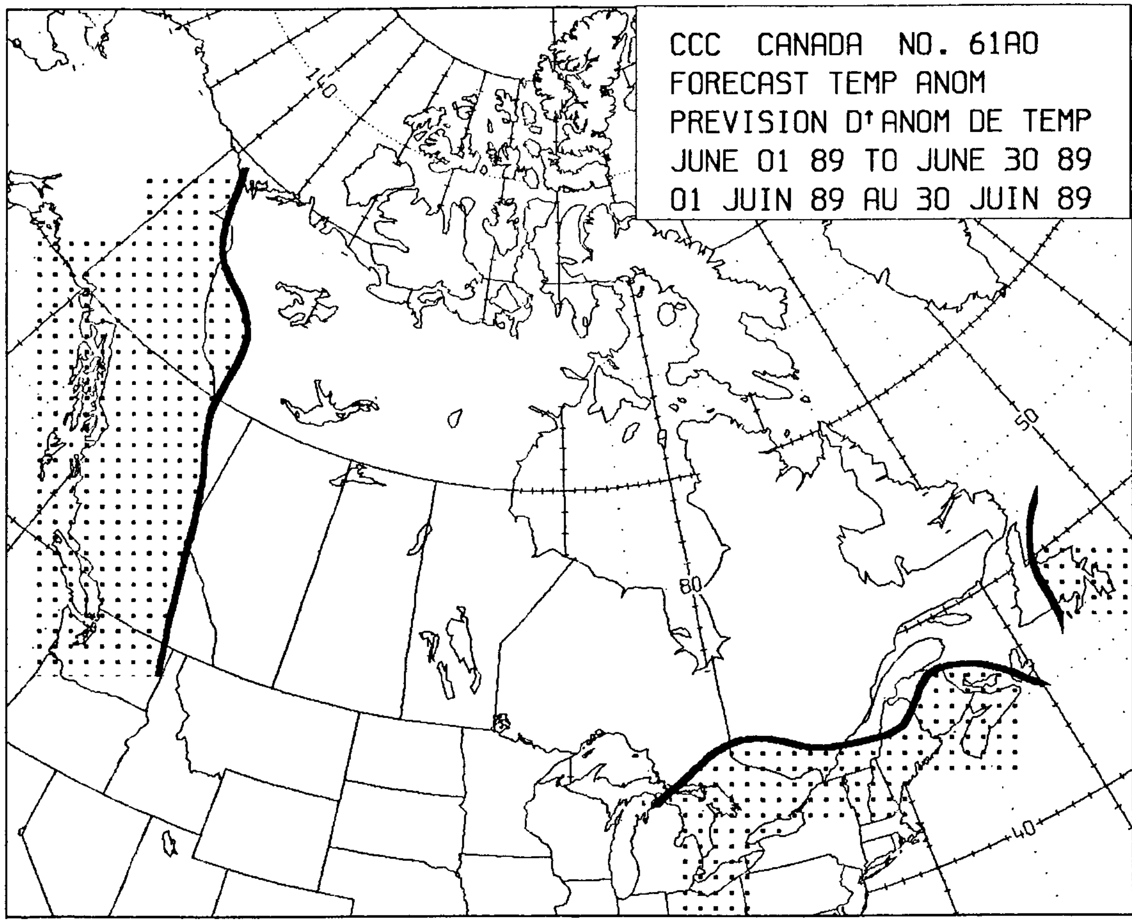
The objective of this activity is to assess various weather and weather-related parameters (for example lake ice) to determine which appear to give the best potential for signaling climate change. Duration 1989-90.

2.6 Mackenzie Valley Impacts Studies

An interdisciplinary study under contract to MacMaster University is underway to assess the potential impacts of climate change on the Mackenzie Valley transportation sytem, with consideration of implications to regional economic and social impacts. More generally, priorities are now being prepared regarding future climate-change impacts work in this region. Duration 1988-1990.

2.7 Satellite Data Assessment

The usefulness of SSMI satellite data to climate-related is underway. Primary interest is applications to monitoring sea ice. Duration 1989-90.



ABOVE NORMAL

AU-DESSUS DE LA NORMALE

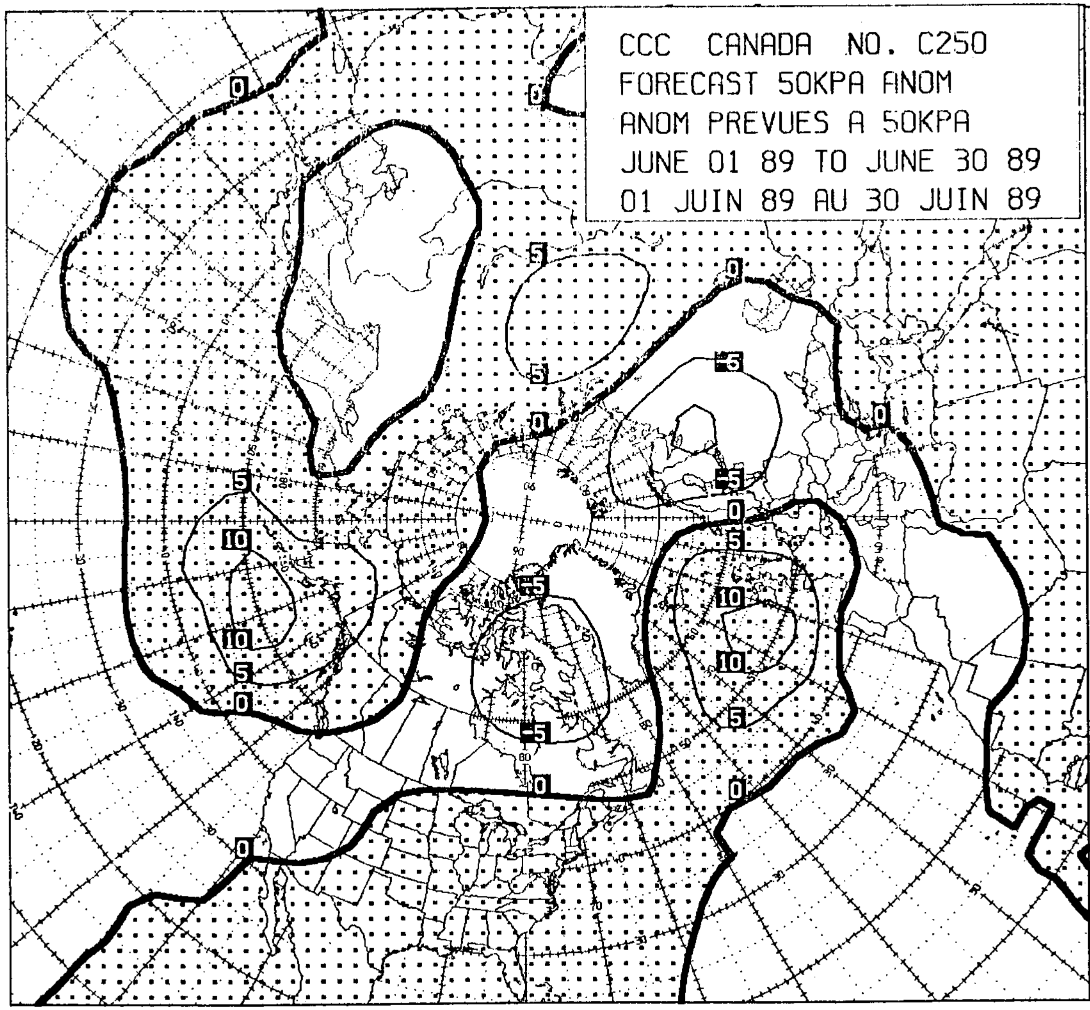
BELOW NORMAL

AU-DESSOUS DE LA NORMALE

NORMAL TEMPERATURES IN DEGREES CELSIUS FOR THE PERIOD FROM JUNE 01 TO JUNE 30

TEMPERATURES NORMALES EN DEGRES CELSIUS POUR LA PERIODE DU 01 JUIN AU 30 JUI

VANCOUVER	15	TORONTO	18
VICTORIA	14	OTTAWA	18
WHITEHORSE	12	MONTREAL	18
YELLOWKNIFE	13	QUEBEC	16
IQALUIT	03	FREDERICTON	16
CALGARY	13	HALIFAX	14
EDMONTON	15	CHARLOTTETOWN	15
REGINA	16	GOOSE	11
WINNIPEG	17	ST. JOHN'S	11



ABOVE NORMAL

AU-DESSUS DE LA NORMALE

BELOW NORMAL

AU-DESSOUS DE LA NORMALE

INTERVAL ... 5 DAM

INTERVALLE ... 5 DAM

To: O'DONNELL.B.M (AES062)
Cc: WOODS.J (AES002)
Cc: CHAMP.D (AES005)
Cc: BIRMANN.L (AES315)
From: CHAMP.D (AES005) Delivered: Sat 10-June-89 2:16 EDT Sys 2021 (
2)
Subject: Input to notes for the Northern Science Conference - Inuvik 1989
Mail Id: IPM-2021-890610-020510960

--More--

---- FOR NICK TYWONIUK ---- VIA BRIAN O'DONNELL

I'll send these by post, as well, along with the slides.
Regards
Don Champ

DOE SCIENCE PROGRAMS AND ACTIVITIES -- AES -- ICE SERVICES

The PURPOSE of AES' ICE INFORMATION SERVICES PROGRAM is

TO PROVIDE OPERATIONALLY USEFUL DECISION SUPPORT
INFORMATION ON SEA-ICE AND ICEBERGS TO THOSE
WHOSE OPERATIONS ARE AFFECTED BY FLOATING ICE

The ultimate purpose of such decision support input is to enable operators in or near the ice to make their operational business decisions in a way that optimizes the human safety and security of the operation, and its impact on the natural environment.

The NATURE of SCIENCE INVOLVED WITH THE AES' ICE PROGRAM is:
--More--

DISCIPLINES: Meteorology; Oceanography; Inter-Media Sciences
R&D Emphases: REMOTE SENSING of ICE and of related variables
- includes VALIDATING remotely sensed data
MODELING of FLOATING ICE.

Schematic slides were used to illustrate the inter-relation of the relevant scientific disciplines, the areas and seasons of the service coverage, and the organization of the actual work done to provide the service. Copies are attached.

The ICE SERVICE Program Organization comprises the following:
1. Data Acquisition [Field, Ice Centre = ICEC]
2. Data Analysis and Synthesis [ICEC, Field]
3. Ice Information Prognosis [ICEC, Field]
4. Delivery of Decision Support Ice Information [Field, ICEC]
5. Climate and other non-real-time SERVICES - including support to EARP/EIS, advice to users, ice climate publications, etc.
6. Operational Infrastructure

ICE INFORMATION SERVICES -- PROGRAM ISSUES for the ARCTIC
1. What service coverage is needed for a Basic Service Level?
2. Global change as it involves floating ice.

3. Can the·the Ice Program infrastructure be useful to others?
4. Are there unserved clients of the program?

ICE INFORMATION SERVICES -- SCIENCE ISSUES for the ARCTIC
1. To implement more operationally useful models for developing ice conditions.
2. How to make the DECISION SUPPORT SERVICE more useful to operational decision-makers.
3. How is/can our services be more useful to the interdisciplinary work which is needed to accomplish real operational results.
4. How can we help others make better use of RADARSAT?
5. How should we deal with Norwegian and Soviet interest in increased collaboration?

A BROADER ISSUE:
HOW DO WE DEAL WITH THE PROBLEM THAT CRISES DUE TO LACK OF ANTICIPATION AND PREVENTION ARE MORE INTERESTING THAN ARE THE MEANS TO PREVENT SUCH CRISES?

Other notes:

--More--

The AES' Ice Program operating funds are provided 70% by Canadian Coast Guard [CCG], which pays for all airborne ice reconnaissance. To CCG this expense is well worth it, as the ice information provided by AES saves it much more than that amount in their expensive icebreaker and ship routing operation.

The program covers the arctic mainly during the "navigation summer" [now May to November], except for the wintertime "Arctic Round Robin". Iceberg surveillance [year-round] is in danger of ending, due to lack of funds; this would be a sad event indeed, as the only reliable iceberg climatology extends from mid-1984 to the present [the previous extensive climatology is really a measure of the "visibility holes" in clouds, rather than of icebergs].

The use of high resolution mapping radar to provide ice imagery was described: imagery is downlinked to major iceberakers, to CCG Ice Operations Centres [where ships are routed through the ice] and to ICEC: this imagery is used with satellite imagery, "recent ice conditions history", and validating visual [from aircraft] and in situ [from ships] ice data to provide analyses of ice conditions. Forecasts are then made. Then field staff brief users on the ice conditions in support of operational
--More--

decisions.

The infrastructure of high-speed computer and telecommunications systems was briefly described, as it allows the service to be timely and useful.

Other Important Interventions by Don Champ

1. In discussing the matter of funding of programs, I believe we cannot count on the massive levels of funding we had in the past, since government no longer commands a tax base which grows with the economy. Therefore, we must learn to use both hard and soft funds. Soft funds should be used for shorter term "engineering applications", while hard funds should cover basic R&D and basic services.
Further, it would be advantageous to start DOE's own soft funding source, using a combination of industry "trust funds" and private "interest group" contributions matched by government to fund "Sustainable Development", particularly the "anticipate and prevent" aspects. This approach would
--More--

not only provide added funding, but it would also provide added broader "public ownership" of Canada's environmental programs.

2. Another consideration would be to get DND to consider the purchase of massive amounts of precision RADARSAT imagery to prevent military surprises around Canada [at perhaps 5% of the projected cost of Nuclear Submarines]. This data could then be available at marginal additional [delivery] cost for all sorts of environmental work.

- 3 -

3. Finally, I asked the following questions, at Fred Roots' request:

SOME NORTHERN ENVIRONMENTAL SCIENCE ISSUES
--More--

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a. How can DOE's DECISION SUPPORT SERVICES be made more USEFUL, and MORE USED by operational decision makers to PREVENT safety and environmental problems from mushrooming?

b. How can we bring our specialized work to bear on, and to be useful for APPLICATION by people in the real world?
- interdisciplinary applications;
- overcoming "language" and "thought process" barriers;
- multi-media modeling [including "parables"].

c. How can we change the INCENTIVE SYSTEM in government [and in society] toward:
- anticipating and preventing problems?
- proactive and collaborative improvement of the total environment?
- minimizing reactive bureaucracy?

Or should we even try to do so?

d. How do we integrate our "science" with other types of knowledge, so that concerned people can and do implement good solutions to anticipated and actual problems?

e. How do we get others to "share the ownership" of environmental issues to the point of funding, collaboration, "moral" support and implementation?

Don Champ
9 June 1989

Disposition: D

End of Mail.

Title: AES in the Arctic - Arctic Air Pollution

Issue: Arctic haze, toxic contaminants, climate change and stratospheric ozone, northern wetlands.

Background

Air pollutants transported over long distance into the Arctic have been shown to reduce visibility, to warm the climate, to accumulate in ecosystems and to interact with ozone in the Arctic atmosphere.

Status

Arctic Haze:

- AES has conducted research on this phenomenon since the late 1970's.
- The cause is the remnant of acid rain pollution transported into the Arctic in late winter and spring.
- The pollution consists mainly of acidic sulphur compounds, black carbon, metals and toxic organics.
- The pollution originates mainly from Eurasia during the winter months.
- Levels of these pollutants in springtime cause reduced visibility and climate warming during April and May.

Toxic contaminants:

- Measurable quantities of toxic organic contaminants, including PCB's and organochlorine pesticides, have been found in Arctic air, snow, surface sea water, sediments and wildlife.
- Excessive quantities of some of these compounds (particularly PCB's) have been found in native human blood and breast milk.
- Atmospheric transport over long distances is considered to be a dominant pathway of these chemicals into the Arctic.
- Sources and movement of organic contaminants are being investigated.
- A paper entitled "Sources, sinks and pathways of contaminants in the North" will be available this summer and published in the autumn.
- AES, as a member of the "multi-departmental Technical Committee on Contaminants in Northern Ecosystems and Native Diet", has prepared a proposal to monitor organochlorines in air at Alert and to model the atmospheric transport of these compounds into the Arctic.
- This proposal is part of a strategy for research in the North to be recommended to departments by the Senior Policy Committee on Contaminants in Native Diets.

Climate Change:

- A high Arctic research station commenced operation at Alert in 1986.
- The greenhouse gases: carbon dioxide, methane, ozone, nitrous oxide, and freons as well as other atmospheric consituents are now being measured to detect trends in global concentrations that will ultimately affect climate

Stratospheric O_3

- Continuous measurement of the total column of O_3 and NO_2 are being made at Alert and Resolute.
- Intensive studies are being conducted to determine if there is a thinning of the stratospheric O_3 over the North Pole similar to that over the South Pole. Results of a study in January and February 1989 are still being analyzed.

WETLANDS

The concentration of methane in the Earth's atmosphere is increasing at a dramatic rate. It has doubled since the turn of the century. It is a greenhouse gas like CO_2, the importance of which in global warming is great. In addition, methane is an important regulator of complex atmospheric chemical reactions that influence the oxidizing potential of the atmosphere and, hence, the concentrations of important gases such as ozone.

Preliminary assessments of the sources of atmospheric methane indicate that northern wetlands, which are concentrated in Canada and the Soviet Union, account for 15 to 40% of the total annual global emissions.

The dependence of methane fluxes from wetland ecosystems on such variables as nutrient content, composition of organic matter, soil moisture temperature and vegetation type is not well understood. The importance of this gap in knowledge was underlined by NASA in 1987 when they proposed to Canada to conduct a major research program in the Hudson Bay Lowlands for six weeks in 1990. This sparked the Atmospheric Environment Service and the Canadian Institute for Research in Atmospheric Chemistry (CIRAC) to host a workshop on 'The role of Canadian Wetlands in influencing the composition of the atmosphere and climate'. Subsequently a multi-university multi-agency research program was designed for the period 1989 to 1991 to collaborate with the short term program with NASA (6 weeks) and to establish a longer term Canadian effort to study wetlands over all seasons in a multi-disciplinary way. AES is a major player in this program as operator of a baseline air chemistry observatory in the Hudson Bay Lowlands, in the measurement of methane flux by micro-meteorological techniques and in the development of a methane exchange model to be used in extrapolating flux measurements obtained in the NASA intensive to other wetlands at other times of years. A secretariat at CIRAC will coordinate the university and government efforts using NSERC funds. At a recent workshop on the Global Atmospheric Chemistry Program in Melbourne Australia, the Canadian Wetlands program was endorsed as a high priority research effort in the study of Global Change. It will be used to focus international efforts which will eventually expand to include those in Scandinavia and the Soviet Union.

D O T S

I N T E R O F F I C E   M E M O R A N D U M

Date: 19-Jun-1989 12:45pm GMT
From: FRIEDA WIEBE
WIEBEF AT A1 AT PKSKLU
Dept: ADMINSTRATION
Tel No: 634-2403

TO: TYWONIUKN AT A1 AT CPEDM

Subject: NORTHERN SCIENCE PROGRAM

NORTHERN SCIENCE PROGRAMS

A CANADIAN PARKS SERVICE PERSPECTIVE

I. CPS and Science

- CPS is not a "science program" but, rather, an applied science program

- CPS is a site (Park) specific program and requires data and analysis related to site (Park) specific issues

- CPS utilizes an ecosystem approach to Park management and therefore wishes to encourage multi-disciplinary science approaches to Park issues

- Increasing trans-park boundary issues and the resulting need for greater inter-agency cooperation necessitates an improved information base on Park resources

- CPS employs few "scientists" and is reliant on other agencies and institutions for much of its research

- CPS has an increasing need for predictive capabilities based on science and credible data

- Science is one factor (often the most significant) in Park decision making, but is balanced against others such as societal needs and expectations, regional economic development, fiscal reality and political process

- A National Park is a maximum protection regime under federal law (NPA) and as such internal environmental impacts are highly controllable. However externally originated impacts (eg. Acid Rain, Toxics, Arctic Haze) are not controllable

II. Northern National Parks

- The greatest potential for establishing new N.P.s is in the North

- Aboriginal people identify N.P.s as protection options which can effectively serve their interests (eg. NYNP, NEB intervention)

- Northern Parks have a major contributing role in tourism development

- With respect to science, there are knowledge gaps in the north, particularly in ecosystem research

- Northern Parks are vulnerable, as is the whole northern environment, to economic development, hunting pressure, global threats and trends, and political inaction

- Existing Northern National Parks (North of 60) are: Kluane, Northern Yukon, Wood Buffalo, Nahanni, Auyuittuq, Ellesmere

III. Existing Cooperative Activities (some examples)

- Whooping Crane Program (Wood Buffalo - CWS)

- Nahanni River Water Quality Study (Nahanni - IWD)

- Glaciology Studies (Kluane - AINA - NHRI)

- Porcupine Caribou Herd (Northern Yukon - CWS - YTG - GNWT - PCMB)

- Law Enforcement (Northern Yukon - U.S. Fish and Wildlife) (Kluane - YTG - U.S. National Parks Service)

- Alpine Flora Studies (Kluane - AINA - Unit of Alaska)

- Grizzly Bear Management (Kluane - YTG)

- Climatology (Northern Yukon - AES)

IV. CPS Needs

- Development and expansion of base line data (multi-discipline)

- Specific Park/issue related research

- Knowledge about global change and environmental trends

- Credible data for the management of traditional harvest activities

V. National Park Opportunities

- Multi-disciplinary base line research stations
- Environmental monitoring
- Specific research projects
- Support for science activities through cooperative agreements
- Controls for studies on northern development

VI. The Aboriginal Voice

- CPS respects the value of traditional knowledge with respect to ecosystem management
- "Science" must be credible in the eyes of aboriginal people to be effective in northern decision making
- Credibility is based on the relevance of science to traditional life and the northern man/land relationship
- CPS supports efforts to integrate "science" and traditional knowledge

D.C. Stewart
Superintendent
Kluane National Park Reserve
Northern Yukon National Park

THE DEPARTMENT OF RENEWABLE RESOURCES CONTRIBUTIONS AND INVOLVEMENT TO SCIENTIFIC RESEARCH IN THE NORTHWEST TERRITORIES

A Presentation made by
Mel Smith
at the Northern Science Seminar
Inuvik, NWT
June 08 - 11, 1989

On behalf of the
Department of Renewable Resources
Government of the Northwest Territories

The mandate of the Department of Renewable Resources is to manage, regulate, and encourage the sustainable development of wildlife and forest resources and to provide environmental protection measures and planning for land and water use in support of the renewable resource economy.

The Department is firmly committed to the integration of local knowledge and traditional activities in our pursuit to learn more about the use and management of the renewable resources of the NWT. Local and scientific knowledge is routinely combined in field work, research and policy formulation that is initiated by the Department.

The Department is divided into six Divisions. The majority of original scientific research is undertaken by our Wildlife Management Division. The Pollution Control, Forest Management, Policy and Planning and Conservation Education/Resource Development Divisions are also involved in scientific research to a lesser degree.

The NWT Centre for Remote Sensing, established cooperatively between the Department of Renewable Resources and the Canadian Centre for Remote Sensing (CCRS) in Ottawa, is also involved in some aspects of scientific research. This centre will become solely administered by our department by 1992.

Research undertaken by the Wildlife Management Division

The Wildlife Management Division has broad responsibility for wildlife and habitat management in the Northwest Territories. The Division works closely with federal, provincial and territorial departments and agencies and wildlife users in the management of the environment and renewable resources of the north.

Research - 1988 and 1989

A study on the exchange of caribou between mainland caribou herds was concluded in 1988. The results of this research support the premise that barren-ground caribou return to the same calving ground each year. The exchange between mainland herds was shown to be minimal during the three year period of the study. The results do not, however, preclude the occasional large scale exchanges that may have occurred in the past and may happen again in the future.

Photographic calving ground surveys were conducted on the Beverly and Kaminuriak herds in June 1988. These surveys indicated that both the Beverly herd and the Kaminuriak herd were no longer increasing but remain stable around the 1984 levels.

In 1989, the results of caribou research conducted over the past

20 years will be analyzed and prepared for publication.

Monitoring of the polar bear population in Foxe Basin has taken place for four years and will continue to be the focus of polar bear research until the year 1992. A telemetry study to define the boundaries of the Foxe Basin population began in 1986 and was completed in 1988. A new tetracycline marking program will begin in 1989 and will continue into the early 1990's. The tetracycline technique enables our biologists to mark bears without having to immobilize them. A draft Northwest Territories Polar Bear Management Plan will be available for public consultation in 1989 or 1990.

The Department has been involved in muskox research on Banks Island since the late 1970's. The focus of the Banks muskox research in 1989 will be on the expanding island population. Population studies, composition surveys and disease studies along with a Landsat imagery analysis of muskox habitats on northern Banks Island will be completed this year. This research will contribute to a draft Banks Island muskox management plan.

Research on habitat use, productivity of various habitats, and dispersal of bison into new habitats in the Mackenzie Wood Bison sanctuary has been underway since 1981 and will continue in 1989. The Division is also contributing to the Federal Environmental Assessment Review Process which is examining alternatives for dealing with brucellosis and tuberculosis infecting the bison of Wood Buffalo National Park and surrounding areas.

A waterfowl project to determine the number of spring waterfowl harvested on the Tuktoyaktuk Peninsula has been under way since 1986. This study is taking place in cooperation with the Tuktoyaktuk Hunters' and Trappers' Association. As well, research into the breeding success of white-fronted geese, Canada geese, brant and tundra swans in the central arctic mainland and Victoria Island has taken place for several years and will continue into 1990.

The productivity of gyrfalcons and other raptors in the central arctic will be monitored again in 1989. The Department is developing a DNA fingerprinting technique which will allow permanent identification of individual birds without physically marking them.

A research program into the productivity of the barren-ground grizzly bear population in the Coppermine area will continue in 1989. Three grizzly bear management plans are in progress: the Inuvialuit Grizzly Bear Management Plan; a Barren-ground Grizzly Bear Management Plan and; a Mackenzie Mountain Grizzly Bear Management Plan.

Several furbearer research projects will continue in 1989 including studies of the impact of trapping on marten south of Great Slave Lake. The age and sex composition of the marten and lynx harvest in several areas of the Mackenzie Valley, and the characteristics of an untrapped marten population in the Fort Good Hope area are being examined.

Last year the Wildlife Management Division participated in a study of contaminants in country foods conducted by Health and Welfare Canada, by providing samples of harvested and trapped wildlife from across the Northwest Territories. This year the Department will initiate a research program to monitor and evaluate contamination in country food in cooperation with the Department of Health.

The Wildlife Management Division has enjoyed an excellent cooperative relationship with the Canadian Wildlife Service in areas such as waterfowl and polar bear research. We look forward to a continued close working relationship on these projects and on such management forums as the Porcupine Caribou Management Board and the Beverly and Kaminuriak Caribou Management Board.

Research undertaken by the Pollution Control Division

The responsibility of the Pollution Control Division is to promote high standards of environmental quality and protection in the Northwest Territories. This mandate is achieved through the development of environmental legislation, the monitoring and control of hazardous wastes and participation in joint research and monitoring programs with federal and provincial agencies.

The Division is involved in several joint air quality monitoring projects. We contribute to the study of acid rain and contaminants through the Western Canada Technical Committee on the Long Range Transport of Air Pollutants; a forum which includes all western provinces and territories. As of September of 1989 chairmanship of the Committee will be held by our Division. The Committee's objectives include identifying current conditions in Western Canada and developing appropriate management strategies for acid rain.

The Division is involved is several other joint research projects including:

- The mapping of aquatic and terrestrial sensitivity to incoming acid precipitation in the NWT,
- The establishment of a station to monitor acid precipitation at Snare Rapids. The Station is part of the Canadian Air Monitoring Network (CAPMON) and is operated by the GNWT while sample analysis is undertaken by Atmospheric Environment Service of Environment Canada.
- A long term project in conjunction with the Inland Waters Directorate in identifying quantities of aerosol (air pollutants) deposits in snow, lake bottom sediments and glacial ice cores, with particular attention paid to organochlorides and pesticides.

- Participating in the Northern Atmospheric Pollution Survey Network by operating an urban air quality monitoring station in Yellowknife. The analysis of the data collected is done by Environment Canada

Research undertaken by the Conservation Education/Resource Development Division

The Resource Development section of this Division is involved in several research projects in the South Mackenzie.

In June, 1987, a joint agreement was entered into by our Department and the federal Department of Fisheries and Oceans (DFO) on an N.W.T. Recreational Fish Stocking Workplan. The purpose of the agreement is to promote federal-territorial cooperation in developing opportunities for recreational fish stocking in the Northwest Territories.

Lake assessment work to identify potential fish stocking sites was carried out along much of the highway system in the South Mackenzie (except Liard Highway) in 1987.

Experimental trout stocking took place in the spring of 1988. A total of nearly 13,000 fingerlings was stocked in the water bodies selected. All of the stocked water bodies were harvested in October, 1988 in order to determine growth and survival rates. Survival of the stocked fish ranged from 0-20%. Research and stocking of rainbow trout will continue in 1990.

A similar stocking program for Arctic char is being undertaken in inland lakes in the Yellowknife area in an attempt to enhance angling opportunities and as a possible source of supply for commercial char aquaculture ventures.

The Department will also be determining the availability and source of supply for other indigenous fish species, such as lake trout and pickerel, for future enhancement of sport fishing in our northern lakes.

Research undertaken by the Forest Management Division (Fire Centre)

The main area of research that is presently being undertaken by the Forest Management Division is taking place through the Forest Fire Centre in Fort Smith in Cooperation with the Northwest Territories Centre for Remote Sensing.

The development of an integrated fire management system is the primary focus of this research. The development of a computer driven fire management system will assist fire managers in rapidly assessing and effectively using fire operation resources. The data base will integrate LANDSAT imagery to demonstrate fire danger, fire weather analysis, lightning occurrence, forest fuels and terrain data, presuppression infrastructure and values-at-risk.

Research projects are also planed in two other areas: 1) determining the effects of fire on soil stability in sensitive permafrost areas and how it relates to industrial activities such as pipeline construction and 2) to develop equipment and methods for effective fire fighting (such as infrared scanners, helitorches, mapping devices and effective retardant application and delivery).

Research undertaken by the NWT Centre for Remote Sensing

The NWT Centre for Remote Sensing will continue to support several Technology Enhancement projects. The wildlife applications of Remote Sensing Technology include muskox habitat evaluations on Banks Island, bison habitat studies west of Great Slave Lake, moose habitat mapping north of Great Slave Lake and Raptor habitat mapping in the Mackenzie Valley.

Besides the projects mentioned above, the Centre is being used to gather baseline data for monitoring environmental impacts of resource development projects. Imagery from two potential major mining development areas is being gathered and will serve as a means of comparison to record any changes in vegetation, hydrology and topography that may result from resource extraction. Studies of the Colomac Gold Mine and proposed Kiggavik Uranium mine have begun.

The Centre is also involved in a wide range of projects involving many government departments (both territorial and federal) and the private sector.

The territorial Departments of Economic Development and Tourism, Transportation, Culture and Communications and the federal Department of Indian and Northern Development have all used the Centre to undertake experimental research.

As mineral exploration becomes more expensive and the location of ore reserves less known, the Centre, through the use of satellite imagery, anticipates playing a larger role in the search for precious mineral.

Research undertaken by the Policy and Planning Division

The Policy and Planning Division is involved in several projects aimed at guiding future developments in the NWT.

This Division has been coordinating the preparation of a Territorial Sustainable Development Policy. The basic principles and guidelines of this policy have been endorsed by our Executive Council. The Policy should be completed by the Fall of this year. It will include specific objectives related to environmental research and monitoring in such areas as pollution control, waste disposal and recycling, energy efficiency and conservation, industrial site restoration, and renewable energy systems.

Policy and Planning just completed a feasibility study for a system of Ecological Reserves, one of the main purposes of which would be to provide undisturbed settings for long term scientific research, monitoring and education. As part of this study, we contacted over 35 organizations and the feedback we received suggests a high level of support for the idea. Close links with the N.W.T. Science Institute will likely be important in coordinating research in Ecological Reserves if they are established.

The Division has made a commitment in cooperation with the Department of Indian and Northern Development and the Inland Waters Directorate of Environment Canada to hold a workshop to examine options of developing a water quality monitoring program for the Slave River. As a result of the workshop, a water quality sampling program will be set up to gather baseline information about the Slave in order to have a means of quality comparison for future sampling efforts.

In response to a public demand for increased knowledge of resource developments in the NWT, the Division published a series of three maps with accompanying text briefly describing the major non-renewable resource development projects that are taking place or may take place in the future.

National and international efforts

Internationally, the Department is involved in several research projects. The recently signed Greenland Protocol between the GNWT and the Government of Greenland commits the two parties to increased cooperation and jointly funded research on issues related to shared wildlife resources. Efforts are being made to increase cooperation in scientific research with other members of the circumpolar world.

On the national level the GNWT is committed to contributing to the national environmental contaminant research that is underway. Our government is responsible for gathering baseline environmental data in the Territories.

NORTHERN SCIENCE: A VIEW FROM THE NORTH

by

Robert R. Janes
Executive Director and Science Advisor
Science Institute of the N.W.T.
P. O. Box 1617
Yellowknife, N.W.T.
X1A 2P2

Paper prepared for presentation at Environment Canada's Northern Science Seminar in Inuvik, N.W.T., June 8-9, 1989.

INTRODUCTION

I would like to begin with the following quotation:

> The great challenge to our times is to harness research, invention and professional practice to deliberately embraced human values... Experts... perform both center stage and in the wings. And all of us speak from the citizens' chorus. The fateful questions are how the specialists will interact with citizens, and whether the performance can be imbued with wisdom, courage and vision.[1]

Meeting this challenge in northern Canada is even more daunting, especially when one considers the recent remarks of a federal government official. He observed, following a visit to Yellowknife, that ... "it was identical to Port Moresby, New Guinea, with snow." This comparison may not be as exaggerated as it first appears.

Consider the fact that the N.W.T. is larger than the subcontinent of India, occupies one-third of the landmass of the second largest country in the world, contains 9% of the world's fresh water, yet is populated by slightly more people than live in Red Deer, Alberta. Of the roughly 53,000 people that live in the N.W.T., nearly 60% are of aboriginal descent and consist of Inuit (Eskimo), Dene (Indian) and Metis (Dene/Euro-Canadian) peoples. In contrast

---

[1] from Modern Science and Human Values by William W. Lowrance (Oxford University Press, 1986).

to most other parts of North America, seven aboriginal languages are spoken daily here.

Taken together, these considerations of a sparse, multi-cultural population, vast distances, underdeveloped transportation and communication networks, plus a political legacy which is only now turning its back on colonialism, are sufficient cause to describe the N.W.T. as a part of the third world. We are not poor, but we are only just emerging. This unique cultural, political and social context has enormous implications for the conduct of science, and the Science Institute of the N.W.T. was established as one means of ensuring that both science and northern residents benefit in the process.

THE SCIENCE INSTITUTE OF THE N.W.T.

The Science Institute is a young organization with major responsibilities. Created by the Legislative Assembly in 1984 and staffed in 1986, this arm's-length, non-profit agency has the task of fostering all types of research in the N.W.T. The specific objectives are:

- to foster a scientific community within the N.W.T. which recognizes and uses the traditional knowledge of northern aboriginal peoples;
- to make available scientific knowledge which is of value to the N.W.T.;
- to support or do research which will contribute to the social, cultural and economic prosperity of the people of the N.W.T.;
- to licence and coordinate research in accordance with the N.W.T. Scientists Act;

- to provide sound and humane advice on scientific matters to the N.W.T. Legislative Assembly and the general public;
- to encourage young people to take an active interest in science.

In general, we believe the best way to ensure that northerners benefit from science is to ensure that they participate in it. The answers we are seeking can only emerge from a process of continuing interaction between the scientific community and the general public.

As a free-standing, non-profit agency, the Science Institute is ideally constituted to facilitate this debate. Though at arm's length from government, the Institute has a responsibility to report annually to the Legislative Assembly through the Government Leader. The work of the Institute is independent of government and is overseen by a Board of Directors, whose members are drawn equally from the general public and the scientific community. This combination of influence and public accessibility puts the Institute in a position to be an effective agent for change.

As part of our search for solutions, the Science Institute has developed the following program of services and a staff of 17 people:

Research Support and Advisory Services

The Arctic is one world, and arctic science is one enterprise. Yet, at present, there is little coordination amongst the agencies involved. In Canada alone, there are literally dozens of organizations and institutes involved in northern research. These include at least seven governments, thirty-five universities and numerous associations and businesses. Generally speaking, there has been little formal collaboration amongst these groups. In those instances where cooperation has been achieved, it has been a result of individual personalities, rather than organizational commitments. This fragmentation comes at a high cost, both intellectual and financial, which northern science cannot afford.

The Science Institute has responded to this challenge by establishing informal communications with a long list of organizations, both southern and northern-based. In addition, we have formal links with the Arctic Institute of North America, the Churchill Northern Studies Center, and Arctic College, through joint Board appointments. All of these contacts become of critical importance when an issue arises that requires coordinated response from the northern research community - the proposed formation of a Canadian Polar Research Commission being a recent example.

From time to time, the Science Institute or its Executive Director - who also serves as Science Advisor to the Government of the N.W.T. - is called upon to act as the official representative of the Northwest Territories. This was the case, for example, in the development of the National Science and Technology Policy in 1987. The Institute also serves as the N.W.T. representative on several national adjudications, including the Northern Scientific Training Program and Science Culture Canada.

Our advisory services are diverse and flexible, in order to meet emerging needs. In recent months, for example, we have advised on research projects sponsored by the Dene Cultural Institute and on archaeological policy and procedures put forward by the Tungavik Federation of Nunavut. We chair the Rayrock Mine Advisory Committee and are contributing to a study committee on northern science and technology, sponsored by the Science Council of Canada.

We are also participating in the environmental assessment process for the proposed Kiggavik uranium mine, near Baker Lake, by helping to adjudicate funding requests from citizens who wish to intervene in the hearings.

One of the official responsibilities of the Institute is the issuing of Scientific Research Licenses. Through the licencing process, we encourage researchers to consult with N.W.T. residents prior to beginning their research and we collect reports and information which are made available throughout the Territories. More about this shortly.

The Institute also encourages direct communication between researchers and northern residents through its Summer Field Program. Every year, we provide funding to researchers to assist them in hiring about two dozen N.W.T. residents as summer field assistants. On occasion, we also support other scientific training and work experience opportunities for northern residents.

A Medical Research Trust Fund is currently being developed, to support research of benefit to the people of the N.W.T.

Scientific Services

On November 1, 1988, after two and one half years of arduous negotiations, the Department of Indian and Northern Affairs transferred its Northern Scientific Resource Centres to the Science Institute. These facilities are now known as the Iqaluit, Igloolik and Inuvik Research Centres, and will remain committed to providing logistical and technical support to resident and non-resident scientists working in the N.W.T. At the same time, the Science Institute will also be using these facilities to address various questions and concerns which are of particular importance to northern residents. Although many of you are familiar with some or all of these facilities, I will give you the following brief summary:

The smallest and newest of the research facilities, the Iqaluit Centre, opened in 1978 to serve the Eastern Arctic Marine Sciences Project. Since then, it has provided significant support to the Arctic Biological Station of Fisheries and Oceans Canada, which is undertaking a long-term study of the marine environment in the Iqaluit area.

The University of Colorado, has used the Iqaluit Centre for many years, to study the history of sea level and climate in the regional over the last 10 to 20 thousand years. The laboratories have also provided support services to Health and Welfare Canada and to Arctic College. The College, for example, used the Centre as a location for the first year of its new Environmental Technician Program. The Iqaluit Research Centre operates from a 260 square meter building near the centre of Iqaluit. As a result of the transfer, there are now two full-time staff - a manager and a technician.

Opened in 1975, the Igloolik Research Centre occupies a unique, futuristic, fibreglass building which dominates the settlement's skyline. To date, Igloolik has served primarily as a centre for cultural and biological research. In addition to the 485 square meters of the central facility, the centre is equipped with storage and workshop space, and temporary accommodation for visiting researchers. The Centre has three permanent staff members, including a manager, an operations manager and a technician.

In 1988, the Inuvik Research Centre, the oldest and largest of the Science Institute's three facilities, celebrated its twenty-fifth year of service. The centre is housed in a large, two-storey building, with adjacent warehouses, transient accommodations, garage, and volatile-stores building. A cosmic ray counter, operated on behalf of the National Research Council, occupies one wing of the main building.

The Centre has three permanent staff members - a manager, a technician and a secretary. Staff will take routine measurements during times when scientists are absent and will also help researchers recruit local field assistants.

Information and Education

"Could a machine help you tell when a seal is coming up to breathe?" "What are the special problems of building on permafrost?" Children ask tough questions! Increasingly, across the N.W.T., they are also coming up with their own answers by participating in local, regional and national science fairs. Since 1986, the Science Institute has been working to encourage the development of science fairs in the Territories. Our program is varied. We have produced original resource materials and distributed them to every classroom in the N.W.T., under the title of Science Alive! We have also developed a multi-media kit for teachers entitled "Why do Walrus Turn Pink: A Guide to Northern Science Fairs". In addition, we provide small grants to first-time fairs, purchase display cardboard for children to use in presenting their projects, and provide funding for travel to national competitions. We also offer a popular referral service called Dial-an-Expert, through which students and teachers are put in touch with researchers and other information resources.

The response to these initiatives has been gratifying. Science fairs are now being held in every region of the N.W.T. and students regularly participate in the Canada Wide Science Fair. Our Science Fair work was funded in its inception by grants from Science Culture Canada and has now become a core activity of the Institute.

This summer the Science Institute will sponsor the Territories' first science camp, for children aged 9 to 12. Forty children from Yellowknife and Rae will spend a week studying fish and fishing from the perspectives of both science and Dogrib traditional knowledge. The Department of Fisheries and Oceans has generously contributed a fisheries biologist to this project.

One other initiative to enhance science education includes an annual subscription of $3,000 to the Shad Valley Summer Program, a month-long motivational experience that combines instruction in science and business. Our involvement ensures that one gifted grade 11 or 12 student from the N.W.T. can participate each year.

Public Information

Twice a year, the Science Institute publishes listings of research projects for which we have issued Scientific Research Licenses. These publications provide a region-by-region guide to some of the current scientific activities in the N.W.T. with brief, plain language explanations of the work that is being done. Some of these documents are available in Inuktitut. We also produce regular one-page newsletters about the work of the Institute. Anyone who wishes to receive these publications may do so on request.

Science hits the airwaves every day at 12:20 p.m., when radio station CKNM broadcasts "Simply Science". The daily series of radio spots is a joint project of the Science Institute and the Native Communications Society of the Western N.W.T., with funding from Science Culture Canada. Selected articles from the show also appear as a weekly column in the "Yellowknifer" newspaper.

Technology Development

For thousands of years, the Inuit of the Arctic coast have hunted seals along the sea ice. Although the hunt continues today, the tools have changed. The snowmobile has replaced the dog team, rifles have replaced harpoons and plywood boats have replaced kayaks. In the case of the boats, the plywood splits and rots; nails rust and fall out, and ice sticks to the wooden hull.

But now, through the cooperation of our lab manager and Inuit hunters, a new and improved version of this flow-edge boat is being built in the Science Institute's Research Centre in Igloolik. Constructed of molded fibreglass, it has been judged a success by the Igloolik Hunters and Trappers Association.

The fibreglass flow-edge boat is an excellent example of the way traditional know-how and modern technology can combine to create a new tool. It is also a good example of how the Research Centres can be used to address local and regional interests.

In 1988, the Science Institute entered into an agreement with the National Research Council to introduce the Industrial Research Assistance Program, or IRAP, into the Northwest Territories. The purpose of IRAP is to enhance the effectiveness of small and medium-sized northern business by improving their use of appropriate technology.

Success in business calls for more than hard work and good management. It also requires the application of the best available information and technology. Canada has substantial scientific and engineering expertise in government laboratories, specialized research centres, universities and consulting engineering companies. There are even larger pools of technology abroad.

Through IRAP, the Science Institute and the National Research Council aim to help northern firms put this technical expertise to work. IRAP assists manufacturing, resource, construction and service industries by providing free consulting services, specialized information and funding for special projects.

One factor is crucial in all of the Science Institute's work, and that is balance. We strive to serve all sectors simultaneously - the general public, government, universities and industry - in a variety of innovative and substantive ways. It is only through the recognition of the diverse needs of all these constituencies that one is able to respond to the human context of science and technology; and that is precisely the challenge of our times.

ENVIRONMENTAL SCIENCE IN THE N.W.T. - 1988

I would now like to give you a summary of current research in the environmental sciences in the N.W.T., based on the research licenses we issued in 1988. The value of licensing is twofold. It allows us to know who is doing what and where, and hence maintain an overview of N.W.T. research. Second, it allows us to act on behalf of both scientists and communities, in a broker role, to ensure that there is mutual understanding and support.

Unfortunately, many individuals who do scientific research in the N.W.T. do not obtain scientific research licenses. As a group, the federal government science departments are consistently the most delinquent. In attempting to address this problem, I have no intention of squandering the modest resources of the Science Institute on legal wranglings to determine whether Territorial

Acts apply to employees of the Crown. The benefits of obtaining a licence are obvious, and I wish to reiterate them. The Institute will assist with community liaison, the research work becomes part of the permanent research record of the N.W.T., and we disseminate research results through our annual research compendium at no cost to the contributors.

SUMMARY OF 1988 ENVIRONMENTAL
SCIENCE RESEARCH IN THE N.W.T.
(PHYSICAL AND LIFE SCIENCES ONLY)

REGION	INUVIK	FORT SMITH	KITIK-MEOT.	KEE-WATIN	BAFFIN	TOTAL
DISCIPLINE TOTALS	25	10	9	10	59	113
Geography	6	2		1	21	30
Geomorphology		2		2	3	7
Geology	5		5		7	17
Botany		1	1		3	5
Paleontology					4	4
Hydrology or ice		1			5	6
Glaciology					1	1
Biology	7	4	1	6	5	23
Marine Biology	1		1	1	6	9
Zoology	1				1	2
Oceanography	2				1	3
Ecology	2		1		1	4
Environmental contaminants	1				1	2
AFFILIATION TOTALS	25	10	9	20	59	113
Canadian Universities	14	6	3	8	42	73
American Universities	1	1	1		5	8
Arctic Institute of North America				3		3
Boreal Institute for Northern Studies	1					1
Institute of Ocean Sciences	2				1	3
Freshwater Institute				1	1	2
Canadian Wildlife Service			1			1
Canadian Forestry Service	1					1
Geological Survey of Canada			2			2
National Parks Service			1			1
National Museum of Natural Sciences		1	1		3	5
Foreign Universities and Institutes:						
England					2	2
Italy					1	1
New South Wales					1	1
West Germany	2					2
Private Consultants	1	1				2
TOTAL PROJECTS						113

CURRENT ISSUES

My purpose here is to acquaint you with some of the other challenges and difficulties we face in attempting to build a resident scientific and technological community in the N.W.T. These issues include:

1. The lack of a northern science policy - Despite the best efforts of the Inuit Circumpolar Conference, the Canada/USSR Arctic Science Exchange Program, and the rapidly-increasing national interest in northern sovereignty and militarization, Canada still lacks a coherent and judicious approach to the conduct of scientific affairs in its northern regions. Bureaucracies and multi-national corporations in the north are not substitutes.

2. The lack of an advanced post-secondary institution - Although the Arctic College is making substantial progress in addressing the educational needs of the N.W.T., we still lack that all-important focus and critical mass (often called a university) which attracts researchers, teachers, graduate students and funding.

   This does not have to be a conventional university, as most of us think of one. As long ago as 1977, the Science Council of Canada recommended that an institution be established in the north with a graduate student emphasis and full extension services. Its purpose would be to provide a focus for the development of northern research activities explicitly designed to solve northern problems. The Science Institute and the Arctic

College are currently exploring this possibility as part of the College's five year strategic planning exercise.

3. The lack of a federal government advocate for resident science and technology - Although this relates in part to my previous comments on the lack of northern science policy, the problem is actually more severe. Without detracting in the slightest from the world-class research and support services of such agencies as the Polar Continental Shelf Project, the Geological Survey of Canada and the Canadian Wildlife Service, the federal science effort in the north is often uncoordinated, reactive and constrained by bureaucratic mandates. The bulk of the federal commitment is directed toward the support of seasonal forays into the hinterland.

4. The lack of public awareness of the value of science and technology - This is a problem which plagues all of Canada, and perhaps the western world. For many in our society, science and technology are either arcane or are a direct threat to fundamental human values, as exemplified by such misfortunes as Chernobyl. Many have forgotten that science is the search for knowledge, and that technology is its practical application. Neither can prosper without a broad base of support.

5. Canadian Polar Research Commission Study - As a result of the recent report, entitled Canada and Polar Science, the Minister of Indian and Northern Affairs requested Professor Thomas Symons of Trent University to assess the feasibility of establishing a Canadian Polar Research

Commission. This Commission would support and coordinate Canadian polar research. It is appalling that this Commission has not yet been established, after more than three years of discussion and a national consensus on its potential value.

PROSPECTS AND OPPORTUNITIES

If you will permit me to look ahead a bit, I now want to identify some prospects and opportunities which are visible on the horizon. Their realization will require enhanced awareness, understanding and commitment from federal science departments working in the N.W.T. These opportunities include:

1. Science and Technology and Sustainable Development - It is time to translate the rhetoric into action by developing clean water and clean air technologies, based on sound scientific research.

2. Contaminants in the Northern Food Chain - This is perhaps the single-most important science and public policy issue that the N.W.T. has ever faced. It is critical that resident infrastructure and expertise be developed in the N.W.T. to ensure systematic monitoring, as part of the long-term research design. The alternative is crisis-driven responses originating in southern Canada.

3. Science Outside of the Classroom - It is clear throughout Canada that science instruction in the classroom is inadequate. All scientists have a

professional responsibility to overcome these inadequacies by contributing to science activities which promote participation, excitement, fun and learning in unconventional contexts. We need to promote a heightened awareness of science and technology among our youth, and science camps and science fairs are only two such means. I hope that all of you will consider contributing to this task when called upon.

4. Hiring Northern Residents - As mentioned earlier, the Science Institute provides money to scientists to enable them to hire northern residents as part of their field parties. The purpose is to expose residents to science in the field and scientists to the value of local knowledge. We require that this be a substantive experience for the residents; not simply doing camp chores or operating a boat.

This program is very popular and the demand far exceeds the available funding. Federal and territorial government scientists continue to rely heavily on this program, much to our surprise. We thought that these scientists would assume increasing responsibility to hire northern residents as a matter of departmental policy. Unfortunately, this does not appear to be happening, and I encourage you to ask why.

5. Gray Literature - The question of unpublished scientific literature, its accessibility and use, are of increasing concern throughout Canada. A Canadian Polar Information System has recently been proposed as one way of addressing this problem. It is imperative that we, as scientists and science managers, address the collection, classification and dissemination

of this information within our own organizations first. Besides being collected at great public expense, this information, were it readily available, could reduce or prevent needless duplication.

6. Climate Change and Research Design - As a member of the committee which allocates Science Institute funding to field projects in the N.W.T., I had the opportunity to read 34 research proposals from university and government scientists for the 1989 field season. Not one of these proposals included climate change as a factor to be considered and evaluated as part of the research, even though the majority of these projects are concerned with the environmental sciences. Although climate change and its implications are controversial, surely it is of sufficient importance to be considered in contemporary research designs.

7. Northern Research Priorities - Correct me if I am wrong, but I am not aware of any attempt to develop short and long-term research plans for northern Canada. If such activities are underway, they are probably occurring within individual government departments. The United States offers a useful model for collaboration and cooperation in Arctic research with its Interagency Arctic Research Policy Committee. This Committee brought together 12 major federal government departments and agencies to prepare the United States Arctic Research Plan (1987).

It would be worthwhile to attempt this in the N.W.T., by organizing a forum, similar to this one, which would involve all those government organizations engaged in northern science. Universities could also be invited. The consensus that does emerge should be reviewed and updated annually. This approach would undoubtedly assist in obtaining sustained funding for northern research, as it is difficult, if not impossible, to obtain long-term funding if there is no long-term plan.

8. Northern Research Fund - Scientific and technological research is a tool for resolving problems and realizing opportunities. Nearly all the funding for northern research originates in southern Canada, where universities, people and research facilities are concentrated. Understandably, research priorities are set there, too.

A research fund, established and administered in the N.W.T., could be an effective vehicle for addressing northern social and economic priorities, and the Science Institute is currently exploring the feasibility of establishing such a fund. I ask you to consider ways in which you and your departments could support this initiative.

9. Support for Resident Scientists - The N.W.T. has a small (about 100), but vital group of resident scientists, the majority of whom work for the territorial and federal governments. With no university in the N.W.T. to facilitate sabbatical leaves, study tours, research leave, etc., all of which are necessary to maintaining professional credibility, it is essential to explore other opportunities for the growth and development of northern scientific staff.

Resident scientists are essential to the balanced development of the N.W.T., and all of us here have a responsibility to attract them and keep them in the N.W.T.

CONCLUSIONS

Perhaps the most unique challenge to northern science is the multicultural environment. The N.W.T. is occupied by two of the world's greatest hunting societies - the Dene and the Inuit. These cultural traditions embrace 7,000 years of adaptation for the Dene and their ancestors, and 4,000 years for the Inuit. The knowledge which lies at the heart of both of these traditions is both empirical and metaphorical. Some argue, in fact, that the traditional knowledge of aboriginal peoples is basically scientific, considering that science may be described as a verifiable body of knowledge from which predictions can be made. You cannot live on the land without detailed knowledge of animal movements, breeding cycles, rates of reproduction, etc.

This sort of argument misses the point, however. Rather, the conventional science of today has to be joined with traditional and local knowledge, so that both will benefit. To deny anything but modern science is to ignore a rich and successful, but different, world view. There are no clear prescriptions for success in fostering this collaboration, but generosity of spirit and outlook are key ingredients.

Northern residents, too, have a great deal of responsibility to ensure the successful use of science and technology. They must:

1. develop resident scientific capabilities, which means making the commitment to post-secondary education;

2. ensure that a year-round scientific effort supports northern needs and aspirations, by fostering a receptive and supportive context for scientific research in the N.W.T.;

3. ensure that northern science is forward-looking, and not simply reactive to industrial initiatives, by making informed and responsible decisions which embrace both science and human values;

4. develop a broadly-based cooperative framework to northern science, involving universities, colleges, government, the private sector and the general public.

In short, the N.W.T. must, in addition to being the object of scientific curiosity and inquiry, become the subject of scientific development (Larkin 1978:119). By scientific development, I mean building a solid base for science in the N.W.T. (including scientists and scientific establishments permanently based in the north), developing educational facilities in the north (including a technical school, a community college and a university), and ensuring local participation in research activities.

In closing, I want to thank you very much for the opportunity to speak to you today. More importantly, I want to acknowledge you and your predecessors for your immeasurable contributions to northern knowledge. There are now some new opportunities to make our work even more effective, and I hope that you will seriously consider all of them.

Thank you.

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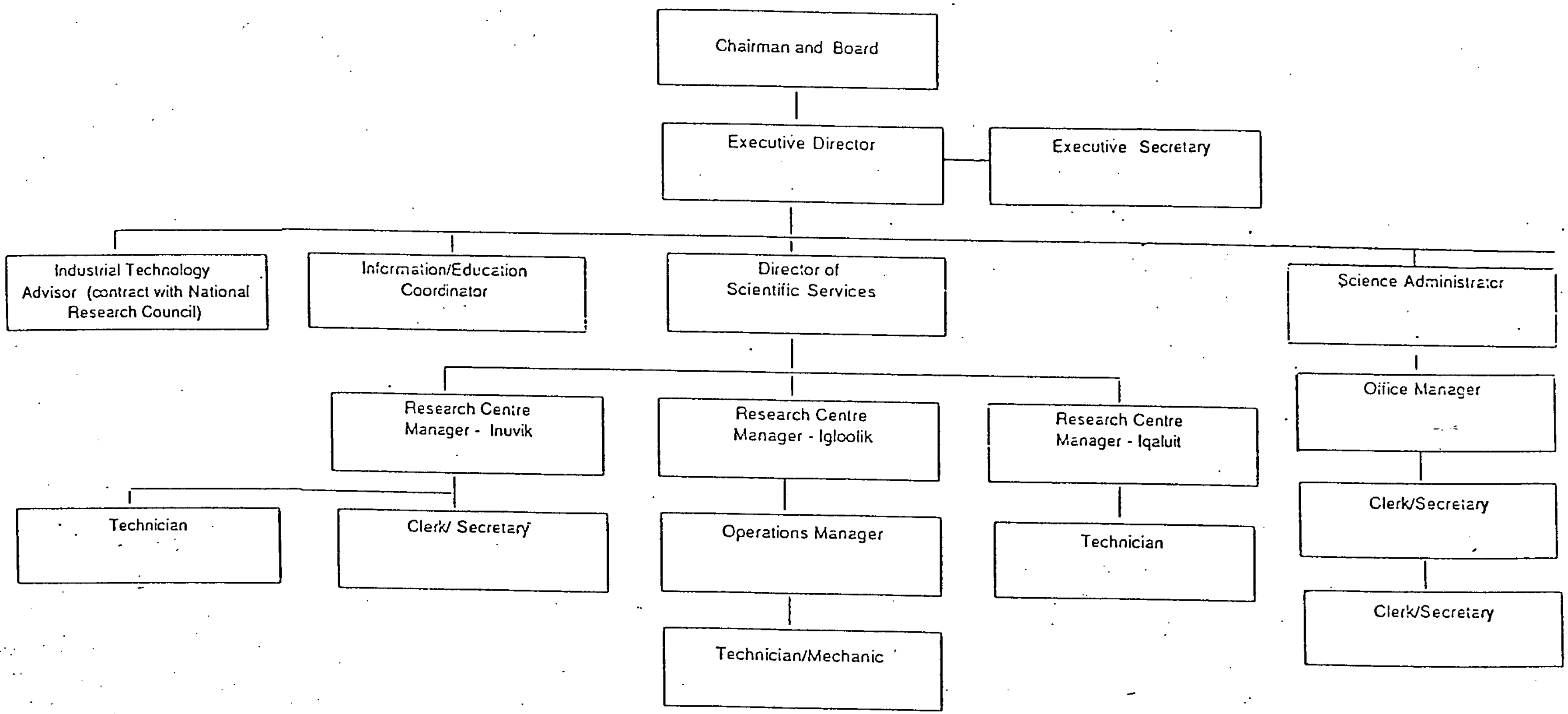
SCIENCE INSTITUTE OF THE NORTHWEST TERRITORIES

Organizational Chart



Approved Robert R. Janes

Date January 30, 1989

SUMMARY OF THE FINDINGS AND CONCLUSIONS OF THE SCIENTIFIC EVALUATION MEETING ON CONTAMINANTS IN THE NORTH HELD IN OTTAWA - FEBRUARY 28 - MARCH 2, 1989

Introduction:

There have been since the early 1970's a number of studies of contaminants in the Canadian North. These studies revealed the presence of organic, metals and radionuclide contaminants in the Arctic ecosystem.

The interdepartmental clean-up of PCBs and other wastes at Canada's abandoned Distant Early Warning (DEW) line sites in 1985 raised initial concern about contaminants in native diets. During the course of this work, surveys were carried out to determine whether any hazardous materials had escaped into the neighbouring environment. The results showed that there was only limited contamination at some of the sites.

In 1985, the Department of Indian and Northern Affairs (DIAND) established an inter-agency working group on contaminants in native diets consisting of representatives from the Departments of National Health and Welfare (NH&W), Environment (DOE), and Fisheries and Oceans (DFO) and the Government of the Northwest Territories (GNWT). The committee first conducted a baseline literature review and determined that there was a definite need to assess the extent of wildlife contamination in the north and to determine the implications for the health of northerners.

One of the first conclusions of this group was that contamination of the North was in fact serious and widespread and that it was highly unlikely that the small quantities of PCBs found at the DEW line sites were contributing to the problem.

Subsequently, a cooperative program was designed involving all of the participants. The program comprised elements of monitoring, research, and evaluation. The first phase, a comprehensive monitoring and research program was initiated four years ago to assess the extent of contamination of local food sources used by northern people.

During the four years that the committee has been investigating the problem of arctic contamination, the scope of interest has been widened to include four classes of contaminants including organochlorines, acids, metals, and radionuclides. The major effort has been on occurrences of these contaminants and not on

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biological effects. The working group also adopted an integrated ecosystem approach to assess the problem which considered all aspects of the problem from sources to transport, freshwater, terrestrial and marine systems, human exposure through diets and finally implications for human health.

The technical committee has been preparing a benchmark report summarizing the current state of knowledge on the subject based on the results of the four year research and monitoring program. A scientific evaluation meeting was held on February 28 to March 2, 1989 to critically review draft chapters of the benchmark report and identify the present limits of our knowledge and the gaps that still remain to be filled. The need to have such a meeting was a priority to ensure that a solid assessment and synthesis of the data took place. Only then can the problem be fully defined and clarified without which responsible decisions cannot be made.

Approximately 50 scientists representing a broad spectrum of interests attended the scientific evaluation meeting including a representative of each of the other seven circumpolar countries. Scientists representing the interests of native organizations were also in attendance. The meeting was divided into six sessions which included sources, sinks, and pathways of Arctic contaminants, marine, terrestrial, and aquatic ecosystem contamination, human health effects and synthesis, conclusions and recommendations. A summary of the major findings of this meeting is given below.

A. <u>SOURCES, PATHWAYS AND SINKS</u>

1. Metals and acids deposited in the North have been primarily derived from Eurasian sources. On an annual basis over 95% of the sulphur entering the North is from this source.

2. The source and movement of organic contaminants is less well understood.

3. Organic contaminants derived from agricultural and industrial sources have been transported to the North through the atmosphere, ocean currents and fluvial processes. Very few measurements of organic contaminants have been made in air, ocean currents and river run-off. Exact source regions are unknown but are global in nature. Some sources are likely Northern Hemispheric in origin.

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4. Deposition of radionuclides north of 60 peaked in the 1960's and has declined ever since. Chernobyl was a minor source in the Canadian Northern compared to the earlier atmospheric bomb testing.

5. Monitoring of organic contaminants in snow, ice, air, and water in the North has indicated the presence of PCBs and chlorinated pesticides such as DDT compounds, toxaphene, hexachlorocyclohexane (HCH), dieldrin, chlordane compounds and hexachlorobenzene (HCB).

B. CONTAMINANTS IN NORTHERN BIOTA

Organic Contaminants

1. Virtually all organochlorine contaminants found in southern Canada have been detected at lower levels in Northern biota.

2. Although sample size for species other than polar bears has been limited, the levels of organochlorine contaminants in fish, marine mammals and wildlife are similar over a wide geographic area in the North.

3. The most abundant organic contaminants found in marine mammals have been toxaphene, chlordane and PCBs. Chlordane compound residue levels in polar bear fat have been reported to be four times higher in levels measured in 1984 than in levels measured in 1969, whereas levels of DDT did not change and the other organochlorines measured have been twice as high. There is however insufficient data to suggest a trend. The highest levels of PCBs in northern biota have been detected in polar bear fat (3-8 ppm).

4. Chlorinated dioxins and furans (2,3,7,8-TCDD and 2,3,7,8-TCDF) have been detected in the Canadian Arctic. Levels of 2,3,7,8-TCDD in pooled ringed seal blubber samples from seven Arctic communities range from 2 to 37 parts per trillion.

5. PCB and DDE (a metabolite of DDT) residue levels in Arctic ringed seal blubber collected at Holman Island, NWT, were lower in 1981 than in 1972. Similar results for PCBs in ringed seals and seabirds from

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central/eastern Arctic have been reported. The DDT levels in Holman Island ringed seal blubber did not change, suggesting new inputs via long range transport.

6. The highest mean concentrations of DDT and PCBs in marine mammals have been found in narwhal blubber from Pond Inlet and Pangnirtung, NWT (both approximately 5 ppm). Beluga have somewhat lower levels (3 ppm in blubber) while ringed seals average 0.8 ppm. The levels in beluga and seals are much lower than Gulf of St. Lawrence animals.

7. Toxaphene levels in Mackenzie River burbot livers were found to be similar to levels measured in samples taken from N.W. Ontario. Toxaphene levels in Arctic char are 10 times lower than in Lake Superior (lake trout).

Metals

1. High cadmium and mercury levels have been found in Arctic marine mammals (mainly associated with kidney and liver). For example, cadmium levels in narwhal kidney averaged 63.5 ppm which was among the highest reported in marine mammals. They are, however, mainly from natural sources rather than industrial ones.

2. Lead in the Arctic region is mainly from industrial sources. This is reflected in Greenland glacial ice deposits and in mussels which show higher concentrations in recent times than in pre-industrial times.

Radioactivity

1. The Cs-137 data base for caribou and other animals is not large but what data exists indicates relatively low levels of radioactivity. Levels in caribou are much lower than during the atmospheric bomb testing period in the late 1950's.

Acids

1. Twentieth century mid-latitudinal pollution has led to enhanced deposition of acidic sulphates and nitrates in the North. Acid levels in precipitation are 10 to 20 times lower than those found in high acid-rain impact areas further south in eastern Canada.

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C. INUIT FOODS AND DIET - AN ASSESSMENT OF BENEFITS AND RISKS
Findings from Contaminant Dietary Surveys in Broughton Island 1985-1988

SUMMARY

Background

In 1985, the community of Broughton Island was asked to participate in a pilot study to determine the amount of PCBs consumed in their diet, the amount of PCBs and mercury present in blood and the amount of PCBs in breast milk. Results of this study, conducted during the month of September, indicated a high intake of Inuit foods and an associated intake of PCBs which exceeded the amount considered "tolerable"* by Health and Welfare Canada (HWC) for 18.9% of study participants. Blood PCBs exceeded the unpublished HWC "tolerable" levels in 29 of 46 children (63%); 26 of 67 women of childbearing age (39%); 4 of 70 males (6%) and 7 of 24 females 45 years of age or older (29%). PCB levels in 3 of 4 breast milk samples were within the range reported in southern Canadian samples (13, 16 and 19 ppb); the fourth contained 69 ppb. The current "tolerable" level is 50 ppb. Blood organic mercury levels in Broughton Island exceeded the guideline range (under 100 ppb) in three persons, all adult males.

In companion studies, it was demonstrated that the blood and breast milk from Broughton Island residents contained up to 10 times the levels of omega-3 fatty acids found in southern Canadian controls. These fatty acids are believed to be protective against heart disease and other diseases, and to serve other important metabolic functions.

The intake of PCBs from food, blood levels for PCBs, and the organic mercury blood levels observed during the pilot survey were not considered to represent any immediate threat, but were of sufficient concern to merit additional work designed to assess seasonal variations in diet and in PCB intake. It was also felt necessary to examine in greater detail the nutritional benefits of Inuit food

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* The word tolerable in this context means the amount of contaminant which could be consumed on a daily basis over a lifetime with reasonable assurance of no adverse effects. Such a level incorporates a "safety factor" applied to the highest exposure for laboratory animals at which no adverse effect was observed.

consumption in a manner which would support a benefit-risk assessment of the diet. Inuit foods have sustained the Inuit over millennia but is now known to be contaminated by PCBs and other chemical residues.

Results of the pilot survey were presented to the Mayor and Council of Broughton Island, and permission obtained for further survey work to deal with these issues. This paper presents some early results of 7 surveys conducted over the period July 1987 to September 1988 in relation to PCB intake. Results relating to the intake of other contaminants will be reported separately.

PCBs in Inuit Foods

1. Inuit foods are used by nearly all Broughton Island residents, and are a major part of the diet for the community. Only about 12% of participants reported no consumption of Inuit foods during any of the survey periods.

2. All Inuit foods tested contain some PCBs; the smallest amounts were found in plants and fish and were higher in animals which feed on them; the largest amounts were found in narwhal and beluga blubber and in polar bear fat.

3. More PCBs are consumed by older than younger persons, and by males than by females. Marketed foods are used more by younger persons.

4. Over all survey periods, about 10% of female participants and 15% of male participants consumed more than the "tolerable" amounts of PCBs - 1 microgram per kilogram of body weight per day (ug/kg); the highest intake was about 5 ug/kg. This intake represents an erosion of the safety factor for PCB intake which is included in the calculation of a "tolerable" level. However, at this time it is not considered advisable to recommend a change in diet.

Nutritional Value of Inuit Foods

1. Inuit foods are nutritionally superior to the marketed foods used in the community.

.../7

2. Blubber, which has the highest levels of PCBs, is rich in at least in one essential vitamin (retinol), and may be its major source in the diet. Blubber also contains high levels of omega-3 fatty acids, which are believed to provide protection against heart disease and other diseases, and to support other metabolic processes, such as the development of nerve tissue (particularly important in utero and during infancy).

3. Inuit food meats - from marine mammals, caribou and char provide large quantities of high protein, and the essential minerals iron and zinc, among other nutrients.

4. The use of Inuit foods provides a uniquely healthful, nutritionally sound diet; breast feeding and breast milk convey enormous benefits to developing infants.

Conclusions

1. The nutritional value of Inuit foods is high.

2. Substitution of Inuit foods with marketed foods currently available and consumed in the community will result in a poorer diet, with risk of damage to health.

3. Based on current information, the benefits of Inuit foods, and of breast feeding to Broughton Island residents are greater than the risk from the PCBs in Inuit foods or in breast milk.

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GUIDEBOOK 3

GUIDEBOOK TO PERMAFROST AND RELATED FEATURES OF THE NORTHERN YUKON TERRITORY AND MACKENZIE DELTA, CANADA

Edited by

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University of Ottawa

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Geological Survey of Canada

Fourth International Conference on Permafrost

and

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Fairbanks, Alaska, U.S.A.

MACKENZIE DELTA AND INUVIK

By
J.A. Heginbottom[1] and C. Tarnocai[2]

MACKENZIE DELTA REGION

The Mackenzie Delta region comprises the northeastern flank of the Richardson Mountains and Arctic Ranges, the modern Mackenzie Delta, the coastal plain of Pleistocene age east of the modern delta, and the northwestern edge of the Anderson Plain (fig. 53). The Pleistocene coastal plain continues offshore as a shallow continental shelf for 100 to 200 km.

Physiography and Geology

Sedimentary rocks in the area range in age from Proterozoic to Holocene. Thick Mesozoic and Cenozoic strata underlie the central part of the Beaufort-Mackenzie basin, which is bounded on the southeast by the rolling plateau country of the Interior Platform and on the west by the mountain ranges of Cordillera (Young, 1978). The geology of the continental shelf portion of the coastal plain is not well known. A generalized cross section showing the relationship between physiography, bedrock geology, and Quaternary deposits is illustrated in figure 54.

Richardson Mountains. Much of the present topography of the Richardson Mountains can be attributed to structures resulting from tectonic deformation of pre-Paleozoic and Mesozoic strata during late Cretaceous and early Tertiary time. Opposite Inuvik, the Richardson Mountains are rugged, containing sharp ridges with steep, rocky slopes and spurs separated by deep, V-shaped valleys. The boundary between the mountains and the delta is a straight, steep escarpment that may be a fault-line scarp. Large coalescing alluvial fans formed at the base of the scarp during postglacial time (Legget and others, 1966).

Mackenzie Delta. The Mackenzie Delta constitutes an elongate north-northeast-trending lowland, the surface of which is a complex network of lakes and anastomosing channels. Mackay (1963) described the morphology and origin of most features on the delta. The large number of thermokarst lakes differentiates it from deltas formed in more temperate latitudes. Mackay believed that most lakes are of a fluvial rather than thermokarst origin; on the other hand, lakes are most abundant in the southern part of the delta where permafrost, vegetation, and drainage conditions favor thermoerosion and thaw subsidence.

Little is known of the stratigraphy directly beneath the surface of the modern Mackenzie Delta. A hole drilled beneath a lake 8 km southwest of Inuvik penetrated 69 m of unconsolidated material before encountering bedrock (Johnston and Brown, 1965). The upper 54 m consisted of organic-rich sand and

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[2]Land Resource Institute, Agriculture Canada.

Figure 53. An uncontrolled satellite photomosaic of the Mackenzie Delta taken in 1973 (Energy, Mines and Resources, Canada, MC-1224).

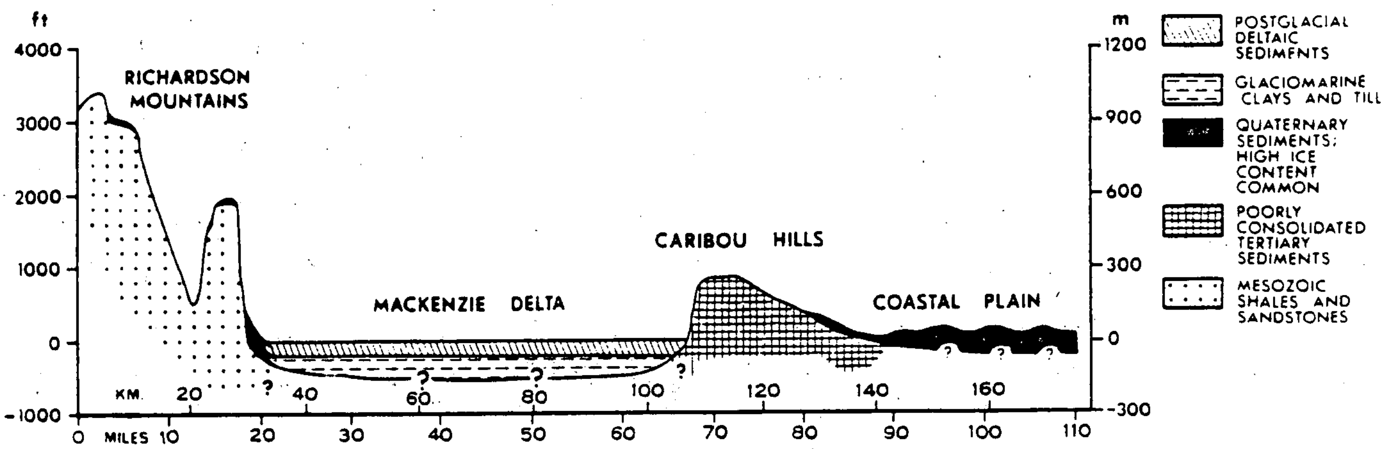

Figure 54. Generalized cross section of the Mackenzie Delta north of Inuvik, showing relationship between physiographic units, bedrock geology, and Quaternary deposits (Fyles and others, 1972).

silt believed to be of a deltaic fresh-water origin. These sediments were underlain by 8 m of dense, silty clay of possible glaciomarine origin. The bottom 7 m of unconsolidated material consisted of pebbly clay of probable glacial (till) origin. Permafrost was absent in this hole but was present in adjacent holes drilled on land. Near the seaward limit of the delta, other boreholes indicate at least 150 m of surficial material.

Caribou Hills. The Caribou Hills form an irregular upland well above the surrounding Mackenzie Delta and the Pleistocene coastal plain. Quaternary materials, generally very thin, cap Tertiary gravel, sand, silt, and coal in the northern part of the hills and Cretaceous shale in the southern part.

Coastal Plains. An extensive coastal plain of Pleistocene age borders the eastern edge of the Mackenzie Delta and Caribou Hills. It is described by Mackay (1963, p. 136) as follows:

> The coastlands . . . consist mainly of Pleistocene fluvial and deltaic deposits. The southern limit is about 10 to 20 miles south of the Eskimo Lakes. Most of the area lies below an altitude of 200 feet with about 50% below 100 feet. . . . the highest altitudes are in southern Richards Island, the areas adjacent to the Caribou Hills, and in an irregular belt on the north side of the Eskimo Lakes between Parsons Lake and Campbell Island.

West of the Mackenzie Delta is the Yukon Coastal Plain, a gently sloping erosion surface completely covered by unconsolidated sediments on its coastal edge (Rampton, 1982). The Yukon Coastal Plain forms a narrow foothill zone between the British and northern Richardson Mountains and the Beaufort Sea.

The coastal plains continue offshore to form the Beaufort Sea continental shelf. Both the emerged and submerged portions of the plain are mantled by surficial deposits.

Anderson Plain. The boundary between Anderson Plain and the coastal plain coincides with the southern limit of thick Quaternary deposits. Cretaceous shales are exposed in many river cuts; toward Inuvik, Paleozoic rocks directly underlie Quaternary materials. Except for some areas of till, unconsolidated materials are relatively thin.

Quaternary History

Most of the lower Mackenzie region and adjacent area was glaciated during early Wisconsin ice expansions (fig. 55). West of the Mackenzie Delta, the limit of this glaciation decreases from an elevation of 90 m in the Richardson Mountains west of Aklavik to present sea level near Herschel (Hughes, 1972; Rampton, 1982). East of Mackenzie Delta, the limit of glaciation can be traced across the Tuktoyaktuk Peninsula and along the western edge of the uplands east of the Anderson River (Mackay and others, 1972). Many islands (for example, Herschel, Garry, and Pelly) and coastal promontories such as Nicholson Peninsula and the Kay Point-King Point ridge are results of thrusting by glacial ice during this glaciation. Permafrost was already present in the lower Mackenzie region by this time because ground ice, contained within sediments deformed by this glaciation, is similarly deformed (Mackay, 1956; Mackay and Stager, 1966).

East of the Mackenzie Delta throughout Richards Islands, Tuktoyaktuk Peninsula, and adjacent to Liverpool Bay, till of probable early Wisconsin age is underlain by glaciofluvial sediments, marine clay, sand, and deltaic sand. This sequence indicates a history of aggradation in which a marine environment was superseded by fluvial (probably glaciofluvial) and deltaic environments.

Late Wisconsin glaciers apparently were confined mainly to the trench underlying the modern Mackenzie Delta and adjacent lowlands. West of Aklavik, the late Wisconsin ice limit is at about 90 m. Much of the continental shelf was exposed during late Wisconsin and earlier glaciations, allowing permafrost to develop there.

Sketchy paleoecological data indicate that the climate was very cold and probably dry during late Wisconsin time. The climate approached conditions similar to those of today around 11,500 yr ago, but was significantly warmer by 8,000 yr ago. Because of this warming, the active layer thickened, ground ice melted, and development of thermokarst basins reached a maximum between 10,000 and 9,000 yr ago (Rampton, 1974). The climate cooled between 5,000 and 4,000 yr ago, and the expansion of thermokarst basins slowed (Ritchie and Hare, 1971). Today, many of these basins are being drained and permafrost is aggrading.

The modern Mackenzie Delta has formed since the retreat of late Wisconsin ice. Silt and clay is being deposited in Mackenzie Canyon and other glacially eroded channels that traverse the continental shelf. Today, shoreline erosion and retreat predominate along the coast.

Permafrost Conditions

Permafrost conditions vary greatly between the modern (Holocene) Mackenzie Delta and the Pleistocene delta and the Arctic Coastal Plain to the

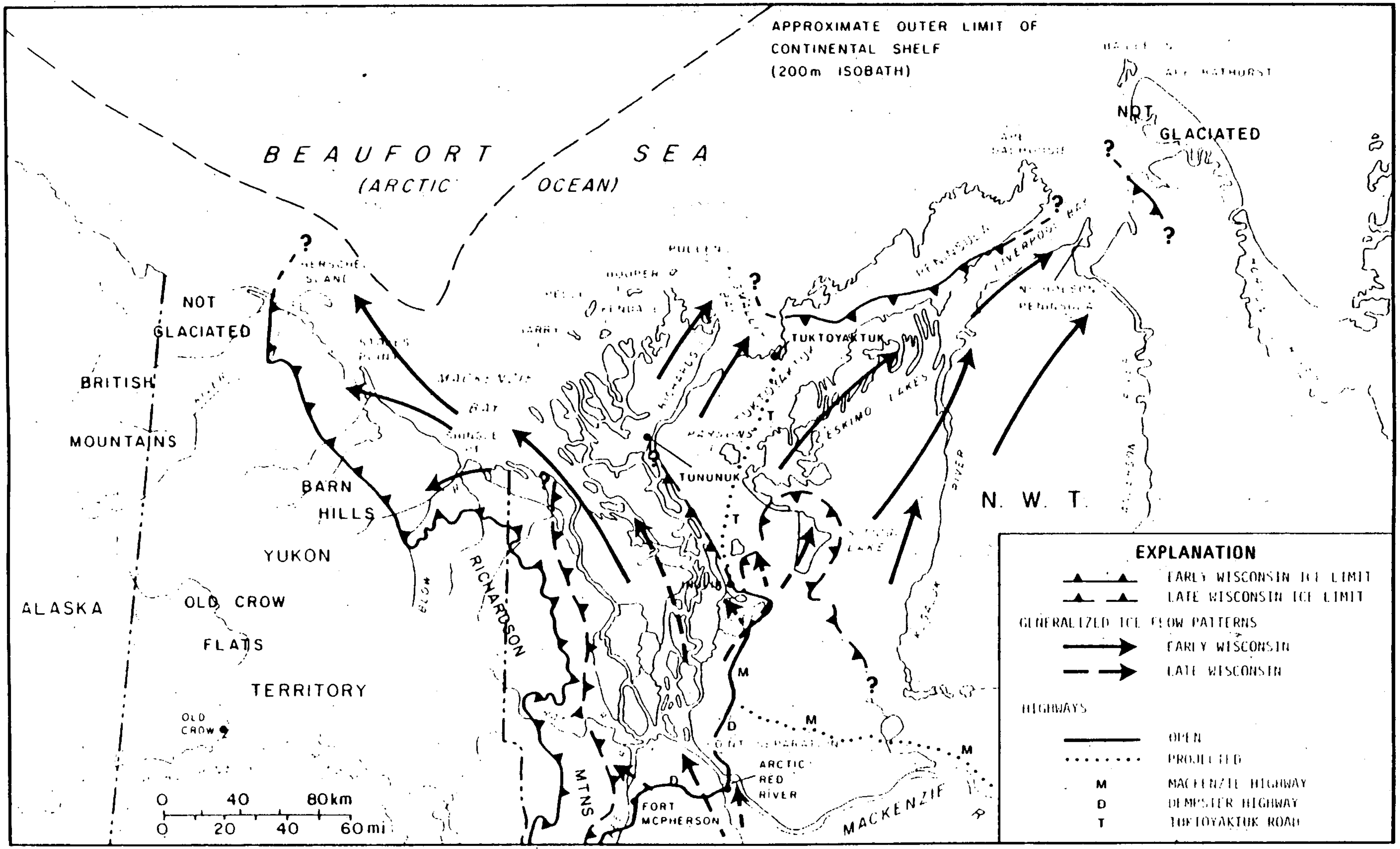

Figure 55. Map showing limits of glaciation and generalized ice-flow patterns, Mackenzie Delta and Arctic Coastal Plain (Heginbottom, 1978).

east and west, respectively. All of the modern delta is susceptible to flooding, with 15 to 50 percent of the total surface area in lakes and channels, and the terrain undergoes continuous geomorphic and vegetational changes. Consequently, the three-dimensional permafrost distribution is extremely complex. Most land surfaces are underlain by permafrost, except for many taliks, which may be closed or connected, beneath the numerous lakes and shifting channels (Smith, 1976). In the southern part of the delta, mean annual ground temperatures are about -3° to -4°C, and permafrost can exceed a thickness of 100 m. In the northern part of the delta, where the land is barely above sea level, ground temperatures are about -2° to -3°C, and permafrost is between 50 and 150 m thick. At the distal end of the delta, where shoals are being built into islands, permafrost is now aggrading for the first time. Permafrost features in the delta are not conspicuous, except for thermokarst lakes, a few ice-wedge polygons, and tilted trees around retreating lake shores. Syngenetic ice wedges are present throughout most of the delta, but they rarely exceed 1 m in width. About 80 pingos occur in the northern portion of the delta; the majority are beyond the limit of trees. Some pingos have grown as ridges up to 600 m long in river channels, rather than as circular features in shallow lakes (Mackay, 1963). The modern delta lacks the massive beds of segregated ice that are abundant in some parts of the Pleistocene delta and Arctic Coastal Plain.

The Arctic Coastal Plain and Pleistocene delta have permafrost that is much older, colder, and thicker than permafrost in the modern delta. Mean annual ground temperatures are in the -6° to -10°C range. Permafrost thickness, except near water bodies, is generally in the 400- to 700-m range (Taylor and Judge,. 1977). Syngenetic ice wedges in glacially disturbed sediments at Hooper Island, about 150 km north of Inuvik, show that the permafrost is very old. Hooper Island is beyond the limit of late Wisconsin glaciation, and the syngenetic ice wedges there grew in sediments of inferred interglacial age.

The sediments of the Pleistocene delta consist primarily of coarse sand and gravel of fluvial, deltaic, and estuarine origin (Fyles and others, 1972). The few areas of higher elevation are commonly underlain by massive bodies of tabular ice, often exceeding 20 to 30 m in thickness (Mackay, 1971, p.397-410; Rampton and Mackay, 1971, p. 11- ; Rampton and Walcott, 1974) and sometimes occurring at depths in excess o 50 m (Rampton and Mackay, 1971, p. 3). Although there is always he poss... lity that some buried glacier ice may be present, the stratigraphy, ice p rofabrics, and water-quality analyses suggest a segregation origi..

Using data from the Mackenzie Valley Geotechnical Data Bank (Lawrence and Proudfoot, 1977), Pollard and French (1980) estimated that ice represents 47.5 percent of the total volume of earth material in the upper 10 m of Richards Island. This area is thought to be typical of conditions in the Pleistocene delta. By compiling a typical ground ice-vs-depth curve (fig. 56), pore and segregated ice are calculated to comprise over 80 percent of the total ice volume. It was also concluded that 14.3 percent by volume of the upper 9.5 cm of permafrost is excess ice. It follows, therefore, that thawing of the top 10 m of Richards Island would cause a general thermokarst subsidence of 1.4 m.

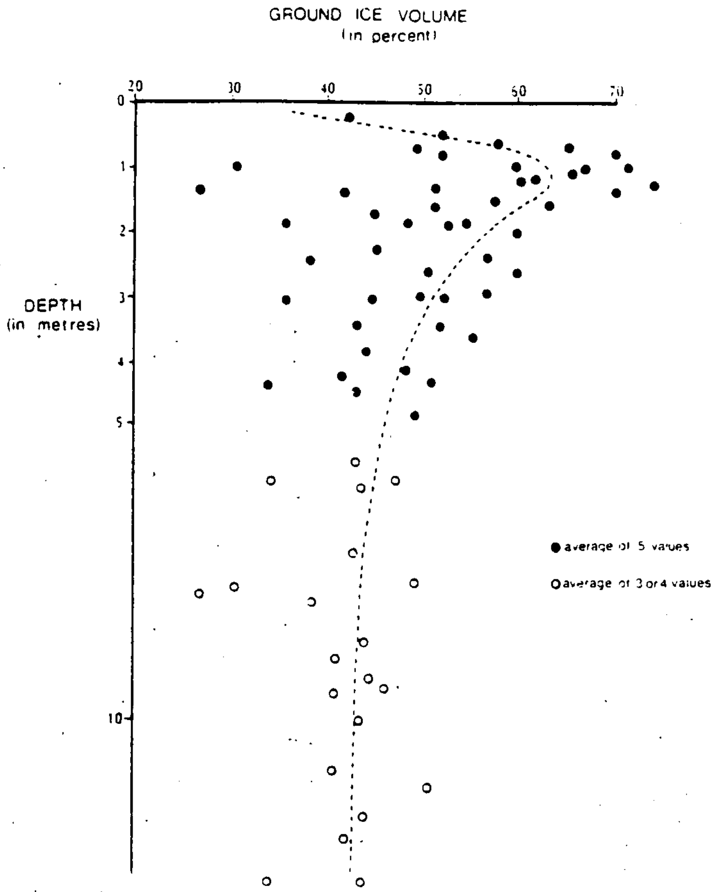

Figure 56. Curve of ground ice vs depth, Richards Island, N.W.T., Canada. Source: Mackenzie Valley Geotechnical Data Bank (Lawrence and Proudfoot, 1977). Note: Curve is a visual best fit and is not calculated (Pollard and French, 1980).

Both massive ice bodies and ice wedges are important types of ground ice in the Pleistocene delta. Pollard and French (1980) concluded that wedge ice constitutes 12 to 16 percent of total ice volume in the upper 4.5 m on Richards Island and may exceed 50 percent in the upper 1 to 2 m.

On Garry Island, ice-wedge cracking rarely occurs before January or after April (Mackay, 1974), and very few ice wedges crack each year. Most of the ice wedges probably postdate the Hypsithermal, although the lower half of relict ice wedges, truncated by Hypsithermal thawing, show that ice wedges were active prior to 10,000 yr ago.

Hydrology and Ice Conditions

The Mackenzie Delta is the largest modern delta in Canada. It extends about 200 km from Point Separation in the south to the Beaufort Sea in the north, and 65 km from the Richardson Mountains in the west to the Caribou Hills and Pleistocene delta islands in the east and northeast. It is an estaurine deposit, built from sediments delivered primarily by the Mackenzie and Peel Rivers. The delta surface is covered by an intricate network of channels of various types (distributary, river, network, lake, reversing, and tidal) and a multitude of lakes of different types and origin (abandoned channel, arcuate, flood plain, thermokarst, and dammed). Surface water covers more than 25 percent of the area and much more during floods. Levee heights, referenced to late-summer low-water elevations, range from about 9 m in the south to about 6 m in the middle and 3 m or less north of a line joining southern Shallow Bay to a point about 15 km south of Tununuk. Interlevee basins are progressively shallower with increasing distance downstream.

Mackenzie and Peel Rivers contribute by far the greatest water and sediment to the delta. Numerous smaller rivers also enter the delta perimeter, among them Rat and Rengling Rivers and Caribou and Frog Creeks. All rivers have their annual discharge maxima during either spring or summer, with the spring flood of late May or early June usually being the greatest hydrologic event (approximately 30,000 m^3/s in Mackenzie River). Flow minima occur in March and April.

Within the delta, the greatest proportion of incoming discharge is carried by the Middle Channel. Below Horseshoe Bend (opposite Aklavik), the Middle Channel transports 80 to 95 percent of total delta inflow, the lower percentages occurring during the summer high-water season. About 10 km southwest of Tununuk, the flow divides in three directions: a) west to Shallow Bay via Reindeer Channel, b) northwest by way of the Middle Channel to Mackenzie Bay, and c) and northeast via the East Channel to Kugmallit Bay.

The Peel Channel at Aklavik is second to the Middle Channel in volume of flow. From 2 to 7 percent of all delta discharge was observed to pass through it during a 1-yr study period.

Data are scarce with respect to suspended-sediment concentrations entering and within delta channels and lakes. However, Mackenzie and Peel Rivers are clearly the most important sediment sources. For the Mackenzie River above Arctic Red River, measured concentrations in the summer are mostly in the 100- to 1,000-mg/l range. On August 12, 1974, a daily extreme of 9,640 mg/l was recorded, with the river discharge at 28,000 m^3/s, which gave a daily suspended sediment load of 2.33×10^7 tons. Concentrations decline below 100 mg/l by the end of September and remain low until the next spring flood. In Peel River upstream from Fort McPherson, concentrations for the period July 1 to August 31, 1973, ranged from 200 to 1,900 mg/l, the maximum occurring during a flood discharge of 2,830 m^3/s to produce a daily suspended sediment load of 4.65 x 10 tons.

In winter, ice forms on lakes and channels. Channels are usually ice covered from late October through mid-May. Maximum ice thicknesses of 0.9 to 1.6 m occur in March or April. Ice development is highly dependent on winter air temperature and snowfall regimes as well as latitudinal position within the delta (Mackay, 1969).

Spring floods of the Mackenzie and Peel Rivers normally peak in late May, but ice starts to move in delta channels about a week before (Mackay, 1965). By the time of peak flooding, much ice has been flushed from the channels. Ice jams can occur, especially at sharp bends or in shallow reaches. Spring floodwaters may rise as high as 7 m above winter ice levels in East Channel at Inuvik, but more commonly are within the range of 3 to 6 m. Consequently, flooding is more severe in the outer delta, where levee heights are lower. Delta lakes also flood during high-water conditions. Breakup of lakes is accelerated as a result, and the ice disappears 1 or 2 wk after channel ice moves out.

Delta water temperatures rise rapidly after spring breakup because of heat input from major southern tributaries, especially the Liard River (Davies, 1975). In addition, there is a high absorption of solar radiation by the sediment-laden waters of Mackenzie River. For example, in 1974, the Mackenzie River reached its spring maximum discharge on May 30 above Arctic Red River and shortly after in the delta. Water temperatures in the East Channel at Inuvik remained close to 0°C until June 6, but rose swiftly afterward to 1.5°, 5.5°, 9.5°, and 12.5°C on June 7, 12, 14, and 26, respectively. On average, channel water temperatures in the delta reach a maximum of 16°C in late July.

The unique spring flood and heat balance in the Mackenzie Delta results in lakes becoming ice free up to a month earlier than lakes immediately to the east in the Caribou Hills. Also, the northward extension of tree line within the modern delta is evidence of the warmth offered by Mackenzie River waters. Finally, the larger, deeper channels and lakes insulate the ground beneath, and taliks can occur in or through the permafrost.

Geomorphology and Vegetation

A distinctive feature of many levees in the delta is their near-vertical erosional bank caused by channel shifting and the presence of permafrost. Although channel migration is not pronounced, cutbanks undergo rapid recession in some locations (Smith, 1976). The greatest levee retreat is caused by the development of thermoerosional niches, which form principally along northwest-oriented distributaries where the prevailing northwest storm winds are opposed to the direction of river flow. High-energy waves that occur along such channels are the principal erosional agents in niche formation. The time of greatest undercutting is mid-July, when water temperatures may reach 20°C. The efficiency of thermal erosion by this water is greatly increased by wave action, which rapidly removes thawed sediments; during periods of high wind, a niche may penetrate 5 m into a frozen levee in less than 48 hr. At this time, large blocks of frozen alluvium fall into the channel, where they are soon removed by thermal and fluvial erosion. At one location, thermoerosional niches have caused levee retreat of 10 m/yr in the past 25 yr.

Delta soils are formed from alluvium derived principally from Cretaceous shales and other sedimentary rocks that underlie the western and central Mackenzie Basin. The soils are uniformly fine grained, ranging from silty loam on upper levees to silty clay in interlevee depressions. Such fine material, together with organic material and the underlying permafrost, maintain high soil moisture and low soil temperature.

Terrestrial vegetation of the delta can be divided into three zones that grade from south to north without distinct boundaries: a) southern forest, b) central forest-shrub, and c) northern tundra (Lambert, 1972).

The southern forested zone is dominated by white spruce (Picea glauca), that often forms closed-crown stands on higher levee surfaces. Because forest fires are absent, trees may be as old as 500 yr. During their growth, a considerable thickness of alluvium will be deposited, and the rising ground surface leads to a corresponding rise in the permafrost table. Long-lived species such as white spruce adjust to aggrading permafrost by extending adventitious roots from the buried stem section into the new alluvium. Spruce stems, with ladderlike horizontal extensions, are exposed along many cutbanks. The only other important tree species is balsam poplar (Populus balsamifera).

The central forest-shrub zone is similar to the forest zone to the south, but the levees are lower and flooding is more extensive. Willows (Salix spp.) and alders (Alnus spp.) become more important, with horsetails (Equisetum) as a pioneer species. The northern tundra zone is dominated by wet sedge meadows, with low growths of willow in better drained areas.

In lakes connected to distributary channels of the delta, aquatic vegetation is dominated by horsetails, sedges, and semiaquatic grasses. These lakes receive an influx of sediment-laden water each spring, forming a miniature delta at the channel entrance. This channel transmits water draining out of the lake later in the season. Thus, there is reversal of flow each year. Lakes not directly connected to distributaries receive nutrient-rich floodwaters over low points in the levees. Because sediment influx is reduced and the lakes are less turbid, they support considerably more aquatic vegetation.

A final group of lakes comprises those bounded by levees that are high enough to prevent overtopping during most floods. They do not undergo the normal process of infilling by alluvium. Moreover, if these lakes are more than 2 m deep, they do not freeze to their bottoms during winter, and the mean annual water temperature is high enough to thaw their ice-rich, perennially frozen banks (Mackay, 1963). Shoreline retreat makes colonization impossible for normal littoral plant successions, and these lakes are bordered consequently by upper-levee vegetation, especially spruce stands. The nearshore trees show evidence of bank retreat (leaning over the lake at various angles).

KM 758. INUVIK. Inuvik (lat 68°21'N., long 133°44'W.) is the main government administrative center and distribution point for Mackenzie Delta and the western Arctic. It is also a major base for petroleum exploration and a business and commercial center. Apart from southern-based companies, there are several locally owned enterprises.

The population of Inuvik has declined in recent years from a peak of over 4,000 a decade ago to 2,065 in 1981. Of these inhabitants, a little over half are white Canadians of southern origin. The remainder is predominantly Inuit, with small numbers of Dene and Metis. Inuvik is the most racially mixed community in the Mackenzie Valley. Most of the native people in Inuvik are dependent on wage employment; some also hunt and fish for food and recreation.

The facilities of the town include general stores, hotel, schools, a 100-bed hospital, police detachment, radio station, banks, liquor store, post office, churches, court house, recreation facilities, and service industries. There is a large wharf with adjacent warehouse, and the town has road connections to Arctic Red River and Fort McPherson via the Mackenzie and Dempster Highways. Apart from the main airport, located 12 km southeast of town, there is a gravel airstrip near the wharf; float planes use the East Channel and a nearby lake. An alignment for extending the Mackenzie Highway to Tuktoyaktuk has been laid out, but construction is not expected to start for several years. Ice roads are built along the frozen delta channels each winter to Aklavik and Tuktoyaktuk.

Townsite Selection

In the early 1950s, the Canadian government decided to establish a major administration, medical, education, transportation, and communication center to serve the growing needs of the western Canadian Arctic. The townsite of Aklavik in the Mackenzie Delta was not suitable because it is situated in the flat, low delta and is subject to flooding each spring. Moreover, drainage is bad, bank erosion would be costly to control, room for expansion is restricted, and water supply and sewage disposal would be major problems. To compound these problems, the nearest sources for granular materials are more than 20 km away in the mountains on the western edge of the delta, and the town is underlain by silty, ice-rich permafrost. Subsurface investigations conducted in 1953 showed that 60 percent by volume of the frozen fine-grained soils is ice. It was decided, therefore, to conduct a detailed survey of the surrounding area to find a more suitable site.

An extensive field investigation was carried out during the late winter, spring, and summer of 1954. Essential requirements for a new site were that it should be a) economically and socially acceptable, b) suitable for installation of permanent water and sewer systems, building foundations, and roads, c) adjacent or close to a navigable river channel, d) convenient to the site of a major airfield, and e) capable of having an adequate water supply. Other considerations, such as convenient disposal of sewage and a good supply of gravel and sand, were listed as 'highly desirable.'

On the basis of airphoto studies during the winter of 1953-54, 12 potential sites along the east and west sides of the delta were selected for detailed field study. Following initial field investigations, eight of these sites were quickly eliminated as unsuitable. Terrain studies, river-breakup observations, topographic and hydrographic surveys, and soils investigations were conducted at the other four sites. By midsummer, a preliminary appraisal indicated one site, on the edge of the delta, 56 km east of Aklavik, was the most favorable. Accordingly, more detailed investigations were carried out at this site in the late summer and early fall of 1954 with emphasis on a potential townsite layout, water supply, airfield, wharf facility, and subsurface conditions (Pritchard, 1962). The site was ultimately confirmed by the Government of Canada in November 1954 as the location for the 'New Aklavik.' In 1958 it was officially named Inuvik (Inuttitut for 'The Place of Man').

Permafrost and Construction

The Inuvik site was selected because it was a well-drained, relatively flat area suitable for the intended size of the town with room for future expansion if necessary. There were large deposits of granular material for use as fill, and a suitable area for a major airport was located nearby. In addition, the East Channel provided good access by water, and acceptable water supply and sewage disposal facilities could be developed (Pihlainen, 1962).

During the summer of 1955, further detailed investigations of site and permafrost conditions, including measurement of ground temperatures, were conducted for the planning of land use, utilities, roads, and an airport. Construction materials were stockpiled, borrow pits opened, roads started, the first construction-camp buildings erected, and several hectares were cleared of brush. The major construction period lasted from 1956-61. During those years, a large school, two large hostels, a powerhouse, a water-treatment plant, several kilometers of utilidors, the airstrip, and several other major buildings plus many housing units were completed. Large-scale petroleum exploration began in the delta area in the late 1960s and early 1970s and spurred a second boom period.

Permafrost underlies the townsite and adjacent areas to depths of more than 200 m. Although granular materials are widespread, soils vary from site to site. In many places, all soil types contain considerable quantities of ice in a variety of forms, including lenses and layers, wedges, coatings on particles, and large, massive bodies several meters thick (Johnston, 1966). Examples of these ice bodies can be seen in most excavations in the area and are often seen in the gravel pits south of Boot Gully. In areas of undisturbed terrain, about 30 to 35 percent of the volume of the ground in the top 3 m is made up of ice (Heginbottom, 1975). Gravimetric moisture contents of soils range from 20 percent to several hundred percent.

Certain basic decisions were made regarding design and construction practices. Every effort was made to avoid disturbance of the existing ground thermal regime and thus preserve the permafrost. Clearing of small trees and brush was done by hand methods, and destruction of the surface organic layer was avoided. All work areas were protected by a gravel layer placed directly on the ground surface. Construction vehicles and equipment were not permitted to operate off the gravel pads, no cuts were permitted, and drainage was carefully assessed, with culverts installed if required. These procedures are still followed today.

Wooden piles were the preferred type of foundation for buildings and other facilities (Johnston, 1966). Initially they were placed in steam-thawed holes. Today, all new piles are placed in augered, slurry-filled holes. A clear air space of 0.1 to 1 m is left between the floor of the structure and the ground surface.

Although piles are widely used, structures are also supported by various other foundations. These foundations range from mud sills and footings on gravel pads for lightweight buildings (houses and small utilidors) to duct-ventilated pads for structures such as maintenance garages, workshops, large heated oil tanks, and aircraft hangars.

The Northern Canada Power Commission (NCPC) operates a generating plant to supply electric power not only to Inuvik, but also to Tuktoyaktuk and Aklavik by overhead transmission lines. NCPC also supplies heat, water, and sewage services to most of the buildings within the town of Inuvik. Water, sewer, and hot-water heating lines are contained in above-ground utilidors. In some parts of the town, water is distributed and sewage and garbage are collected by truck. Sewage flows by gravity to a lagoon north of the town; effluent from the lagoon discharges into the East Channel downstream of Inuvik.

Points of Interest

This section comprises notes on selected buildings or points of interest within the town of Inuvik, keyed to the maps in figures 57 and 58.

Town monument (fig. 59). The three arms of this sculpture in the center of the town represent the three races of people involved in Inuvik: Inuit, Dene (Indian), and Caucasian. The monument was unveiled at the official opening ceremony at Inuvik by the Right Honorable John G. Diefenbaker, P.C., M.P., the first Prime Minister to visit any part of Canada north of the Arctic Circle, who did so on July 21, 1961.

Roman Catholic Church (fig. 60). The Church of our Lady of Victory in Inuvik is also known as the Igloo Church because of its shape. The resemblance to an igloo was intentional. The church was designed and built by the Oblate Fathers---missionaries to northern Canada. It is one of the few heated buildings in Inuvik that is not on a pile-ventilated foundation. Instead, the foundation consists of a circular pad of reinforced concrete, about 30 cm thick, laid on a pad of gravel some 2 m thick that in turn was built up on a layer of brushwood and the undisturbed, natural vegetation. The church is of timber-arch construction 23 m in diameter and 21 m high; it seats 350.

Scientific Resource Centre (fig. 61). This scientific laboratory is operated by the Department of Indian and Northern Affairs. The purpose of this center is to support arctic research by universities, government, and industry by providing well-equipped facilities; it serves as a base from which field studies can be undertaken. The Centre contains laboratories, photographic darkroom, library, offices, seminar rooms, and workshop and storage facilities.

Power station and tank farm. Electrical power and heating water are supplied from a powerhouse complex near the East Channel. The original powerhouse was constructed in 1958 with a concrete mat floor supported above the ground by 9-m-long wooden piles driven into permafrost. Under this floor is an insulated crawl space that encloses the underfloor piping and has an air space of 0.6 to 2.5 m. This arrangement was designed to prevent thawing of permafrost around the piles. The soils at this site are very stony, and during pile installation a combination of steaming and drilling had to be employed. There was concern that too much steaming was done at several locations. To check on this situation, seven thermocouple cables were installed in drilled holes adjacent to selected piles, and ground-temperature readings were taken at 2-wk intervals for several years. These observations show no adverse ef-

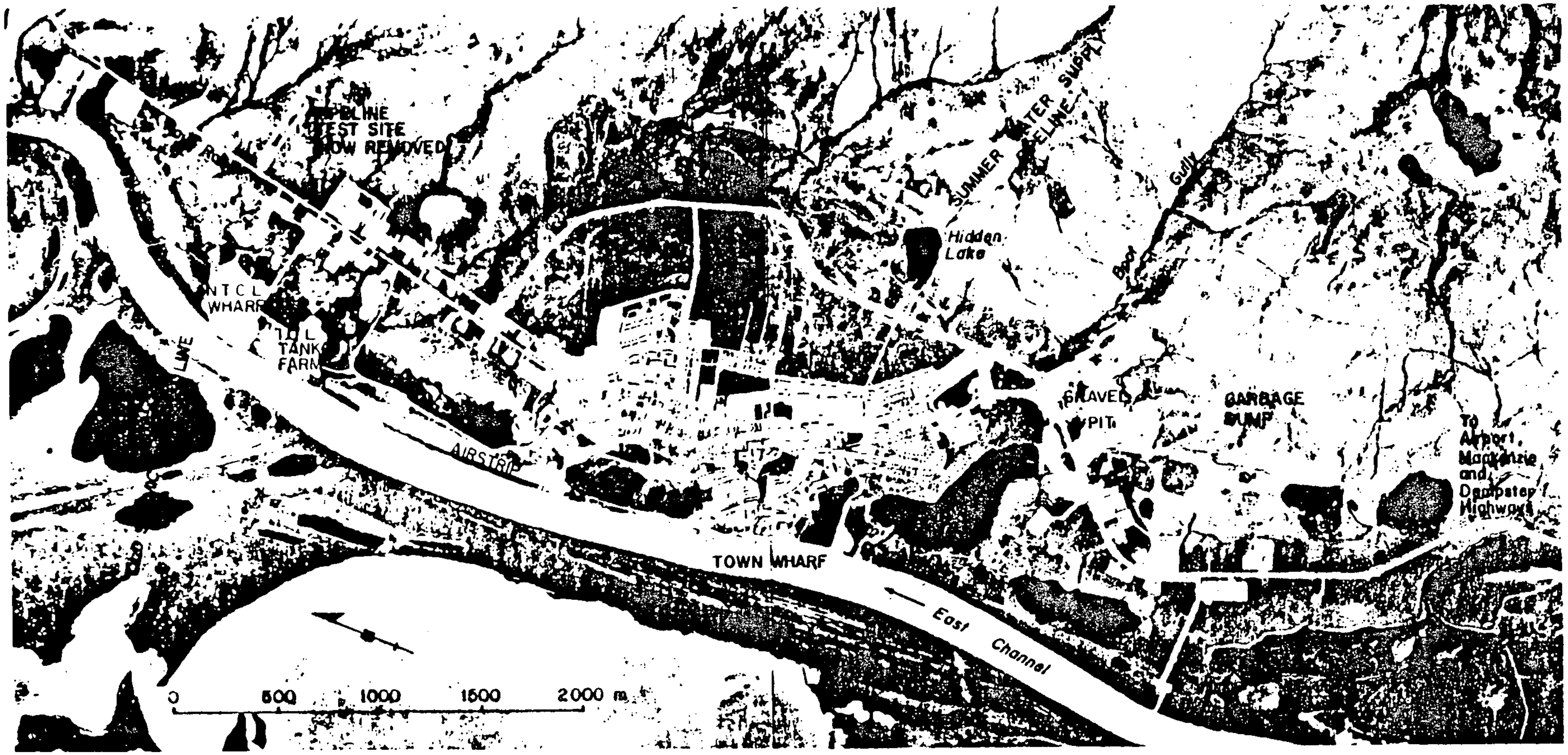

Figure 57. Annotated airphoto mosaic of Inuvik and vicinity.

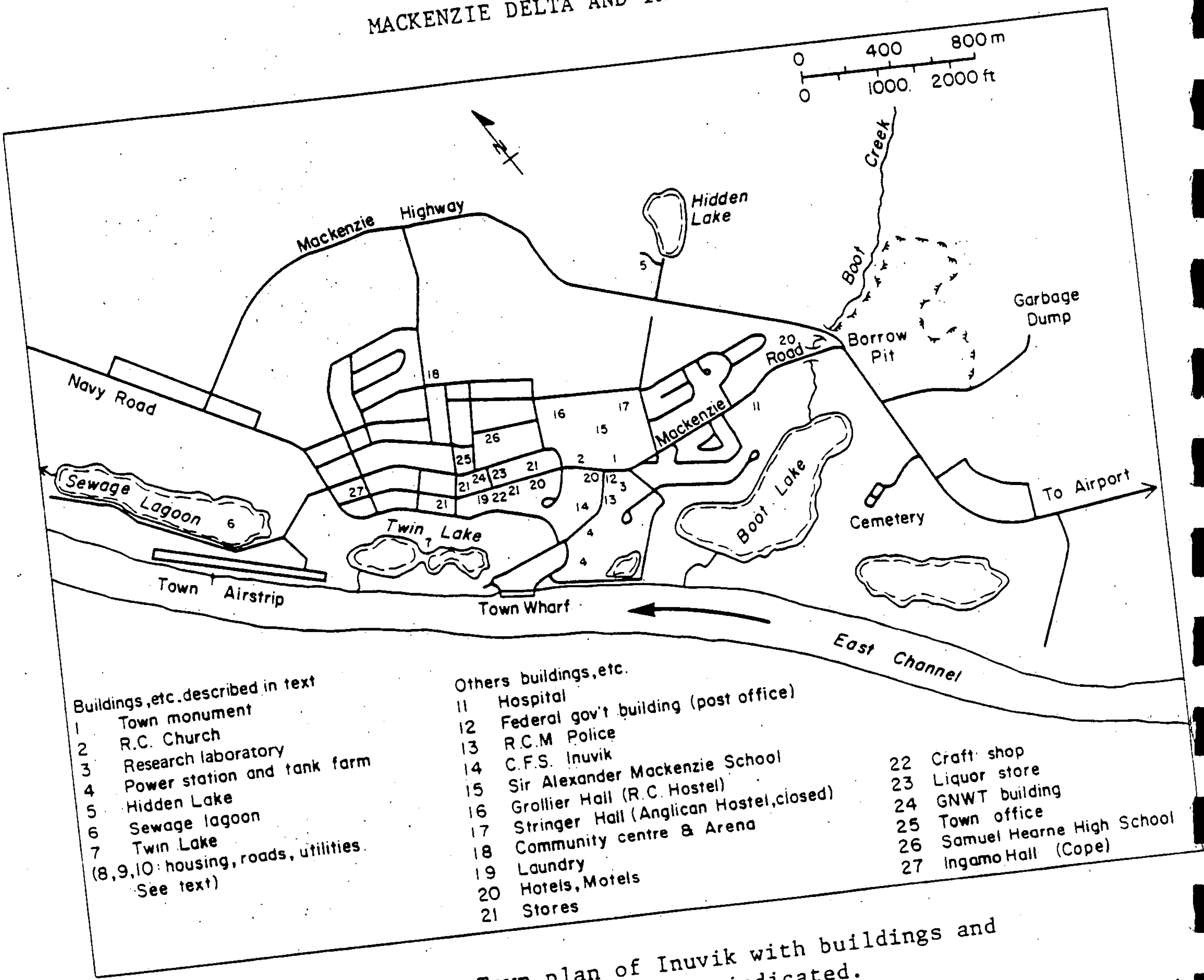

Figure 58. Town plan of Inuvik with buildings and points of interest indicated.

Rapid growth of Inuvik necessitated an addition to the powerhouse in 1967. A very different foundation design was selected (fig. 62). The main feature of the foundation is the duct system buried in the base of the fill and joined by headers at each end, through which cold air is circulated during winter months. Ground-temperature conditions beneath this extension were also monitored by thermocouples installed during construction.

Continued growth led to the construction of a second powerhouse in 197 which contains one large generator. This powerhouse was built on piles which had been installed many years earlier. The generator block is supported separately from the main floor and the superstructure of the building.

The fuel-oil tanks at Inuvik have been constructed on a variety o different foundations. A number of the tanks are heated during winter. M tanks are built on circular pads of gravel or crushed rock with ventilat ...el culvert pipe. Typically the ducts are 45 or 60 cm in diamet

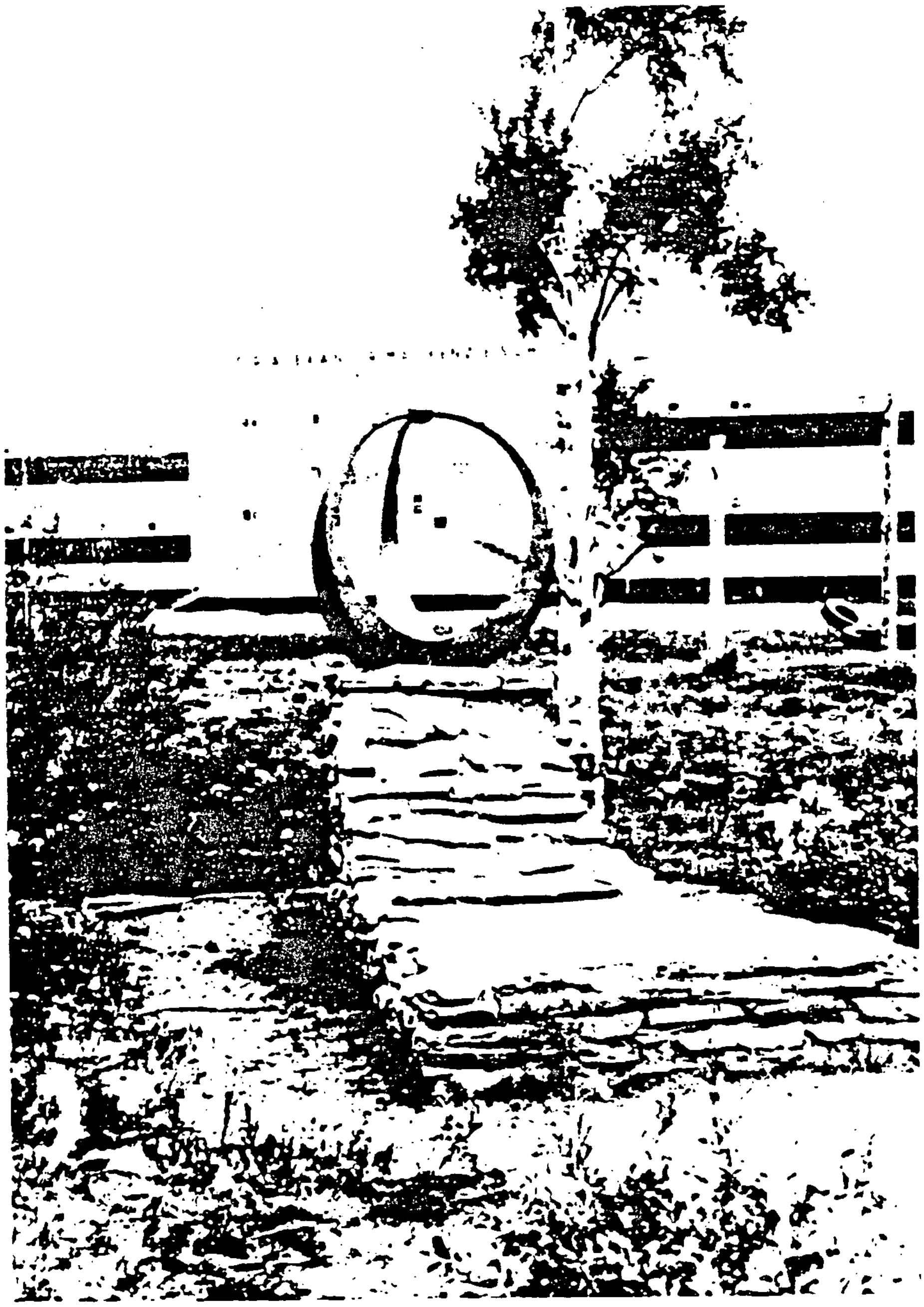

Figure 59. The Inuvik town monument (Photo: July 1982).

and spaced 1.2 or 1.4 m apart (center to center). Where possible, the ducts are oriented (108 degrees true azimuth) so that the prevailing wind blows directly through. There is a thickness of 0.1 to 3.6 m of gravel below the ducts and 1 to 1.2 m above them. Some of the pads also include one or more layers of urethane foam insulation, 5 to 15 cm thick. Only one tank is on a pile foundation. This tank is built on a circular concrete pad, 25.6 m in diameter by 38 cm thick, supported on 282 wooden piles (each 10 m long); it has an air space not less than 75 cm high. The piles are arranged in a series of concentric circles, with an average spacing of about 1.4 m. The foundations of all the tanks appear to have performed satisfactorily, with no more than ordinary maintenance required.

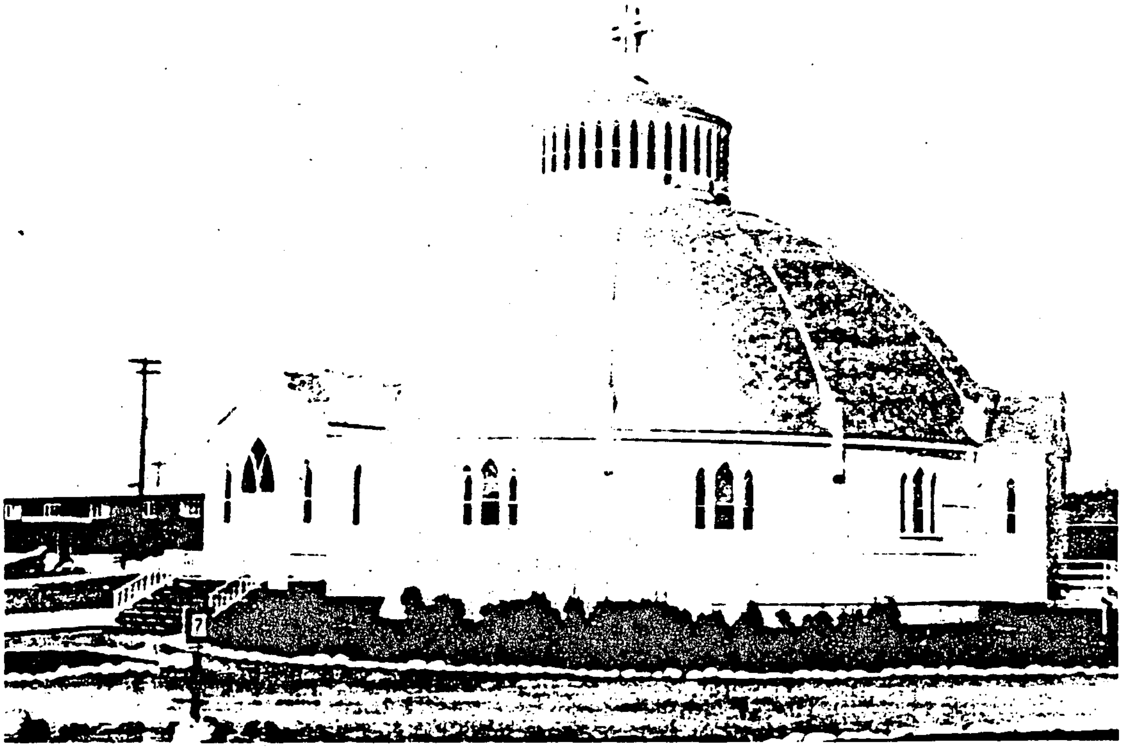

Figure 60. Roman Catholic Church, Inuvik (Photo: July 1982).

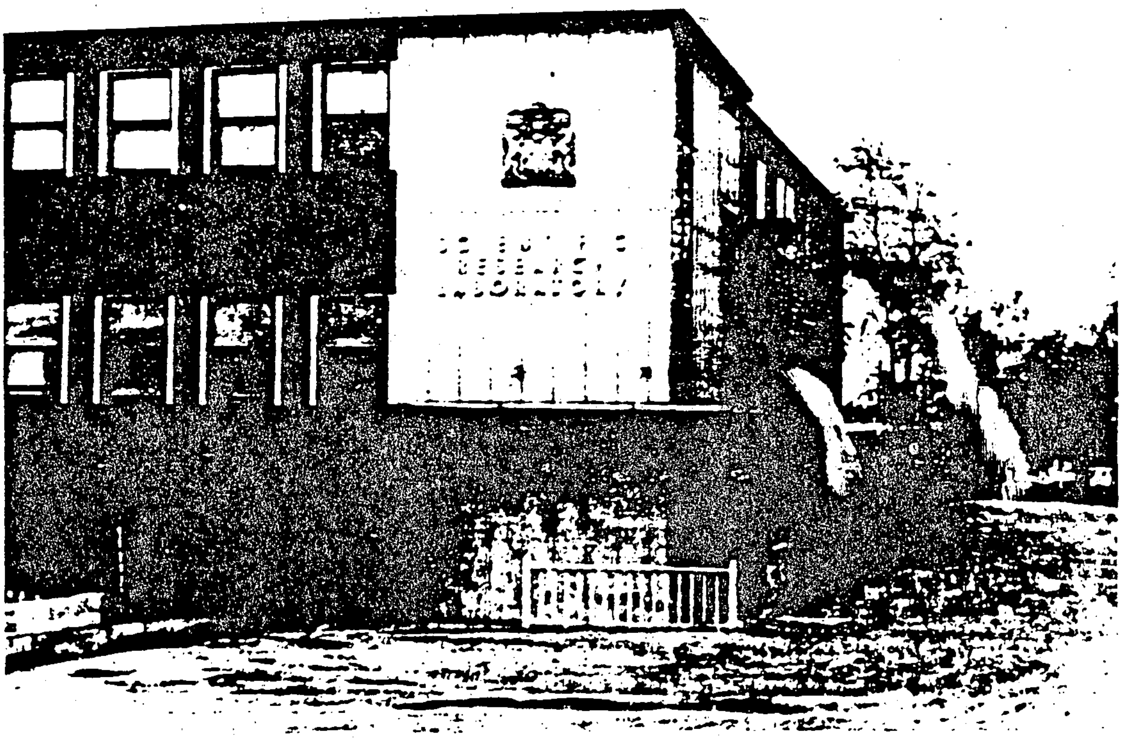

Figure 61. The Scientific Research Centre, Department of Indian and Northern Affairs, Inuvik (Photo: July 1982).

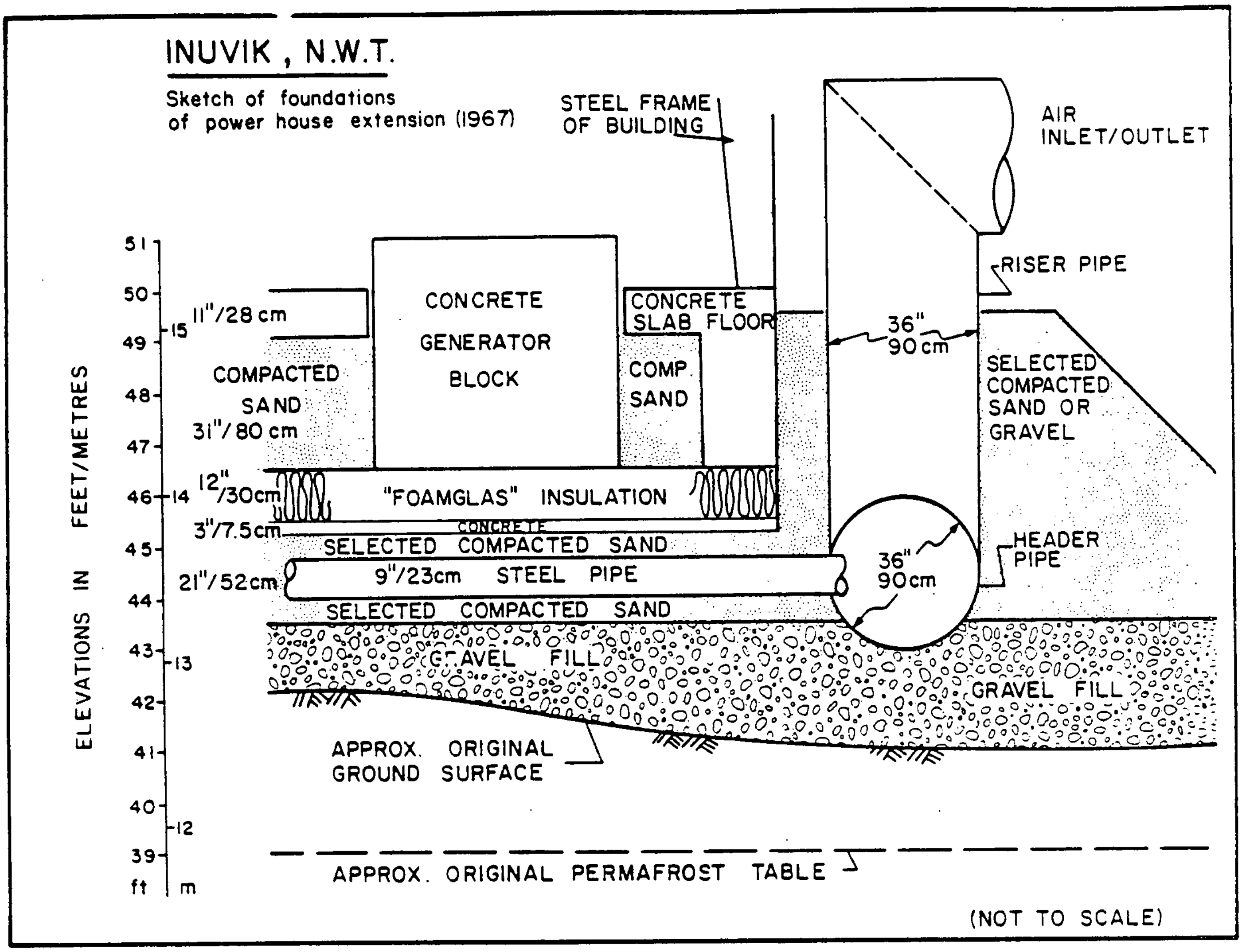

Figure 62. Diagrammatic sketch of the ducted foundation for the 1967 extension to the Inuvik powerhouse (Johnston, 1982).

Hidden Lake. This small lake immediately behind the town was the original drinking-water supply for Inuvik. Water for the town is now drawn from the East Channel and from another lake about 5 km to the east. The lake basin probably originated as a thermokarst depression.

The antenna dish above the town receives television and commercial communications signals from southern Canada via satellite. There is a good view across the town and Mackenzie Delta from near the antenna structure.

Sewage lagoon. All sewage piped from the town system flows through the utilidor system and is discharged into this lagoon, which was formed by damming a natural depression and raising a berm adjacent to the East Channel. Some vegetation was stripped off the bottom of the lagoon to provide a greater depth by thawing the permafrost. The purpose of the lagoon is to store sewage for discharge into East Channel during those times of the year when there is no danger of contaminating the water supply. Discharge from the lagoon is via a sluice at the north end. The lagoon was reconstructed in 1982.

Sewage from the unserviced parts of the town is collected by tank trucks, which also discharge into the lagoon but at the north end near the outfall. In winter, a partial ice cover forms on the surface of the lake. The warm effluent inflow keeps a large area of water open all winter at the south end of the lake. This pool attracts early migrant birds, and even tempts some species to winter here.

Twin Lakes. The lakes, which are really a single lake, are considered to be kettle holes. A thick deposit of peat in the northeast bank has been described by Mackay (1963, p. 41), Mackay and Terasmae (1963), and Kuc (in Fyles and others, 1972, fig. 5). The peat is 340 cm thick and overlies about 15 m of glaciofluvial gravel and till. Six radiocarbon dates provide ages ranging from 11,500 ± 160 yr B.P. (GSC-1514) at the base of the peat to 5,420 ± 70 yr B.P. (WIS-279) at 30 to 40 cm from the top. The macrofossil sequence identified by Kuc records the change from an aquatic environment through swamp to forest and agrees with sequences proposed by Mackay and Terasmae (1963) and Ritchie and Hare (1971).

Housing. Housing in Inuvik includes a mixture of government-, company-, and privately owned houses and apartments.

The original government housing included apartments for single staff members and either four-unit row houses or single-family dwellings for married staff. Each type of dwelling was provided with complete water, heat, and sewage services by means of utilidors. Each building contains its own heat-exchange unit. Apartments have a living room with kitchenette, bedroom, and bathroom; a common laundry room is provided within the building. The row houses each have three bedrooms and a bathroom upstairs, with a large living room and a kitchen downstairs. Each is equipped with a refrigerator, washing machine, and clothes dryer. The single-family houses include another bedroom and a separate dining room.

Private houses and apartments include a wide variety of styles and designs. Most are built on pile foundations, and most use the utilidor for water supply and sewage. A few also use the heating water from the utilidor, but many have their own oil furnaces for space heating.

Roads and sidewalks. As in most communities in northern Canada, the roads of Inuvik were all gravel surfaced until 1979. Although satisfactory in winter, they were either dusty or muddy in summer. The original sidewalks were boardwalks.

In 1979, the main street was asphalted as an experiment. The section in the town center, which receives the most traffic, broke up within 2 yr and was repaired in 1981 using chip seal, a mixture of oil and sand spread out, compacted, and covered with a layer of rock chippings. Chip seal was also used on the road to the airport, where it has worn better than in the center of town.

The concrete sidewalks were laid in the summer of 1980 and appear to be holding up well.

Utilities. There are at least eight utilidor designs in service in the townsite. Utilidors distribute drinking and hot water and collect waste water and effluent. The original utilidors were constructed with a 1- by 1-m steel frame, clad with aluminum and insulated with 7.5 cm of fiberglass (fig. 63). The system was supported on wooden piles driven into the permafrost at least 6 m. Connections to dwellings were by smaller 'utilidettes' containing smaller pipes. Some housing units (rows) were later built astride the main utilidor.

Several other utilidor designs have since been developed. They include insulated sections of metal or insulated plywood boxes. Most utilidors are supported on piles, but some sections use timber sleepers laid on a gravel pad and others use gravel-filled oil drums. One problem that results from the use of above-ground utilidors is the difficulty of arranging road crossings (fig. 64). This problem has resulted in the construction of several bridges where roads go over utilidors. There is also one underpass, which was constructed after the utilidor was in place.

Electric power is distributed around the town by normal overhead lines. The supporting poles are strapped to piles driven deep into the permafrost, and most piles are stable. The powerlines to Tuktoyaktuk and Aklavik are supported in the same manner.

ROAD LOG AND SITE DESCRIPTIONS

The site descriptions are arranged in order from southeast to northwest, following the progression of the sites along the main Dempster and Mackenzie Highways. The distances continue to be related to the southern terminus of the Dempster Highway at Klondike Lodge.

KM 748-760. Airport Road sites. The original concept for Inuvik placed the airport immediately north of the town, where the present Mackenzie Highway bypasses the town (fig. 58). Fortunately, the present site, 11 km east of the town, was chosen instead, thus sparing the townsite the noise associated with a busy airport. In recent years, a number of industrial and commercial enterprises have been established along Airport Road (fig. 57).

KM 748. STOP 1. INUVIK AIRPORT. The Inuvik airfield was constructed between 1956 and 1958 on a site underlain by frozen fine-grained soils containing considerable ice. Its design and performance were therefore of considerable concern. The airfield consists of a rock-fill embankment constructed on the undisturbed ground surface in a thickness sufficient to prevent (or minimize) thawing of the frozen subgrade soils (from 2.5 to 4.2 m, and averaging about 3 m) (fig. 65). The airfield was paved with asphaltic concrete in 1969. From 1958 to 1974 ground temperatures were measured at several locations in the subgrade and in the embankment (Johnston, 1982). All temperature observations showed that the permafrost table moved up at least 0.6 m into the fill after construction was completed in 1958 and remained at about the same level in subsequent years, even after paving. The airstrip has performed extremely well and has required little maintenance work.

In addition to the runway, taxiways, and apron, the airport includes a number of buildings with different foundation designs. The control tower and terminal are founded on piles installed between 1956 and 1958. Hangars with

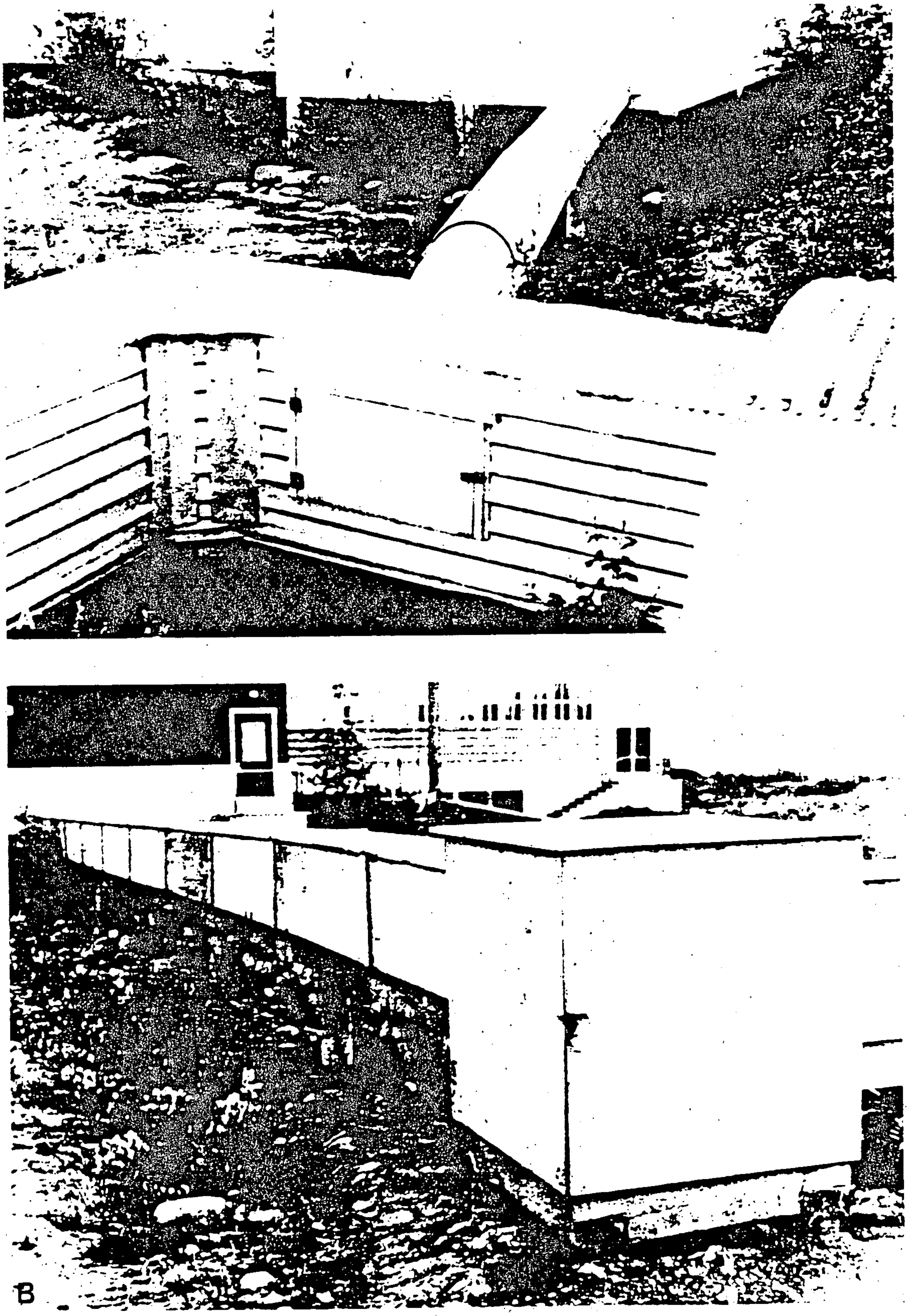

Figure 63. Original utilidors in Inuvik townsite, 1982. (A) Original metal-clad utilidor and 'utilidette' house connection; (B) wooden box on piling utilidor.

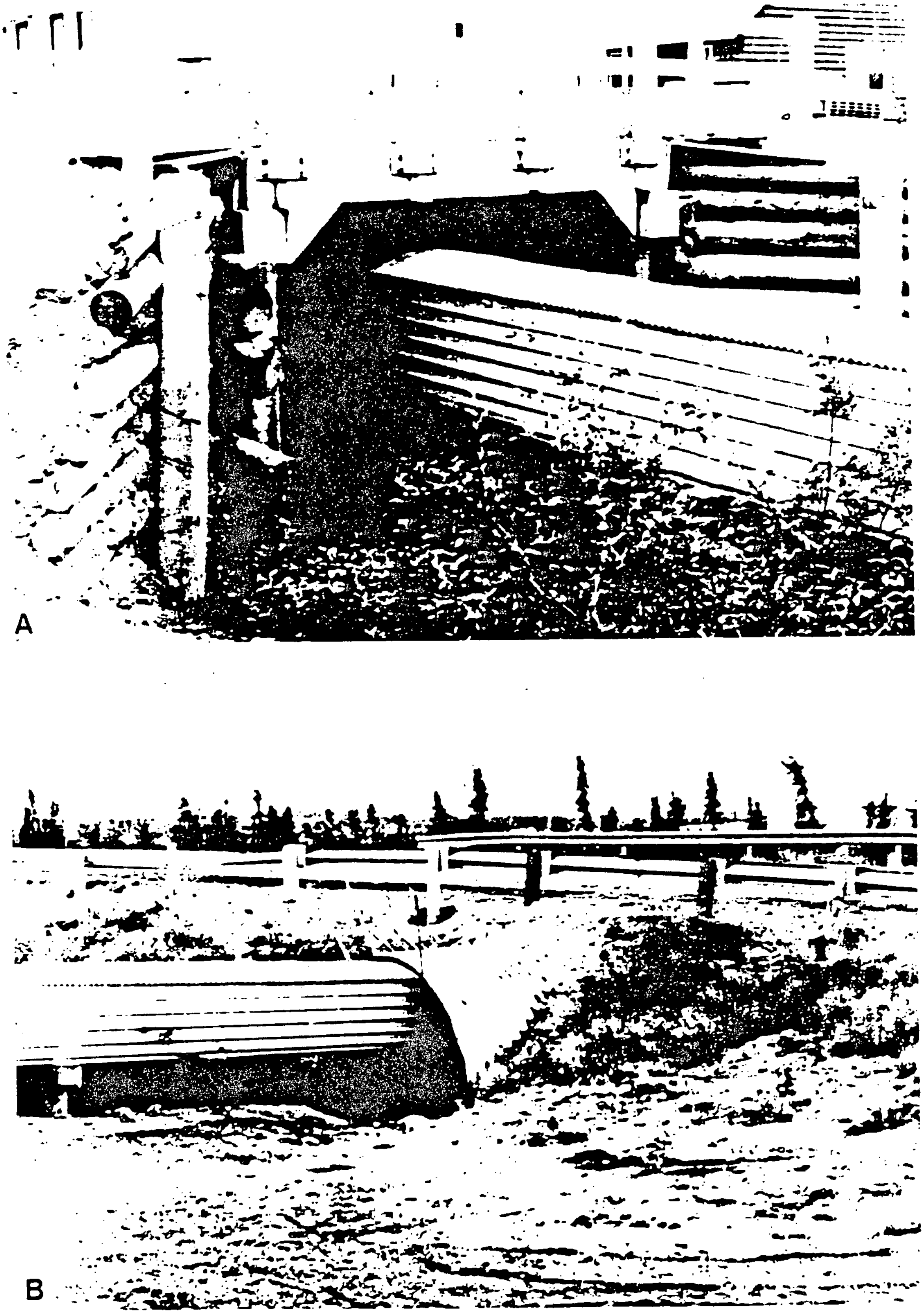

Figure 64. Road crossings of utilidor, Inuvik townsite: (A) original pattern concrete bridge; (B) current metal culvert.

duct-ventilated foundations were built for Imperial Oil Company, Ltd. (Nixon, 1978) and Okanagan Helicopters in 1959 and 1972, respectively; both seem to be performing satisfactorily.

KM 749. STOP 2. SNOW-ROAD TEST SITE. (Note: this site is on airport property and the permission of the airport manager is required prior to any visit.)

Snow-road construction and performance studies were undertaken in this area during the winter of 1973-74 (Adam, 1978). The test site consisted of a lane 520 m long and a loop of about 625 m for a total length of about 1,150 m. Site preparation consisted of clearing trees by hand methods (although willows and alders were left in place). After the snow road was constructed, trafficability was tested with various vehicles having gross loads up to 36 tons and conducting as many as 1,600 vehicle passes. When the site was examined the following summer, there had been a reduction in the shrub vegetation, but there were no significant changes to the mosses and lichens, root systems of shrubs, ground-surface elevation, organic layer, or active-layer thickness (Younkin and Heltinger, 1978).

KM 754. STOP 3 (OPTIONAL). GAYNOR LAKE. In 1967, Imperial Oil Ltd. ('Esso') installed one of the first 'test' pipelines at this location. The 30-cm-diameter line was about 600 m long. Most of the pipeline was buried beneath the ground. One 80-m-long sector was laid beneath 'Gaynor Lake,' and part was laid on the ground and covered with a low berm. A section was also laid beneath the roadbed. The line and the ground along the right-of-way were monitored for a few years. Originally it was planned to circulate crude oil through the pipeline. Today, it is heavily overgrown with willows, alders, and fireweed.

<u>1968 forest fire</u>. A serious forest and tundra fire burned around Inuvik from 8 to 18 August 1968 and destroyed many tens of square kilometers of lichen-rich tundra and forest-tundra. As a direct result, some bare hillslopes became gullied, sediment was transported into otherwise clear lakes, ice-rich permafrost degraded, flow slides developed, bulldozed firebreaks subsided, and the active layer thickened over most regions. The fire started between Gaynor Lake and 'Tower Lake' and spread to the north and east. Studies of the effects of this fire and of the fire-fighting activities were started in 1969. Surveys show that the depth of the active layer, where the vegetation had been burned, increased rapidly from 1968 to 1972, but more slowly since then (fig. 66). Beneath the bulldozed firebreaks the response was even more rapid.

KM 759. STOP 4. 'BOOT GULLY' AND TOWN BORROW PIT. Boot Gully served as a meltwater channel during deglaciation. The valley connects the Campbell Lake-Sitidgi Lake lowland and the Mackenzie Delta. At the west end of the gully is a 10-m-thick deposit of outwash gravel about 1 km^2 in extent. This gravel overlies gray clayey silt. Most of the gravel has now been removed for use as general fill during construction of the town and for road building. Several masses of ground ice, including large lenses and wedges, were found in the gravel during borrow operations (fig. 67). At times, their presence led to considerable slumping and thermokarst, which hampered use of the borrow pit.

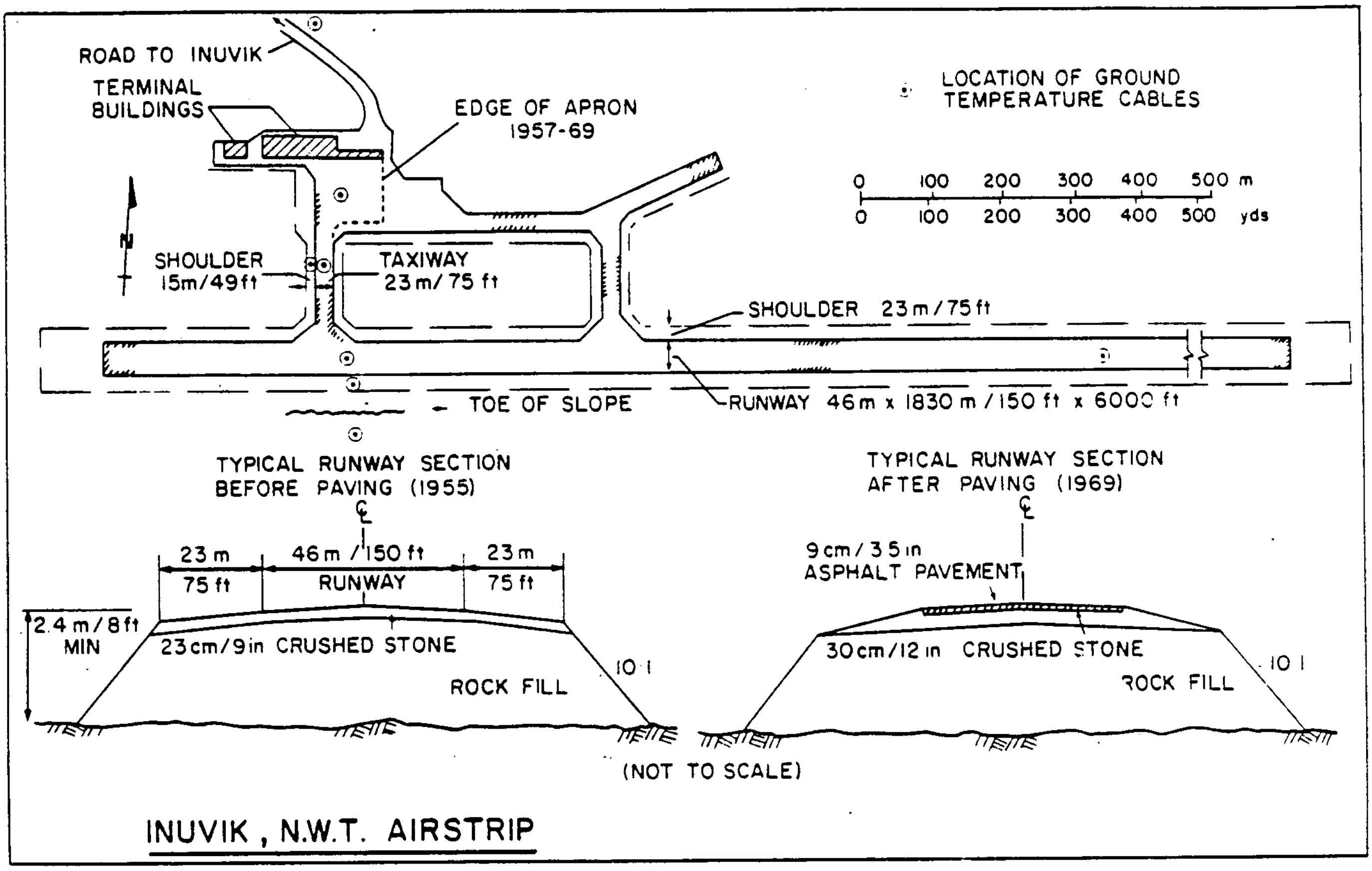

Figure 65. Plan showing the general layout of the Inuvik airstrip and typical sections of the runway before and after paving (Johnston, 1982).

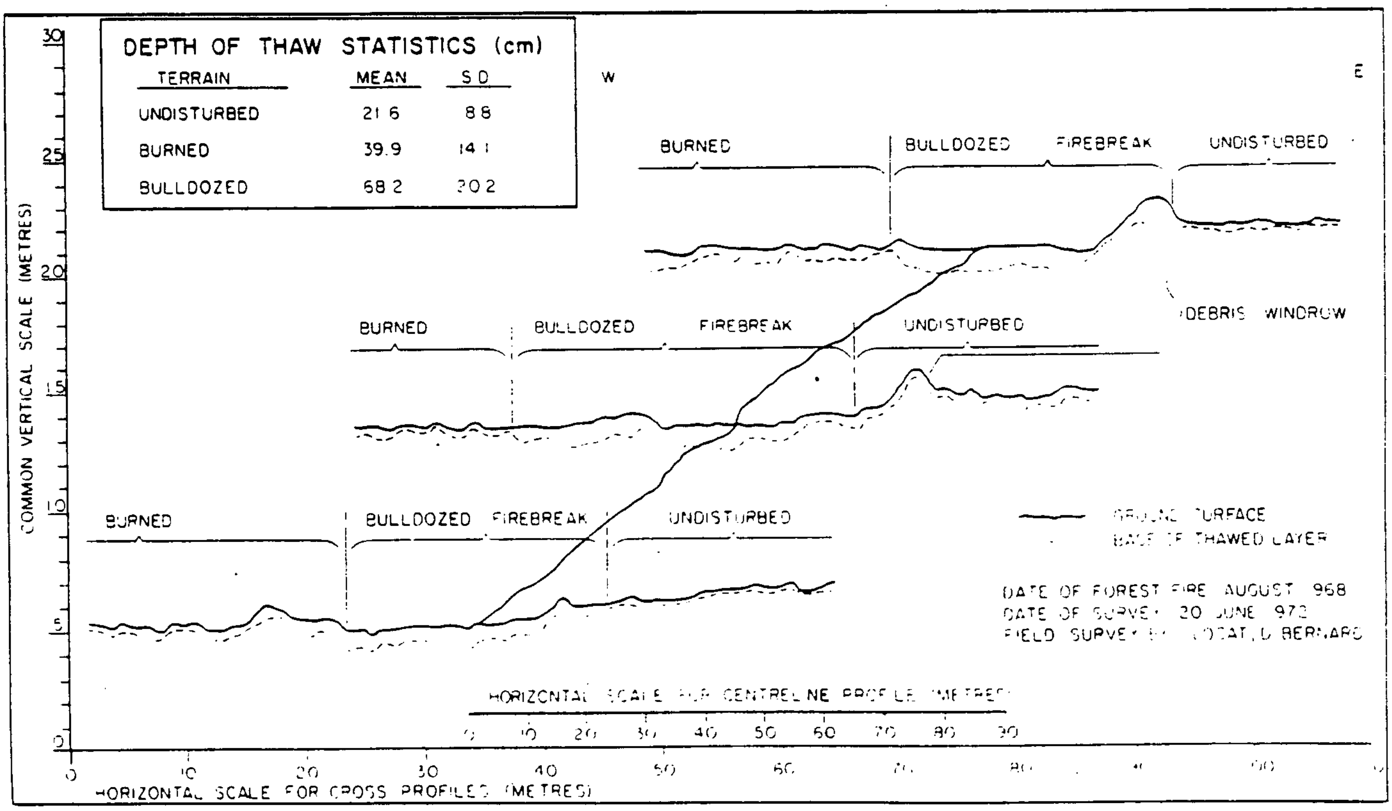

Figure 66. Profiles of ground-surface elevation (arbitrary datum) and depth of thaw across the firebreak north of Inuvik.

Figure 67. Small ice wedge in gravels at 'Boot Gully' borrow pit, 1971.

Navy Road Sites

North of Inuvik is an industrial area, which includes the main wharf warehouse of Northern Transportation Company Ltd. and the Imperial Oil Com tank farm beside the river.

KM 760-764. Navy road to CFS Inuvik. For 12 km north of Inuvik, is a bench about 1,500 m wide between the delta and the hills. This bench covered by low-angle fans of clayey silts that extend from gullies in hills. Under these fans, gravel occurs in several places, generally depth of 1.5 m or more. These gravel occurrences are interpreted as terrace deposits laid down between the hills and a late glacial ice lobe the Mackenzie Delta. Excess ice is found in both the silty clay an gravel, with up to 90 percent ice by volume in some horizons. The layer is typically 15 to 100 cm deep. In winter, the uppermost meter of ground contains an average of 30 percent excess ice by volume. The unde meter of soil typically includes an average of 50 percent excess ice th out the year. Any ground-surface disturbance, whether by fire or bulldoz leads to a virtual disappearance of excess ice in the top meter and a sig cant decrease in the second meter (fig. 68).

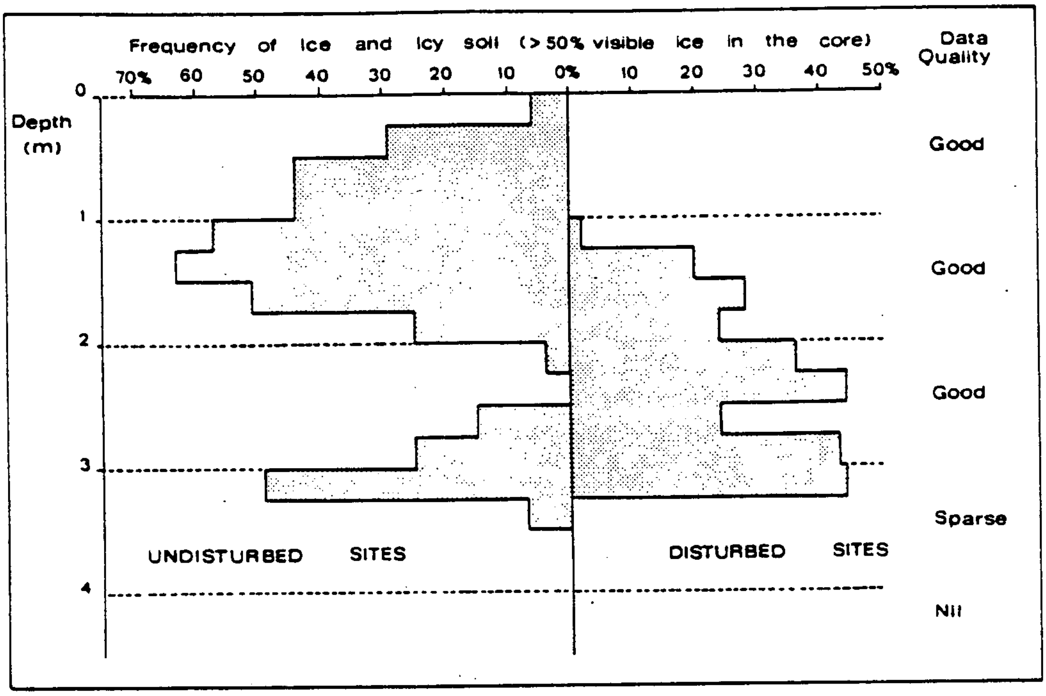

Figure 68. Effects of surface disturbance on ground-ice content and distribution in the upper 3 m of the ground near Inuvik (Heginbottom, 1975).

KM 761. STOP 5 (OPTIONAL). PIPELINE TEST SITE. A hot-oil pipeline test facility was constructed in 1969 by Mackenzie Valley Pipeline Research Ltd., a consortium of 16 oil and pipeline companies. The facility consists of a 610-m-long closed loop of 1.22-m-diameter pipe containing crude oil from Norman Wells. Half of the pipeline was supported above ground on piles and the other half was laid on a gravel pad and covered with a gravel berm. Various types and thicknesses of insulation were installed on different segments of the pipeline and heated oil was circulated around the loop. The site was chosen to simulate the severe climatic and permafrost conditions that would be encountered by an arctic pipeline system. Soils at the site consisted of 2 m of ice-rich silt containing ice lenses, overlying 4.5 m of well-drained sandy gravel, over frozen or plastic clay of low-moisture content. The test facility was operated from February 1970 until late 1972. It has since been dismantled and removed except for the gravel pads.

KM 762. STOP 6. HUMMOCK FROST-HEAVE SITE. In 1975, J.R. Mackay and others started a field program at this site to determine if volume changes (frost heave) could be detected in the active layer after the entire active layer had cooled below 0°C and frozen through to permafrost. Three different methods were used to measure frost heave: a) a 'bedstead' arrangement, b) heavemeters, and c) wooden stakes leveled with reference to three invar rod benchmarks, which were the supports for the bedstead. The elevations of these various devices were measured to an accuracy of 1 mm or less. The results (fig. 69) show that frost heave can occur in fine-grained soils from January to late spring, after the entire active layer is at a temperature below 0°C (Mackay and others, 1979). The cumulative results show that ground-surface heave of 1 to 2 cm occurs after January with some heave continuing until May. There is some evidence that the amount of heave relates directly to the thickness of the active layer.

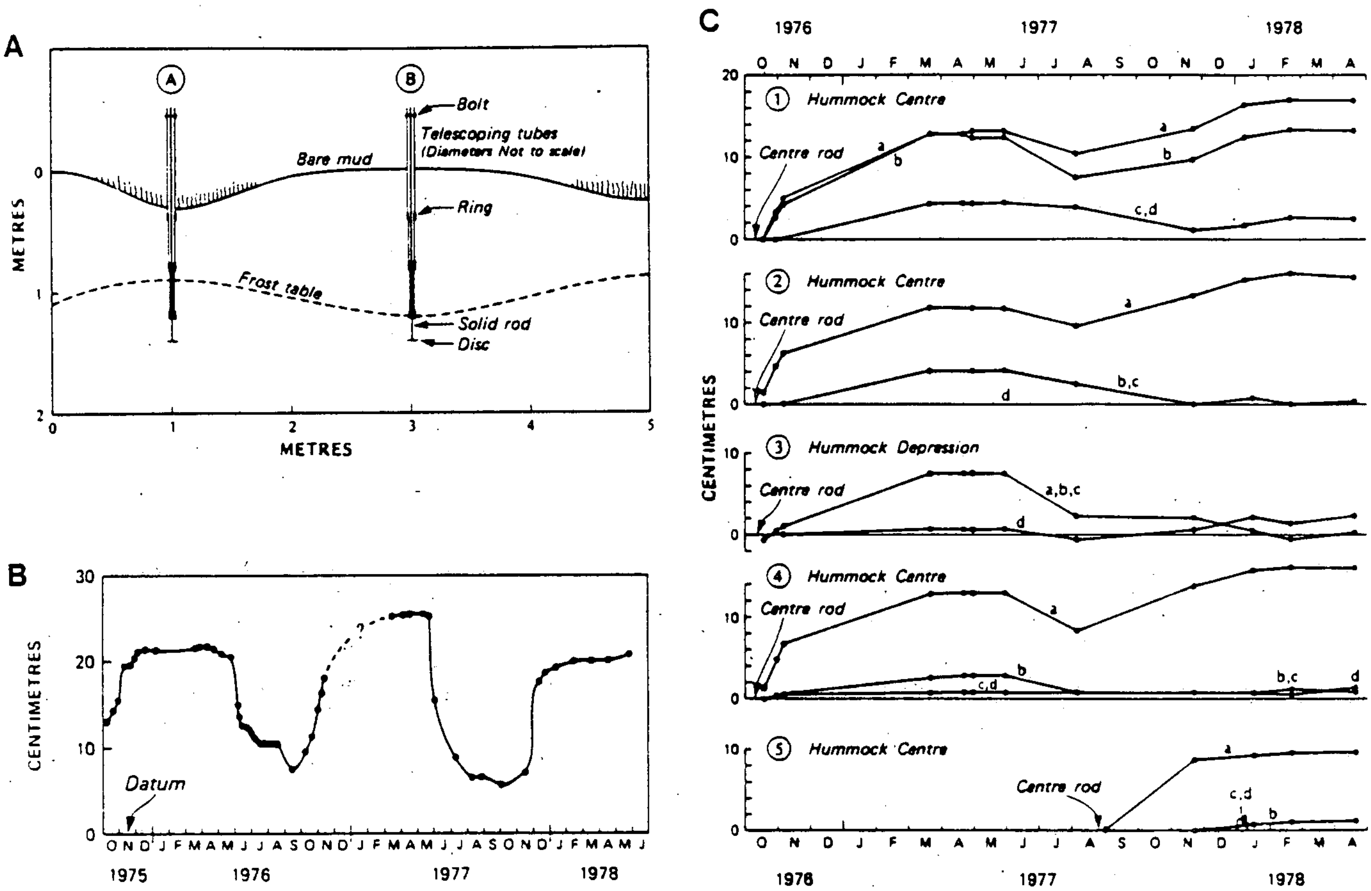

Figure 69. Winter frost heave at mud hummocks (Stop 6), Inuvik, N.W.T. (A) Schematic diagram of telescoping tubes with one set installed in an inter-hummock depression, the other in the hummock center. The bolts serve to keep the tubes in position during insertion. (B) Graph showing the amount of heave of one of the six invar spindles (No. 2 that rested on the surface of a mud hummock. (C) Graph showing the amount of heave of the five sets of telescoping (tubes a, b, c, d) heavemeters referenced to their datum center rod.

Hummocks (nonsorted circles) occur widely in the arctic and subarctic regions of northwestern Canada. At Inuvik, the hummocks are composed of fine-grained frost-sensitive soils. The late-summer frost table is bowl shaped and the hummocks grade from those that are completely vegetated (earth hummocks) to those with bare centers (mud hummocks). Mound form is usually attributed to an upward displacement of material resulting from cryostatic (freezeback) pressures generated in a confined, wet, unfrozen pocket of the active layer. Theoretically, cryostatic pressure should not develop in a frost-sensitive hummock soil because ice lensing at the top or bottom of the active layer will desiccate the last unfrozen pocket so that the pore water is under tension, not under pressure.

Field observations by Mackay (1979a, 1980) on Garry Island and at Inuvik provide no evidence for the cryostatic theory. Instead, they suggest that an equilibrium model of hummock growth is more appropriate (fig. 70). The upward displacement of material is believed caused by the freeze and thaw of ice lenses at the top and bottom of the active layer with a gravity induced, cell-like movement, because the top and bottom freeze-thaw zones have opposite curvatures. The cell-like circulation is evident from the grain-size distribution of the hummock soils and from upward-moving tongues of saturated soil observable in late summer. The most active period is late summer.

KM 764. STOP 7 (OPTIONAL). BRUNISOLIC TURBIC CRYOSOL. This site is located on strongly cryoturbated, fine-textured colluvium at the edge of the 1968 forest fire. The soil is classified as a Brunisolic Turbic Cryosol. The vegetation is mainly sedges and cottongrass, but in an adjacent unburned area there is a typical black spruce-lichen subarctic forest. The earth hummocks here are much larger than average, but, because of the deep active layer resulting from the burn, they are good for illustrative purposes (fig. 7A). Note in particular the intrusions of peaty materials and the subsurface organic horizon (Ohy) near the frost table. Analytical data for the soil profile at this site are presented in table 12.

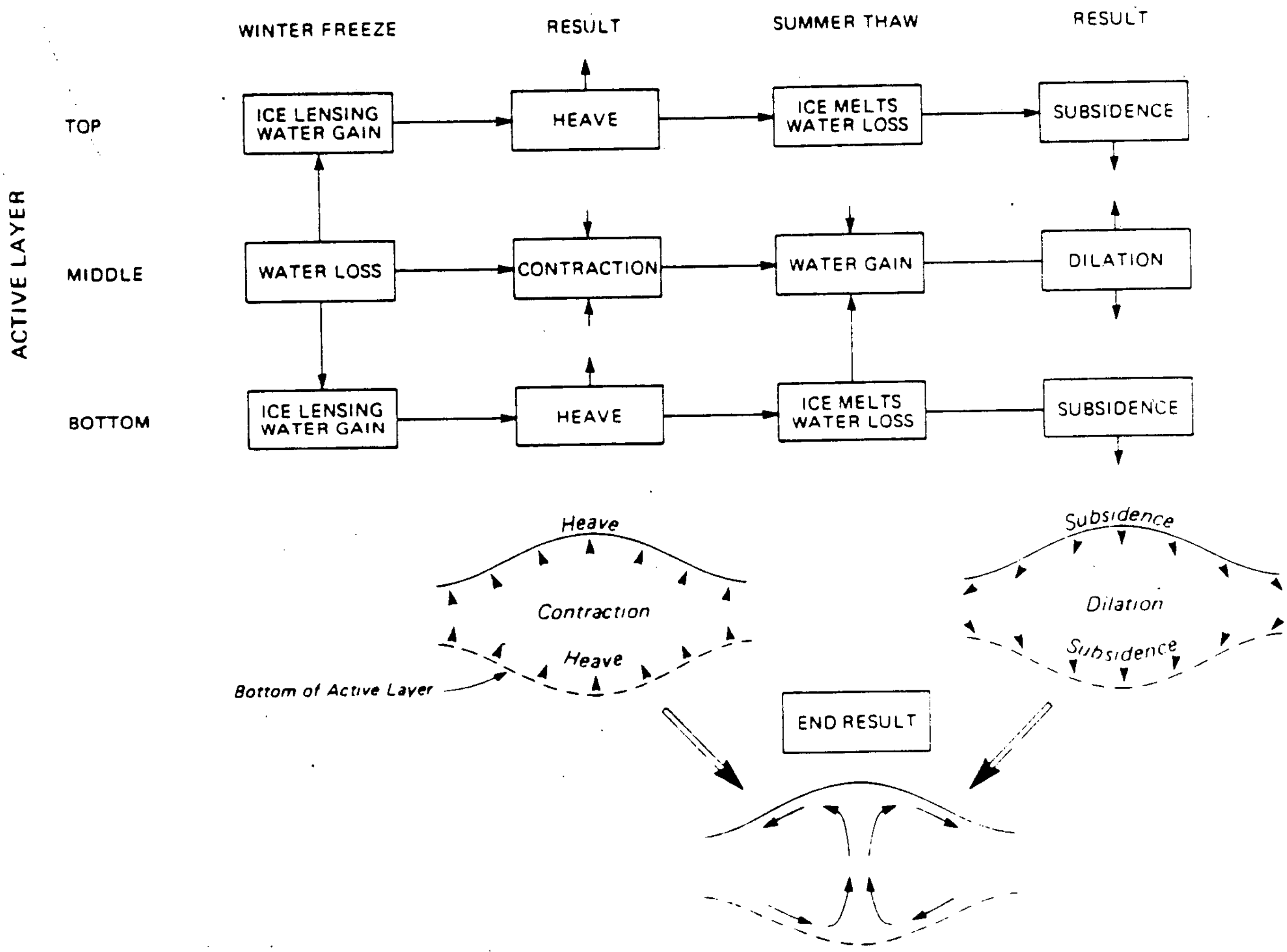

Figure 70. The equilibrium model for hummock growth (Mackay, 1980).

Table 12. Analytical data for the Brunisolic Turbic Cryosol at Stop 7, Navy Road, near Inuvik (Pettapiece and others, 1978).

Horizon	pH		Total	Total		Exchangeable cations (me/100 g)									
						Neutral salt extraction					Buffered NH_4OAc (pH7)				
	H_2O	$CaCl_2$	C%	N%	C/N	K	Ca	Mg	Al	Total	Total	Ca	Mg	Na	K
Bm	4.3	3.8	2.0	0.17	12	0.5	0.1	0.2	8.0	8.7	26.9	0.1	0.2	0.1	0.3
BCy1	4.2	3.7	1.2	0.09	13	0.5	0.2	0.2	7.0	7.9	25.4	0.2	0.3	0.1	0.5
BCy2	4.2	3.7	2.3	0.17	13	0.5	0.7	0.3	6.1	7.6	26.9	0.6	0.5	0.1	0.6
Ohy	4.4	4.1	17.4	0.76	23	0.7	3.4	1.2	5.7	10.9	78.0	2.4	1.3	0.2	0.5
Cg	3.8	3.7	2.7	0.26	11	0.9	7.0	3.2	2.2	13.2	25.7	6.8	3.8	1.2	0.7

Horizon	Sesquioxides (%)						
	Dithionite			Oxalate		Pyrophosphate	
	Fe	Al	Mn	Fe	Al	Fe	Al
Bm	3.15	0.30	0	1.67	0.27	0.74	0.29
BCy1	3.17	0.34	0	1.66	0.29	0.66	0.26
BCy2	3.06	0.27	0	1.58	0.29	0.72	0.27
Ohy	1.93	0.64	0	1.84	0.45	1.46	0.56
Cg	2.76	0.14	0.01	0.91	0.07	0.29	0.11

Horizon	Available nutrients (ppm)				Organic matter					Mineralogy (<2 µ clay)[a]						
					Extracted			FA	HA							
	N	P-Brav	K	S	%C	%N	Cha/Cfa	E4/E6	E4/E6	Mica	Chlor.	Koalin	Smect.	Verm.	Quartz	Felds.
Bm	1	0	101	41	33	53	0.43	7.6	3.6	tr	--	tr	1	tr	2	tr
BCy1	1	0	138	50	41	41	0.40	5.0	3.4	1	tr	tr	1	1	4	tr
BCy2	--	--	--	--	--	--	--	--	--	1	--	tr	1	1	2	--
Ohy	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cg	--	--	--	--	--	--	--	--	--	1	tr	tr	1	1	4	tr

Horizon	Physical											
	Fiber content		Particle size distribution - %<2 mm				Moisture %		Atterberg		Classification	
	Unrub %	Rub %	Sand	Silt	Clay	F-Clay	1/3 atm	15 atm	PL	LL	Unified	USDA
Bm	--	--	3	49	48	17	35	24	--	--	--	C
BCy1	--	--	2	45	53	20	--	--	28	44	--	C
BCy2	--	--	3	47	50	17	--	--	29	43	--	C
Ohy	50	5	--	--	--	--	--	--	--	--	--	--
Cg	--	--	2	48	50	14	--	--	--	--	--	C

[a] Amount estimated from X-ray diffractograms: tr = trace, 1 = 2-20%, 2 = 20-40%, 3 = 40-60%, 4 = 60-80%, 5 = 80-100%.

There is a uniform particle-size distribution throughout the profile. However, marked differences in structure and bulk density are characteristic. The surface horizon (Bm) has a loose granular structure and a low bulk density (0.89 Mg/m^3), whereas the transition horizons (BCy1 and BCy2) have high bulk densities (1.46 Mg/m^3 and 1.42 Mg/m^3, respectively) and massive structure.

The Bm horizon at the top of the hummock is always better drained than the other horizons during the warm part of the year. The combination of drying during the summer and freezing in the fall and winter is responsible for the development of a characteristic granular (shotty), loosely packed structure in the Bm horizon. The central portion of the earth hummock has a higher moisture content in summer than in winter. During winter, high bulk densities and massive, structureless and closely packed microstructures develop as a result of desiccation.

The soil is extremely acidic and contains very small amounts of exchangeable calcium and magnesium. The pyrophosphate-extractable iron and aluminum, on the other hand, are high, especially in those horizons (Bm, BCy2, and Ohy) that are associated with more organic material. The total organic carbon is high in all horizons. Most of the organic carbon is mixed into mineral horizons as a result of cryoturbation, often as an accumulation near the permafrost table, which forms an organic horizon (Ohy). The subsurface organic horizon is composed of porous mineral and organic material in alternating but distorted layers. The large amounts of pore space are likely the result of ice lensing. Radiocarbon dating of material from the Ohy horizon yields a date of 1,660 ± 90 yr B.P. (BGS-321). Organic-matter fractionation indicates that acid is the major soluble component, although over half of the total organic carbon was found to be insoluble, residual, humic material (table 12). Qualitative clay-mineral analysis indicates the presence of all major species of phyllosilicates, but mica, kaolinite, and vermiculite tend to dominate. There is usually some degradation of mica in very acidic surface horizons and often some increase in expanding-layer clays, but this phenomenon has not been studied in detail.

North of here, the forest fire of 1968 crossed the road and extended to the river. The effects of the fire were quite severe in this area.

Mackenzie Delta Ecosystems

A short boat excursion is taken into the Mackenzie Delta to demonstrate the vegetation, soil, and permafrost relationships at a site 8 km down East Channel.

STOP 8. BOMBARDIER CHANNEL SITE. Four major ecosystems are encountered at this site, each having distinct vegetation, soil, drainage, and permafrost components (fig. 71). A brief description of the four ecosystems, named according to their vegetation association, and beginning at the water's edge, is as follows:

a) *Equisetum*. This ecosystem covers a 14-m-wide strip along the Bombardier Channel. The highest part is about 2 m above the water level, as measured on August 28, 1980. The vegetation consists of 90 percent *Equisetum fluviatile*. Minor species are a moss (*Leptobryum pyriforme*) that gives a

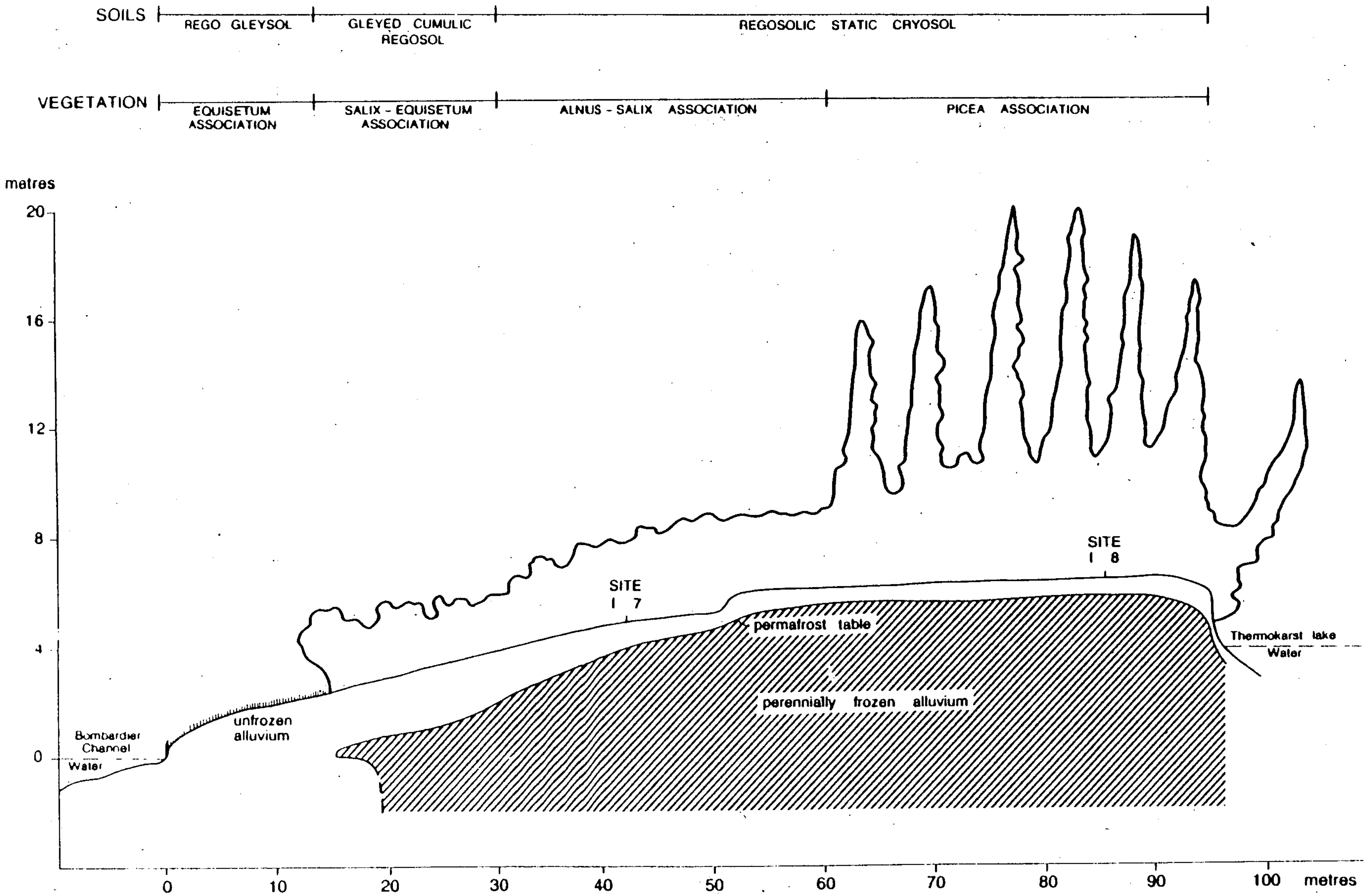

Figure 71. Cross section showing vegetation, soil, and permafrost conditions for an ecosystem sequence at the Bombardier Channel in the Mackenzie River Delta.

greenish appearance to the soil surface, *Salix alaxensis*, *Potentilla egedii*, and some *Carex* spp.

The soil in the ecosystem is a poorly drained Rego Gleysol with a silt loam texture. No permafrost is encountered within a depth of 4 m.

b) *Salix-Equisetum*. This ecosystem occurs above the *Equisetum* zone and covers a strip about 17 m wide and 2 to 4 m above the water level. The shrub layer consists mainly of *Salix alaxensis*, which grows to a height of 3 to 4 m and covers about 80 percent of the area. The herb layer is dominated by *Equisetum arvense*, which covers about 40 percent of the area.

The soil in this ecosystem is an imperfectly drained gleyed Cumulic Regosol with a silt-loam texture. Permafrost was encountered at a depth of 110 cm.

c) *Alnus-Salix*. This ecosystem occurs above the *Salix-Equisetum* zone and covers a band about 30 m wide and 4 to 6 m above the water level. The ecosystem lies just above the average flood level, which is marked by a thick band of driftwood that is usually lodged at the foot of this (*Alnus-Salix*) zone. The dominant species of the ecosystem are alder (*Alnus crispa*) and willows (*Salix arbusculoides*, *S. glauca* and *S. alaxensis*). These shrub species range in height from 0.5 to 3.5 m. The low-shrub and herb layers consist of *Arctostaphylos rubra* and *A. alpina*, *Hedysarum alpinum*, *Pyrola grandiflora*, *Picea glauca* seedlings, and mosses.

There is a well-developed litter layer (L and F horizons) associated with soils in this zone. Permafrost is encountered at a depth of 70 cm, and the soil is a well-drained Regosolic Static Cryosol with a silt-loam texture and medium ice content.

Soil temperatures measured in this ecosystem at site 17 (fig. 71) were found to be colder in winter and warmer in summer than temperatures at site 18, located in the *Picea* zone (table 13).

d) *Picea*. This ecosystem represents the climax stage on the delta south of the arctic tree line. It is situated just above the *Alnus-Salix* zone, 6 to 6.3 m above the water level of the Bombardier Channel and drops about 4 m down to the level of a thermokarst lake.

The vegetation is dominated by an open stand of white spruce (*Picea glauca*), which are distinctly spire shaped. The white-spruce trees are 10 to 12 m tall with trunk diameters up to 25 cm. Associated high shrubs are *Alnus crispa*, *Salix glauca* and *S. arbusculoides*. The low shrub and herb layers consist of *Arctostaphylos rubra* and *A. alpina*, and *Hedysarum alpinum*. There is also a well-developed moss layer.

The soil is a well-drained Regosolic Static Cryosol with a silt-loam texture, medium to high ice content, and a well-developed litter layer (L and F horizons). These soils have a better developed granular and weak blocky structure than do soils in the previous association. Permafrost is encountered at 35 cm depth.

Table 13. Soil-temperature regimes, Bombardier Channel site, Mackenzie Delta.

Site	Depth (cm)	MAST[a] (°C)	MSST[b] (°C)	Number of frost-free days	Date of 0°C		Minimum temp.		Maximum temp.		Date of 5°C		Days above 5°C
					Spring	Fall	°C	Date	°C	Date	Spring	Fall	
17	2.5	-2.2	5.9	130	5/26	10/3	-16.3	3/16	13.6	8/17	6/29	9/7	70
	5	-2.1	5.2	128	5/28	10/3	-16.1	3/16	11.8	8/17	7/5	9/7	64
	10	-2.5	3.9	123	6/4	10/5	-15.6	3/16	9.1	8/17	7/6	9/12	68
	20	-3.1	2.4	113	6/15	10/6	-15.3	3/16	7.0	8/17	7/15	8/29	45
	50	-3.5	0.1	88	7/9	10/5	-13.3	3/16	2.9	8/17	--	--	0
	100	-3.3	-1.4	0	--	--	-11.1	3/23	-0.3	--	--	--	0
18	2.5	-1.7	6.3	134	5/22	10/3	-14.2	3/16	12.0	8/10	6/24	9/7	75
	5	-2.4	5.1	126	5/30	10/3	-13.8	3/16	10.1	8/10	7/6	9/7	63
	10	-3.2	1.1	110	6/24	10/3	-11.1	3/22	4.1	8/17	--	--	0
	50	-3.2	-0.6	87	7/10	10/5	-10.0	3/16	0.2	9/1	--	--	0
	100	-3.1	-1.2	0	--	--	- 8.6	3/22	-0.4	--	--	--	0

[a] Mean annual soil temperature.
[b] Mean summer soil temperature.

The *Picea* ecosystem usually occupies the highest areas in the delta and, as a result, is only infrequently flooded. Even though white spruce is able to grow adventitious roots into newly deposited sediments, it can only do this after reaching a certain age. For this reason, white spruce is not encountered in areas that are flooded on a regular basis.

Soil temperatures measured at site 18 (fig. 71) on this ecosystem are presented in table 13. Although the soil temperature of the rooting zone (0 to 30 cm) at this site was the lowest of the soils monitored in the Inuvik area, its forest productivity is probably the highest, suggesting that forest growth is controlled to a greater extent by the nutrient status of the soil than by soil temperature. The higher nutritive and pH values result from periodic inundation by the Mackenzie River. A similar phenomenon was found on disturbed sites in Alaska by Chapin and Shaver (1981).

NHRI NORTHERN SCIENCE PROGRAMS

In October 1986 N.H.R.C. opened for business in Saskatoon.

Initially most of the staff were transferred from Ottawa, Winnipeg and Vancouver. All of the hydrologists and those working in northern programs came from Ottawa.

The scientists at N.H.R.C. in Saskatoon continue on in the traditions of northern studies through the seventies until now.

The current studies are solidly based on these previous studies which embodied a large range of work in The High Arctic: Mackenzie River Basin/Mackenzie Delta and the Yukon Territory.

Throughout the seventies the bulk of the studies were descriptive and influenced policies and programs such as:

- Mackenzie Valley Pipeline
- Inuvik-Tuk Highway
- Baseline data on High Arctic Glaciers - now of potential value for climate variability studies.
- Yukon Water Supply
- Resource Management

Early in the 1980's studies shifted towards a less descriptive approach to a more analytical modelling strategy.

By 1986, all northern research was reassessed.

1. It became very evident that environmental sciences required a more integrated approach. All systems are interrelated and single discipline studies should give way to interdisciplinary approaches.

2. Available resources are less which requires a strategy of strategic partnerships to extend the range of government expertise.

3. The reality that climate averages would not continue brought to the fore that hydrology as a science was deficient in its ability to deliver adequate information on processes for the purposes of water resource management.

   There's in fact something of a <Hydrological Science Crisis>.

.../2

Issues now expressed as sustainable development made it clear that all systems are not only connected, all of them can and are disturbed by man, requiring adjustments between the systems and the establishment of a new equilibrium.

Sustainable Development does not mean maintaining the original dynamic interactions but arriving at an acceptable new dynamic equilibrium.

All of man's activities, affect one or all of the systems. Effects are transported from their source - by wind and water.

Nowhere is it more important to understand these dynamics interactions than in the North.

Evaporation and precipitation are essentially equal so that a change in either could influence greatly the current net water supply.

In order to address these concerns, N.H.R.I. operates a Northern Research Programme. Programme 3 is directed to Northern Science and addresses basic processes which are essential to address sustainable development questions.

The special hydrologic problems of the North require special knowledge.

Programme 3 attempts to address these special hydrological problems presented by northern terrain. As mentioned at the outset - a broad approach is now required for environmental issues. Because of this, strategic alliances or partnerships have been established where possible.

These partnerships lie within and without D.O.E.

Some details of the Northern Program are:

Project: Hydrology of Permafrost Zones

Permafrost studies cover topics of Water balance, snow melt, evaporation, groundwater, remote sensing, basin response.

Three sites for these studies are planned.

75^{o}N Cornwallis Island - Continuous Permafrost (ongoing study)

68^{o}N Inuvik, Near discontinuance (ongoing study)

60^{o}N Fort Simpson. Discontinuous permafrost. (new study)

.../3

Some early studies indicate that zones which previously had permafrost now no longer have it.

Run off processes will be summarized by using a model.

This model must address the unique conditions governing run off and infiltration in northern terrain.

Ice Jams The effects of upstream development, such as dams, are exported downstream. In rivers with ice jams, studies of existing systems do not provide predictions after the spring run off is altered in discharge on timing.

Jams and floods are very dynamic - and models are needed to assist planning and management.

MACKENZIE DELTA HYDROLOGY

Basic text prepared by Dr. Philip Marsh.

Studies have been underway for six years.

1. The MacKenzie Delta Project has evolved from a simple descriptive phase to more rigorous process based studies.

2. It is aimed at improving our ability to predict environmental changes.

3. It is an integrated program, involving a number of researchers in NHRI.

4. It is multidisciplinary in nature. It attempts to link certain aspects of the physical and biologic aspects of the system. When we ask what are the environmental effects of something, the answer will include the change in the hydrologic regime and the resultant effect on the ecosystem.

5. As with many aspects of the Northern Program, a major difficulty is the lack of long term data. For example, water level records for East Channel in the Delta did not begin until 1972. Methods to allow extension of the record by "Proxy Data" have been sought .

6. Continuity is required for the research program - answers require several years of research. There must be long term research projects. This doesn't mean that nothing is published or learned for the first few years of a program, but that new questions arise over time as one begins to better understand the system. Another aspect of this is that one must make observations over a number of years to get a reasonable understanding of the natural variations. For example, snow melt runoff processes are studied at a site in the MacKenzie Delta for the last 6 years. This year was the FIRST year that there was any snow melt runoff. A single year study this year would have produced very misleading data.

.../5

Why carry out research in the MacKenzie Delta?

- The MacKenzie is a unique northern ecosystem. It is at the northern end of a system of wet lands extending down the MacKenzie Valley. Considering its latitude (68N) and location in the continuous permafrost zone, it is a very productive ecosystem with surprisingly dense stands of vegetation and large populations of waterfowl, fish, and fur bearing mammals.

- Since it is an important breeding ground for water fowl, this is not a local issue but a North American issue.

- It plays an important role in the local economy of the four towns in the area both for fishing and trapping, but also for tourism. It is also important in maintaining traditional lifestyles.

- The Delta is very complex and interesting scientifically, since it is at the interface between the land based hydrologic system and the oceanic system. As a result it undergoes rapid sedimentation and therefore is quite dynamic, undergoing constant change as it attempts to equilibrate with changing conditions. Therefore to understand why the MacKenzie Delta is like it is and how it will respond to changes, one has to understand the local conditions, and what is happening in the MacKenzie Basin and in the Beaufort Sea.

- The MacKenzie Delta has and is still undergoing development pressures, with the resulting changes in natural conditions. Remember that the Mackenzie Delta, though in the far north, is at the mouth of the Mackenzie River, the largest river in Canada. As a result the Delta is influenced by development far to the south. Fortunately, Lake Athabasca and Great Slave Lake, filter out some of the effect of development in the southern parts of the basin, but not all. There is also development going on and planned in the more northerly parts of the Mackenzie Basin. For example, development at Norman Wells introduced the possibility of spills which would move down river to the delta. There is also the potential for further development. For example hydro-electric dams on tributaries of the Mackenzie or even the Mackenzie itself, and oil and gas production in the Delta.

Second question - Why Hydrology?

- Start with a quote from Arctic Interactions - Recommendations for an Arctic Component in the IGBP,

  "Of all the elements of the arctic environment, the hydrology is one of the most pervasive in its influences, one of the most complex, and perhaps the least known.

.../6

- The water cycle is the driving force for the Delta ecosystem. There are some 25,000 lakes in the delta covering up to 50% of the area. These lakes and wetlands in the delta provide a rich habitat. But one can't look at these lakes and wetlands in isolation. It is the interaction between them and the Mackenzie River which is important. These lakes are very sensitive to changes in the Mackenzie Regime and they are perfect "sinks" which are able to collect and store pollutants. With the Mackenzie supplying sediment, nutrients, solutes and energy to the lakes.

- We must understand the hydrological processes in order to understand the rest of the system. Any changes to the hydrological regime will have serious consequences to the Delta ecosystem.

<u>Third question</u> - What are the goals of this program?

- To develop an understanding of the processes controlling water levels in lakes in the Mackenzie Delta.

- To determine how the hydrologic system changed in the past and how it is currently evolving.

- Using this information, develop a model which will predict lake levels under (a) natural conditions and (b) changed conditions. Whether these changes are due to development, climate change or rising sea level.

What have we learned so far and what implications does this have?

- I would like to start with a very brief description of the Lakes-Delta system, then describe some of the important findings of our work in the delta, the implications of this work, and finally the future directions this work will take.

- For water balance in a delta lake, the components are those that one would normally expect, inflow from the surrounding land, groundwater flow, precipitation and evaporation from the lake, and channel inflow. This channel flow may be in either direction depending on the relative level of the lake and main channel. With flow into the lake if the main Mackenzie water level is higher than the lake, and out of the lake in the main Mackenzie water level is lower than the lake. The main lake feature controlling this flow of water is the elevation of the lake relative to the main channel. One refers to this feature as the lake sill level. Lakes in the Delta have widely varying sill levels.

.../7

- It is the interactions between the Mackenzie River and the lakes which is important. Dominant spring peak, occasional summer peaks influence and govern the flow into the lake. In terms of water levels, spring peak is even more dominant because of ice jams. Note that NHRI is doing extensive work on ice jams. This is important to understand the Delta hydrologic regime.

- We have found a number of interesting things about the hydrological regime of these lakes. These include:

1. Snow melt runoff is negligible

- normally snow melt runoff dominates annual hydrograph in permafrost basins. Our work in the Delta, however, has found that in many years, snow melt runoff from the basins surrounding the lake to the lake is negligible. In fact this year was the first time in 6 years that we observed snow melt runoff.

- Why? Even though the soils are frozen they are very dry at freezeup and because of the annual sedimentation they are very porous. As a result, they are very permeable.

2. Lake Evaporation - Precipitation

- From detailed energy balance work we have found that summer evaporation is approximately 230 mm. This is much larger than the summer precipitation and is similar in size to the annual precipitation of 266 mm at Inuvik.

- The result is that for lakes with no other source of water, water levels decline over the summer, and on an annual basis, lakes with no other source of water are in a fine balance. During dry years the water level would decline, and during wet years the level may go up. The overall effect, would generally be declining water levels.

3. Lake Flooding Dominates

- Spring flood dominates the hydrographs. As shown here the spring peak is always greater than the summer peak.

- Given this info. on return periods of given water levels, and this data on lake sill elevations vs the number of lakes and lake area, we can determine how often a given lake is flooded.

.../8

- From this we know that some 47% of lakes in the area near Inuvik are flooded only for a brief period during the spring melt and this occurs on less than an annual basis. These lakes are very sensitive to changes in Mackenzie River regime.

- An interesting point is that 98% of all lakes have sills between the mean low and mean high water levels. i.e. they are in equilibrium with the current Mackenzie River water level regime. Lakes which are too low would quickly infill with sediment, while lakes which are too high do not have a sufficient water supply to survive.

- This implies that any changes in the Mackenzie River regime would result in changes to the lake sills, and or changes to the number of lakes, since lakes which are not flooded every few years are not viable - hence loss of habitat.

- One such lake in the southern Delta last flooded in 1982, with lake levels declining by about 3 m since that time.

- This confirms our earlier data, which suggested that lakes are not viable without flooding by the Mackenzie River.

4. Using our knowledge of the important processes we were able to develop a model which can accurately predict lake levels. This model could be easily applied to wide range of lake types.

Implications and Applications

1. Hydro Development - The effect of hydro development would be to reduce lake flooding, resulting in fewer lakes in the Delta. This is similar to what happened in the Peace Athabasca Delta after the construction of the Bennett Dam. From our data and models, we could predict the effect of a given change in Mackenzie levels,

2. Oil Spills - If oil spills occur in the Mackenzie Delta or on the Mackenzie River upstream from the Delta, the oil will flow through the main channel system of the Delta and depending on the water level, it will flow into the Delta lakes. Given the information that we have on lake sill levels and on the statistical behaviour of the main channel water levels, we could predict (1) the probability of the number of lakes affected for a spill on a given date, or (2) if a spill occurred, the number of lakes which would likely be affected.

3. Climate change - The predicted rise in summer air temperatures as a result of CO_2 induced climate warming, are difficult to predict.

.../9

(a) Increased air temperatures will shift the fine balance between evaporation and precipitation in favor of more evaporation which would result in declining water levels during the summer and shallower water at freeze up. This could be very important since the lakes are often in the 1 to 1.5 m depth range. With typical ice thicknesses of .5 to 1 m this doesn't leave much water under the ice. This under ice water is important to muskrats over wintering.

4. Rising sea level - the Mackenzie Delta is very low lying, with late summer water levels at Inuvik for example of only 1 to 2 m asl. Rising sea level will therefore have a tremendous affect on water levels in the Delta. In the outer or lower Delta many areas would be flooded continuously and there would be extensive salt water intrusion into many lakes. Not to mention rapid coastal retreat! The big question is how much of an effect would there be upstream in the delta. There are a number of ways to attack this question. As a first approximation we have looked at short term rises in sea level (ie. storm surges) which are similar in size to many estimates of sea level rise in the coming decades. This work has shown that a very short duration 1 m rise in sea level can induce a .25 m rise in water levels at Inuvik, some 60 km upstream. This would result in a number of changes to the lakes, ie. increased flooding, increased sedimentation.

FUTURE WORK

(1) Research -

(a) connection between physical and biological. Currently an NSERC visiting fellow (Dr. L. Lesack) is working with N.H.R.I. and the Fresh Water Institute to look at nutrient and solute fluxes to the lakes. (ie. how important is the Mackenzie River in introducing nutrients to the lakes? What will happen if this source of nutrients is altered?)

(b) long term evolution of the delta lakes. An important question is how quickly do these delta lakes infill with sediment? How quickly do they evolve from a low sill elevation lake to a high sill elevation lake? In order to answer types of questions sediment coring program is under way.

(c) long term changes in the Mackenzie River regime. Using the same lake cores described above, to provide estimates of the Mackenzie River regime. Because the delta lakes occur over a range of elevations it provides a perfect opportunity too for obtaining proxy data.

.../10

(2) Application

- for logistical, and cost reasons, much of the work has been carried out in a few small regions of the delta. In order to carry out a complete environmental assessment of the affect of hydro development for example, similar work would have to be conducted at a number of sites within the delta to determine things like the distribution of lake sill levels. Now that techniques are developed this could be done relatively easily. This is also true for the development of a lake level model.

NWRI NORTHERN INITIATIVES AND PROSPECTS

INTRODUCTION

1. Lack knowledge about the north, but not about science.

2. Purpose in comming, to listen and learn.

3. Grateful to organizers.

4. Have as much to gain by listening to others as by contributing.

WHAT IS NWRI?

1. National program of R&D in the aquatic sciences addressing high priority societal and scientific issues.

2. National in scope - work all across the country.

3. Mission oriented - arrived by DOE priorities.

4. Multidisciplinary - environment quality focused.

5. Program tasks determined by:

   a) DOE priorities
   b) capability to contribute
   c) resource availability

Mention digest

NWRI NORTHERN INITIATIVE

1. Modest program - currently developing, growth likely.

2. Priority of North increasing for NWRI.

   a) Minister's agenda.
   b) Emerging focus on toxic chemicals problem.
   c) Link to global change, atmospheric deposition.

3. Current Program.

   a) Athabasca

      - fate and effects of heavy oil products in Athabasca
      - broad spectrum of interest
      - PERD funding in doubt
      - could be expanded to address pulp & paper concerns
      - 3-5 years, $1M

.../2

b) Fortunate to hire Denis Gregor (experience in northern resources).

- focus - atmospheric deposition of toxic chemicals
- fits well with need to address global change issues
- fits well with out air/water interactions program
- gives our expertise mix a clear northern dimension

c) Collaboration with Petroleum Industry

- design of petroleum islands - Norman Wells
- pipeline trenching
- wave action on drifting platforms - Beaufort Sea
- design to prevent overtopping

d) Northern Wetlands Project - Marlene, Walter

4. The Future

a) Limited growths

b) Environment quality focus, specifically processes controlling cycling of toxic chemicals in northern ecosystems

c) Partnerships (Modus Operendie)

- funding agencies
- operational agencies
- research agencies

NORTHERN SCIENCE AND TECHNOLOGY

A PERSPECTIVE FROM CPG

AND THE ENVIRONMENT CANADA SCIENCE COMMITTEE

Wayne Richardson
Corporate Policy Group
June 4, 1989

For presentation by Sandy Lewis, CPG
Inuvik, NWT, June 8&9, 1989

ENVIRONMENT CANADA SCIENCE COMMITTEE

- EVOLVED FROM WORKING GROUP ON SCIENCE MANAGEMENT
- TERMS OF REFERENCE SOON TO BE FORWARDED TO EMC
- A MAJOR FORUM FOR INTERNAL AND EXTERNAL S&T LIAISON, IDEA AND INFORMATION EXCHANGE, S&T REPORTING AND STRATEGIZING

ENVIRONMENT CANADA SCIENCE COMMITTEE

- MEMBERS:

DG/IWD, DG/EP, DG/ARD, DG/CCC, DIRECTOR NRB/CPS, SCIENCE ADVISOR, DIRECTOR S&E/CPG

- OBSERVER MEMBERS:

DG/CWS, DIRECTORS OF ALL SCIENCE ESTABLISHMENTS, AES SCIENTIFIC PROGRAMMES COORDINATOR, SECRETARY - CPG

- CHAIR:

ALTERNATES ANNUALLY BETWEEN C&P AND AES AT DG-LEVEL
CURRENTLY - ALEX CHISHOLM, AES

ENVIRONMENT CANADA SCIENCE COMMITTEE

ACCOMPLISHMENTS

- DEPARTMENTAL CONFERENCE ATTENDANCE POLICY (1987)
- ANNUAL S&T PLAN (1988)
- UNIVERSITY STRATEGY (1988)

ENVIRONMENT CANADA SCIENCE COMMITTEE

CURRENT WORK

- FIRST ANNUAL REPORT ON DEPARTMENTAL S&T
- STRATEGIC APPROACH FOR DEPARTMENTAL S&T

ENVIRONMENT CANADA

UNIVERSITY STRATEGY

ENVIRONMENT CANADA
UNIVERSITY STRATEGY

- OBJECTIVES
- EXISTING PROGRAMMES
- FUTURE DIRECTIONS
- COOPERATION WITH NSERC

ENVIRONMENT CANADA

UNIVERSITY STRATEGY

OBJECTIVES

- TO ENSURE THE PROVISION OF TRAINED GRADUATES IN THE ENVIRONMENTAL SCIENCES
- TO ENSURE A BROAD KNOWLEDGE BASE EXISTS WHICH WILL SUPPORT THE SCIENCE, TECHNOLOGY AND OPERATIONAL NEEDS OF THE DEPARTMENT
- TO ENSURE THAT CENTRES OF EXCELLENCE EXIST OUTSIDE GOVERNMENT IN PRIORITY ENVIRONMENTAL SCIENCE AND TECHNOLOGY AREAS

ENVIRONMENT CANADA

UNIVERSITY STRATEGY

EXISTING PROGRAMMES

- NSERC CHAIRS - MCGILL, CLIMATE, AES/NSERC
  - YORK, ATMOSPHERIC CHEMISTRY, AES/NSERC
  - MCMASTER, ENVIRONMENTAL ENGINEERING SYSTEMS, WTC/TEXACO/NSERC
- SUBVENTIONS, CONTRACTS, JOINT VENTURES
- ADJUNCT PROFESSORSHIPS, POSTDOCTORAL FELLOWS, SCHOLARSHIPS
- FACILITY CO-LOCATION
- STAFF AND FINANCIAL SUPPORT TO NATIONAL AND INTERNATIONAL SCIENTIFIC ORGANIZATIONS

ENVIRONMENT CANADA

UNIVERSITY STRATEGY

FUTURE DIRECTIONS

NSERC CHAIRS
- MARINE METEOROLOGY, AES/NSERC
- HAZARDOUS WASTE MANAGEMENT, WASTEWATER TREATMENT, AIR POLLUTION CONTROL, POTABLE WATER, GROUNDWATER, EMERGENCY RESPONSE
- SUPPORT FROM INDUSTRY, CONSULTANTS, MUNICIPALITIES, EC, NSERC

DEVELOP 50/50 MATCHING GRANTS STRATEGY

EXPLORE EXCHANGES/SECONDMENTS WITH UNIVERSITIES

MORE FACILITY SHARING AND JOINT PROJECTS

ENVIRONMENT CANADA

UNIVERSITY STRATEGY

COOPERATION WITH NSERC

- WE WILL WORK WITH NSERC TO FOCUS THE ENVIRONMENT AND RESOURCE STRATEGIC AREAS AND OUR LINKS WITH THE OTHER AREAS

- WE MUST WORK TOGETHER TO OVERCOME INSTITUTIONAL IMPEDIMENTS:

  * INTERDISCIPLINARY
  * INTERNATIONAL
  * LINKS WITH SSHRC, MRC, ...

UNIVERSITY STRATEGY

IMPLEMENTATION UPDATE

- HIGH POTENTIAL FOR SUCCESSFULLY ESTABLISHING MORE INFRASTRUCTURE "INDEPENDENT" FROM GOVERNMENT AND PRIVATE SECTOR

- AES

  - 2 NEW CHAIRS AT DALHOUSIE (MARINE METEOROLOGY, CLIMATE)

  - CURRENT UNIVERSITY GRANTS AT ABOUT $600K - 700K/YEAR

  - NEGOTIATING WITH NSERC TO DOUBLE CURRENT GRANTS.

UNIVERSITY STRATEGY

IMPLEMENTATION UPDATE

- C&P

  - CENTRE ST. LAURENT NEGOTIATING WITH NSERC TO ESTABLISH 50/50 GRANT PROGRAMME ($500K/YEAR TOTAL PROPOSED)

  - WTC NEGOTIATING FOREST PRODUCTS WASTE TREATMENT CHAIR WITH UBC, BC ENVIRONMENT, INDUSTRY, NSERC (ABOUT $600K PER YEAR)

  - CWS NEGOTIATING WITH NSERC ON WILDLIFE TOXICOLOGY AND ENDANGERED SPECIES FUNDS

  - CWS PLAN FOR 5 CHAIRS; DISCUSSIONS WITH BC FOR FIRST ONE UNDERWAY

  - OTHER TECHNOLOGY CHAIRS IMMINENT

- BC ENVIRONMENT

  - HAS $3M FOR CHAIRS IN B.C. - WILDLIFE/FOREST PRODUCTS UNDER NEGOTIATION

UNIVERSITY STRATEGY - UPDATE

- STRATEGIC GRANTS AREAS BEING REVAMPED
- WE ARE PARTICIPATING IN PROCESS DEVELOPING THE MISSION STATEMENT FOR THE NEW ENVIRONMENT AREA

ANNUAL REPORT ON S&T

- ECSC WORKING GROUP ESTABLISHED TO DEVELOP FIRST ANNUAL REPORT FOR 1988/89
- DATA BASE REQUIREMENTS AND CPG COMPUTER CAPABILITY BEING FINALIZED
- EMPHASIS ON ACCOMPLISHMENTS, PARTNERSHIPS, LINKAGES

STRATEGIC APPROACH FOR S&T

- ECSC/CPG WORKSHOP JULY 10-12, 1989 NIAGARA INSTITUTE
- PURPOSE IS TO DEVELOP INTEGRATED STRATEGIC APPROACH FOR EC'S S&T PROGRAMMES FOR CONSIDERATION BY DM AND ADMS
- EC SCIENCE COMMITTEE PLUS 5 INVITED OUTSIDE PARTICIPANTS

STRATEGIC APPROACH FOR S&T

- MAJOR OPPORTUNITY FOR REVIEWING INTERNAL AND EXTERNAL FACTORS AFFECTING S&T AND FOR DEVELOPING APPROACH TO INFLUENCE DEPARTMENT, CABINET COMMITTEE ON ENVIRONMENT AND PRIORITIES AND PLANNING COMMITTEE PRIOR TO DECISIONS ON ENVIRONMENT AGENDA DURING AUGUST

- THIS NORTHERN S&T MEETING WILL BE ABLE TO CONTRIBUTE

INDUSTRY, SCIENCE AND TECHNOLOGY (ISTC)

ENVIRONMENTAL INDUSTRY SECTOR CAMPAIGN

- $4M BUDGET IN PLACE FOR NEXT THREE YEARS
- WORK PLAN BEING FINALIZED (JULY, 1989)
- FOUR WORKING GROUPS:

  1) CRITICAL TECHNOLOGIES
  2) INDUSTRY CAPABILITY
  3) DOMESTIC & INTERNATIONAL MARKETS
  4) ECONOMIC CHARACTERISTICS

ENVIRONMENTAL INDUSTRY SECTOR CAMPAIGN

- CRITICAL TECHNOLOGIES WORKING GROUP MOST IMPORTANT
- ALL TECHNOLOGY INITIATIVES MUST BE WOVEN INTO SECTOR CAMPAIGN (I.E. ORPHAN SITES, WASTE, GREAT LAKES, CEPA,...)
- HOPEFULLY IN NEXT YEAR OR SO WILL HAVE IN PLACE:

  1) A UP-TYPE PROGRAMME FOR ENVIRONMENTAL INDUSTRY

  2) A DEMONSTRATION, BIG $ PROGRAMME FOR ENVIRONMENTAL INDUSTRY

- NO MAJOR, WELL-RESOURCED INSTITUTE IN THE NORTH
- EVEN IF MORE RESOURCES, DO WE NEED OR WANT SUCH AN INSTITUTION(S)?
- WOULD IT BE BETTER TO FOCUS ON A FEW GOOD UNIVERSITY/GOVERNMENT/INDUSTRY CENTRES (I.E. CCORE, CFER,...)?
- IF NOGAP OR EQUIVALENT REINSTATED, MUST REFLECT NEW REALITIES (GLASNOST, CABINET PRIORITIES, UNIVERSITY LINKS, ETC.)
- DEVELOPMENT OF AN MC MUST LINK WITH ISTC NORTHERN S&T STRATEGY (SME MC?), AND MUST LINK DEPARTMENT WITH OTHER GOVERNMENT DEPARTMENTS (MEQ & OCEANS, ...), UNIVERSITIES, PRIVATE SECTOR AND INTERNATIONAL REQUIREMENTS

CONCLUSIONS, MISSING LINKS,...

- THE MYTHOLOGY OF THE FEDERAL GOVERNMENT DOING LOTS OF NORTHERN S&T

- EC/C&P HAS ABANDONED OR UNDERFUNDED MANY OF ITS NORTHERN S&T PROGRAMMES (I.E. - NORTHERN ENVIRONMENTAL TECHNOLOGY DIVISION, MAJOR WILDLIFE FIELD PROGRAMMES, LESS AMOP $ BUT CHEMICAL SPILLS ADDED,...)

INTERNATIONAL POLAR SCIENCE

Recent Developments (1988-89)

Papers 1 and 2, attached, present a summary of the background to some aspects of the current situation regarding international co-operation in arctic science. The following points outline in very brief form a few selected further developments, including some notes on international developments in the south polar regions.

International Arctic Science Committee - (IASC) - At the 1987 Stockholm meeting (see Attachment 2), representatives of the eight arctic countries agreed to form an International Arctic Science Committee. The Roots-Rogne-Taagholt (RRT) proposal for separate government-policy and non-government scientific structures was rejected (by the U.S.) in favour of a single structure. Subsequent negotiations by a drafting group have been directed at finding a way of accommodating the policy concerns of the eight arctic governments into a scientific body open to all scientific researches, including those from non-arctic countries. Drafting sessions were held in Moscow (July 1988) and Leningrad (December 1988). At Leningrad a compromise suitable to the drafting group was achieved; the proposed schedule was that governments of all countries would approve or modify the text for a final drafting in Helsinki in April, after which there would be a formal "founding" meeting in northern Canada in the summer of 1989.

After the Leningrad meeting, representatives from non-arctic countries with arctic programmes (FRG, UK, France, Netherlands, Japan) became concerned that they were being "excluded" from the central organization of the proposed Committee, and made formal representations of objections. The concerns were largely misconceptions and could have been met by drafting changes; but the formal level at which they were presented, together with some internal concerns in the U.S., raised the discussions from being essentially on scientific co-operation to national and international policy. All other arctic countries, including Canada, agreed with the Leningrad text, but at the last minute the U.S. said that it could not accept. The Helsinki "final" drafting meeting was postponed a month, then held in mid-May. At this meeting, the USA, which wanted a completely open structure, and the USSR, which (with the other six countries on its side) wanted a special responsibility for countries with arctic territories, could not at first agree. A last-minute breakfast caucus by US, USSR, and Canada produced a draft text for a quite different structure, which the other "five" arctic nations will accept if US, USSR and Canada can endorse. Canada has had an interdepartmental discussion (June 2), and, with some misgivings which are based mainly on uncertainty about what the US and USSR will accept, can work with either the Leningrad or Helsinki texts. The next "drafting" session is scheduled for Moscow for the week of June 12.

Leningrad Conference on Co-operation in Arctic Science. Immediately following the Leningrad drafting session for IASC, but separate from it, the first major international multi-discipline conference on arctic science was held in Leningrad, December 12-15, 1988, hosted by the USSR Academy of Sciences and the Arctic and Antarctic Research Institute. More than four hundred scientists took part, two hundred of them from Soviet Bloc countries, and fifteen Western nations; Japan and China were represented. The scientific presentations were divided into six main subject areas:-

- Upper Atmosphere and Near Space;
- Arctic Ecosystems;
- Interaction between ocean and atmosphere: Arctic climate change;
- Geology, geocryology, and glaciology;
- Environmental conservation;
- Socio-economic, educational and cultural problems of the indigenous peoples of the North, the problems of polar medicine.

In each subject area the technical presentations were followed by discussion that attempted to identify critical or priority areas for new international research in the arctic regions. The topics for these areas of priority are listed in the summary statement issued at the close of the Conference (Attachment 3). Several of these are now being considered or introduced into bilateral and multi-lateral research activities in the arctic.

International Geosphere-Biosphere Programme (Global Change)

This major long-term programme of the International Council of Scientific Unions, which appears likely to become the centre of the largest co-ordinated world-wide multi-discipline research effort yet attempted, has been seen in its early planning stages to require a number of special studies in the polar regions just as did its predecessors IPY (1882-83), IPY-II (1932-33), IGY (1957-58) and IBP (1967-72).

The Royal Society of Canada, the Office of Interdisciplinary Earth Studies of UCAR, and the Institute of Arctic and Alpine Research took the initiative in identifying the needed research for IGBP in polar regions by bringing before the Scientific Committee for Antarctic Research (SCAR) the need for IGBP planning for Antarctica, and by organizing a series of workshops to identify priority arctic research. The result of the latter exercise was the eventual publication in September 1988 of the report "Arctic Interactions: Recommendations for an Arctic Component in the International Geosphere-Biosphere Programme" - editors, J.A. Eddy, M.F. Meier, E.F. Roots.

"Arctic Interactions" considers the state of knowledge about earth and environmental processes in the arctic that are important to global change in the arctic or in the planet as a whole, in thirteen different subject areas, and attempts to assess the most important research needs. It concludes that seven multi-disciplinary research themes are most important for international co-operative study in the arctic in order to understand the processes and effects of global change:

- Response of arctic terrestrial and freshwater ecosystems to change in climate and sea level.
- Role of arctic peatlands in planetary biogeochemical cycling.
- Biota in relation to the ocean-ice margin in the arctic.
- Arctic glacier and ice sheets effect on sea level - the response to climate.
- The hydrological cycle in the arctic, including soil formation and geochemistry of permafrost.
- Chemistry and dynamics of the arctic atmosphere.
- Arctic Ocean/sea ice/atmospheric interactions.

These and other recommendations, with supporting detail, were presented to the international arctic scientific community in Leningrad in December (by M.F. Meier and EFR) with the suggestion that the IGBP National planning committees of all arctic nations (each arctic nation has announced its participation in IGBP) take them into account to develop a coherent or compatible arctic IGBP activity. The Canadian planning committee for IGBP has an Arctic Working Group which helped to develop the "Arctic Interactions" paper and is now working on a proposal for a Canadian programme.

For the Antarctic, SCAR has appointed an ad hoc Steering Committee for the IGBP which is well along in developing an Antarctic IGBP programme, multi-national in nature, in which the main components will deal with the climate record and variability, atmospheric chemistry, glaciology, palaeoenvironments, terrestrial and marine ecology, sea ice, ocean dynamics, and upper atmosphere magnetophysics. A number of workshops to develop these programmes are planned over the next year. These studies will for the most part be funded through the respective national antarctic research programmes.

Arctic Oceans Sciences Board

Preliminary planning well along for an international study of arctic polynyas, concentrating first on comparisons and processes in the North Water (Greenland Ellesmere), Banks Island, Bering Sea, and Svalbard Polynyas. Biological, physical oceanography, and meso-scale climate processes are involved. Likely to be related to IGBP. At present, Canada, Denmark, FRG, Switzerland, and USA are involved in planning; USSR has taken interest.

UNESCO Man and the Biosphere Northern Science Network

The Network has been re-invigorated; the international secretariat is in the process of moving from Edmonton to Helsinki (but seems for the time being to be stuck in Ottawa en route). No new multi-national co-operative programmes have yet been accepted, although some are under consideration. The Network operates at present as an information exchange. The Northern Science Network Newsletter has been revived.

"Finnish Initiative"

One of the potentially more significant developments related to the arctic environment, which may have an influence on polar research is not primarily scientific in nature, but political. The government of Finland, concerned about the vulnerability of the arctic environment to natural and human-caused change, and conscious that any effective moves to protect the arctic must be circumpolar or regional and thus international in nature, has invited governments of all other countries to join with it in discussions of common actions that could be taken to maintain the quality of the arctic environment. The invitations have been sent jointly by the Minister of Foreign Affairs and the Minister of Environment of Finland, to their counterparts in the other seven arctic countries. Finland has a special Ambassador for Polar Affairs, Amb. E. Rajakoski, who for the past year has been energetically promoting what has become known as "the Finnish initiative". Some will recall his presentation to the True North Strong and Free Conference in Edmonton last March.

Attachment 4 is a copy of the general background paper to the Finnish initiative.

The initiative has met with a generally favourable response in principle in the USSR, Sweden, Norway, Denmark, Iceland, and Canada. The USA has so far been unenthusiastic.

Bi-lateral scientific programmes in the polar regions

Among those in which Canada is currently active are those with:
- USSR;
- France;
- Argentina.

Among those for which mechanisms for co-operation in polar science are in place, but where there is little or no activity at present are the agreements with:
- United Kingdom;
- Federal Republic of Germany;
- Norway;
- Japan;
- Denmark.

E.F. Roots
2 June 1989

Encl. (4)

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International and Regional Cooperation in Arctic Science: A Changing Situation

Introduction

I was pleased and surprised to receive an invitation from Professor Rønning to attend this conference, and it is a great privilege to be the only "utlending" present to take part in the discussions. I must say that I do not feel like a foreigner, for I have many friends among you, and I have been in contact with aspects of science in Nordic countries for many years. But still, perhaps I may be in a position to listen to your discussions from a slightly different perspective and I hope that I can provide some comments that are useful.

Professor Rønning asked me to say something about international and regional cooperation in Arctic science, as an introduction to our final discussions on "planning, management, and research priorities."

Many — indeed most — of the speakers at this conference have described research programs that involve several institutions, or scientists from different nations; and others have described environmental or resource development problems and concerns that are shared by all arctic countries. That is one of the reasons for this conference — so that Nordic nations can discuss the scientific needs, problems and opportunities that they have in common. Many of those same needs, problems and opportunities are also shared by other countries with territories in the polar regions, and so it may be useful to look at some of those aspects of arctic science that benefit from being considered in a circumpolar context, or undertaken through international cooperation.

The perspective that each of us brings to considerations of international cooperation in science, its opportunities and its problems, and what it means to the accomplishment of science itself as well as its role in the larger picture of national policies and international cooperation, is inevitably based on our own involvement and experience in science programs that have an international dimension; and what we see as successes or failures in cooperation depends largely on our expectations and viewpoint. I have had the good fortune to have been directly involved in a number of international, multi-disciplinary and cooperative studies in the polar regions. Some of these — perhaps the best — have been the quiet one-on-one cooperation between scientists of one country and another. This is the kind of cooperation that does not make headlines or engage the attention of policy-makers or ministries of foreign affairs. Other activities have been the kind of organized international programs that require government-to-government arrangements and have been a part of the evolving international policy development in polar regions. And most of our international arctic science lies somewhere between these extremes.

My comments will be followed by brief presentations, put together here at Ny-Ålesund during the past few days, presenting some reasons why Nordic countries should play an increased and active role in international research in Arctic regions. Spokesmen from our six working groups will make suggestions on some areas related to arctic science where increased attention by Nordic countries is particularly needed. So in these remarks, I will not dwell on the reasons for arctic research by Nordic countries, or give a list of subject priorities for future research, or the questions of education, funding etc. that need to be addressed if Nordic countries are to play a strong role in international arctic science. Instead, I hope to make some basic comments about international arctic research and how it is changing. I hope that these remarks may be of some use both to directors or policy people who have to manage and support arctic research, and to the scientists who must understand the system and adapt to its changes if they expect to continue to do first-rate science in the Arctic — or indeed any science at all.

The Scale and Diversity of International Cooperation in Arctic Sciences

In considering the needs and opportunities, the problems and successes of international and regional cooperation in arctic sciences, there is a natural tendency to think mostly about the formally organized international programs, that have involved agreements or arrangements between several institutions or governments. These tend, for several reasons, to be relatively large programs or projects, as science goes today, and it is probable that it is to these programs that most of my following comments will apply. But it is very important for each of us to keep in mind that there is an important place for more modest and informal international scientific cooperation. This is the cooperation that comes about when scientists from one country or institution join those of another, to work on a common scientific problem or opportunity that happens to suit the interests and abilities of each. All good science today works in this way, and each of us here, in our various responsibilities, should do all we can to ensure that such individual and spontaneous cooperation can continue in arctic regions.

However, there is a different level of cooperation that is very important to arctic science today, and is likely to be even more so in the future. This is the kind of cooperation where two or more countries, or two or more institutions, deliberately get together to carry out some joint research that neither one could accomplish alone, or where several countries engage in a complex program in which each plays an essential part, and the scientific goals of any one country could not be achieved without the participation of the others. This kind of cooperation, which involves *cooperation in deciding what we want to do the research for* as well as evaluation of the scientific merit and opportunity, is becoming essential for much of the most advanced science and new discoveries in the world today. Such basic cooperation is not restricted to pure science, but is important in the applied and industrial and social sciences as well. Nowhere is this more true than with respect to research in the arctic regions.

The following are a few examples of scientific activities in the polar regions which have had an essential or important international component, and from which we can, I think, draw some lessons that will help us achieve more effective and useful international cooperation in the future. These are activities with which I have been directly involved, so that more details can be provided from personal experience if we wish to return to them later in discussions:

The Norsk-Svensk-British Antartisk Expedition 1949-52 (The Maudheim Expedition). This was perhaps the first of the modern series of international multi-discipline cooperative studies in the polar regions, and it has had an influence on many later international programs. It is noteworthy that this expedition was organized and undertaken through the initiative of Nordic countries.

The International Geophysical year (IGY) 1957-58 was the largest coordinated international research program ever undertaken to that time. Fifty-one countries took part, including all the arctic nations. Observations and special studies in the arctic and antarctic regions were an essential part of the total program.

Studies such as these seem a long time ago, now. They are in the past, scientifically more than in actual years, and viewed in the context of international cooperation. They have a distinctly old-fashioned and perhaps simplistic flavour. A sampling of some more recent or current international arctic activities in which I have been involved shows a change of character and style. Many of you, I know, have had equal involvement with a different but similarly varied list:

The Canadian Polar Continental Shelf Project, for which I was coordinator for fifteen years, supports studies by various government departments and universities in the Canadian Arctic and Arctic Ocean, in all fields of science, and has from the beginning in 1958 included researchers from many countries. In addition to coordinating more than one hundred individual field parties each year, it has made possible major focussed integrated studies such as AIDJEX (Arctic Ice Dynamics Joint Experiment), *LOREX* (Lomonosov Ridge Experiment) and *CESAR* (Canadian Exploratory Studies of the Alpha Ridge), each of which has had an important international dimension.

The *Polar Research Board* of the U.S. National Academy of Sciences provides a basis for reviewing, both in an international and U.S. context, major research advances and research needs in the arctic regions. It helps make recommendation for priorities for U.S. funding for international polar research programs (such as the *Greenland Ice Sheet Program, or GISP*, referred to by Dr. Dansgaard), and thus has an influence on the mechanism and emphasis of international arctic science.

International scientific bodies such as the *International Commission of Snow and Ice* are responsible for such international activities as the *World Glacier Inventory (WGI)* referred to by Dr. Heintzenberg, whose completion depends directly upon international cooperation in arctic science.

Other current examples, each different in its scope, purpose and mechanism, would include the *Northern Network of the Man and the Biosphere Program*, with which several people at this conference are directly involved; the *Comité Arctique International*, also involving other members of this conference; the newly formed *Arctic Ocean Sciences Board*, the Baffin Island Oilspill Study (BIOS) described by Prof. Eimhjellen as an example of one type of international research collaboration; the *Arctic Aerosol Sampling Program*; and the recently signed reinstatement of the *Canada-USSR Protocol for Cooperation in Science and Technology in the Arctic and the North*.

These — and many more could be given as examples — show the diversity and indeed the ubiquity of international cooperative activities in arctic science. Cooperation between scientists from different nations and institutions is a natural way to approach major arctic science problems. As noted, at least half of the papers given at this conference have described studies that involved international cooperation. But such cooperation sometimes does present difficulties in the arctic context — difficulties both for the scientists and those who support and direct arctic research.

The Early Development of International Cooperation in Arctic Science

The clearest expression of the benefits of considering arctic sciences in an international and circumpolar context, and also of the organization and coordination needed to achieve effective scientific results through international cooperation, was also one of the very first. The questions we are discussing today were described in detail more than one hundred years ago.

Most of you know the story of Karl Weyprecht, but I will recall parts of it here because it is very pertinent to our subject of international cooperation in arctic science. Also, Weyprecht's activities and ideas led to the establishment of a scientific station at Ny Ålesund and thus had a direct influence on our presence here today.

Weyprecht was an officer in the Austro-Hungarian navy. He was trained as a physicist, with a special interest in magnetism, and he developed an early passion for polar exploration. In 1872-73 he was co-leader of the German North Polar Expedition, and was both scientist and in command of the ship. On that voyage, which discovered the archipelago of Franz Josef Land (which he named after the Austrian emperor), he noted that the activity of the aurora increased to a maximum and then decreased as he travelled farther north, and also that the aurora displays were most intense during times of magnetic instability.

Weyprecht became convinced that simple geographic exploration, or attempts to discover new lands or to reach the farthest north, should be replaced by international science carried out according to a plan. Beginning in 1875 he gave a series of lectures to academies of science and prestigious scientific institutions throughout Europe. Some of his comments, made more than one hundred years ago, read as if they could have been prepared expressly for our conference here today.

Scornfully calling traditional arctic exploration "an international steeplechase to the North Pole" and an activity where "immense sums were being spent and much hardship endured for the privilege of placing names in different languages on ice-covered promontories, but where the increase in human knowledge played a very secondary role", Weyprecht claimed that the arctic regions offered opportunities unparalleled anywhere on the planet for scientific studies of the Earth's physical and natural processes, including geology and zoology. Many of Weyprecht's statements make good reading — and careful thinking about — today: (Let me read a few — informal English translation from the German):

> "The Earth should be studied as a planet. National boundaries, and the North Pole itself, have no more and no less significance than any other point on the planet, according to the opportunity they offer for phenomena to be observed."
>
> "Science is not a territory for national possession"
>
> "Small nations must be able to take part in arctic research"
>
> "Uncoordinated observations can have only relative significance"
>
> "Scientific knowledge of lasting value can result from coordinated and cooperative studies undertaken according to an agreed plan, with the results of the observations freely shared without discrimination".

Weyprecht's ideas may sound like what we all expect good science to be today; but a century ago these thoughts were unorthodox, not widely shared, and to some they were heresy. Academies of science and royal societies in 1875 were proudly nationalistic, and an exclusive or narrow approach to their own scientific activities was part of the process of enhancing national prestige. These organizations did not take easily to the idea that their observations and data should be shared freely with everyone else, or that their researches should be considered just a part of a larger international program in which other institutions, perhaps from rival countries, took an equal part. Nor did distinguished professors always like the idea that the value of an observation should be judged on the care with which it was taken, rather than according to the reputation of the observer or his institute. Nevertheless, the arguments of Weyprecht and his friends were persistent and persuasive, and gradually they became endorsed by leading institutions interested in the physical phenomena of the Earth.

Weyprecht proposed a coordinated and synchronized program of observations of meteorology, magnetism, tides, aurora and electromagnetic phenomena, for a full year, at at number of locations in the north and south polar regions. These observations were to be synchronized with simultaneous observations at established permanent observatories around the world in lower latitudes. In 1879 the International Polar Commission was formed to put these ideas into practice. The planning was not smooth — a war, personal and institutional jealousies, failure to receive promised funding, the desire of some countries to take more of the glory, all caused difficulties; and Weyprecht died before his plans were put into operation. But the result, as we all know, was the *International Polar Year, 1882-1883.*

TABLE I

INTERNATIONAL POLAR YEAR 1882-1883

ARCTIC STATIONS AND SUBJECTS STUDIES

Station	Location	Latitude	Longitude	Sponsoring Country	Leader	Aurora	Geomagnetism	Meteorology	Longitude	Earth Currents	Atmospheric Electricity	Gravity (pendulum)	Soil Temperature	Tides	Sea Ice Thickness.	Sea Ice Movement, Structure	Oceanography	Geology	Botany	Zoology	Anthropology
Ssagastyr Island	Lena delta, Siberia	73°23'N	126°35'E	Russia	N.D. Jurgens	x	x	x	x				x	x			x		x	x	x
Kara Sea	Arctic Ocean	69°-71°N	64°-62°E	Netherlands	M. Snellen	x	x	x	x						x	x	x		x	x	
Karmakule Bay	Novaya Zemlya, Siberia	72°23'N	53°45'E	Russia	K.P. Andreief		x	x	x				x	x							
Sodankyla	Finland	67°26'N	26°34'E	Finland	S. Lemstrom	x	x	x	x	x	x	x	x								
Bossekop	Norway	69°58'N	23°15'E	Norway	A.S. Steen	x	x	x									x				
Cap Thordsen	Vestspitzbergen, Svalbard	78°20'N	15°25'E	Sweden	N.G. Ekholm	x	x	x	x		x	x	x	x	x	x					
Jan Mayen Is.	North Atlantic	70°60'N	8°28'W	Austria	E.E. Wohlgemuth	x	x	x	x				x	x	x		x	x	x	x	
Godthaab	W. Greenland	64°11'N	51°44'W	Denmark	A.F.W. Paulsen	x	x	x	x					x			x				
Ft. Conger	Ellesmere Island, Canada	81°45'N	64°58'W	U.S.A.	A.W. Greely	x	x	x	x			x		x	x		x	x	x	x	
Kingua Fiord	Baffin Island, Canada	66°35'N	65°30'W	Germany	W. Giese	x	x	x	x	x		x					x	x	x	x	x
Fort Rae	Gt. Slave Lake, Canada	62°39'N	115°44'W	Gr. Britain	H.P. Dawson	x	x	x	x	x			x								
Point Barrow	Alaska	71°18'N	156°24'W	U.S.A.	P.H. Ray	x	x	x	x				x	x	x	x	x		x	x	x

During the IPY, as it is familiarly called, eleven nations sent 14 separate expeditions to locations in the arctic and sub-antarctic. The sites for study were selected in advance for their expected ability to provide particularly useful observations of meteorology, magnetism, and aurora. About twenty special temporary observatories were also established in subpolar regions; and 39 permanent already established observatories in 25 countries around the world cooperated in making simultaneous observations. The observing program was rigorous, including manual observations (this was before the days of electrical or photographic recording) every hour, and every 20 seconds for given periods every fortnight, and was maintained at all stations for almost the full twelve months. In addition, a large number of other researches, ranging from anthropology and botany to marine science and zoology, were undertaken on the different expeditions according to the opportunity and location (Table 1).

All northern countries, including each of the Nordic countries, took part in the IPY. Of special interest to this conference, perhaps, was the Swedish expedition to Kap Thorsden in Spitzbergen, which was just off to our right as we crossed Isfjorden en route from Longyearbyen to Ny Ålesund. I am pleased to note that the IPY expedition house at Kap Thorsden, originally built some years earlier by Nordenskjöld, has now been restored as part of the one hundred years' anniversary celebrations of what is now usually called the First International Polar Year.

Starting with the idea of international cooperation to achieve effective arctic science, the IPY became truly the first coordinated multi-disciplinary study of the whole planet. Some aspects of its significance certainly could not have been imagined at the time. For instance, toward the end of the polar year period, when the world-wide observing program was running smoothly, the volcano Krakatau in Indonesia erupted, sending a great amount of fine particulate matter into the troposphere and stratosphere. The IPY observing network enabled the movement and distribution of the dust clouds to be traced over the entire planet for the first time, providing information on global atmospheric movements and on the resident times of particulate matter in the atmosphere at different levels and latitudes in a way that before then was not possible, and for which since then there has rarely been the same opportunity. Today, the IPY data on the atmospheric effects of Krakatau, obtained one hundred years ago, are being studied with new intensity in connection with calculations of the potential climatic effects of nuclear warfare.

The contribution of the IPY to world baseline data in a number of subjects, and to the concepts and understanding of planetary geophysical processes is impressive; but what is perhaps more important in the context of this conference is the influence that this one coordinated activity had in bringing about a change in the character of science. From being an exclusive activity, pursued by a privileged few and often jealously guarded for reasons of national prestige, world science developed into an open activity, where everyone who was qualified could take part, and where the results belong to the whole world. It became an activity whose quality came to be judged by the criticisms of other knowledgeable scientists, as they learned of the results which were published in the open literature. IPY also marked the beginning of the practice of governments to use public funds to sponsor scientific research in a number of fields, even if the research was not carried out in the sponsoring country, and the information obtained would not be the sole property of the sponsor. Whether or not these developments would have come about anyway, without the IPY, will of course never be known. But there is no doubt that very quickly from the time of the IPY onwards, Academies and Royal Societies became noticeably international in outlook. International professional societies, which were structured to avoid domination of a field of science by one nation or institution, came into being in a number of disciplines; and international scientific symposia became the accepted and highly regarded way in which ideas on scientific advances were exchanged and discussed in an open manner.

International Arctic Science Today

That was one hundred years ago. International cooperation in arctic science had provided the impetus for a tremendous advance in world science and international cooperation and interdependence of knowledge in general. Despite wars and politics, and competitive industrial development, science has remained international and interdependent. Today, we often take for granted that it should be so. We tend to forget that these ideas had their clear first expression in arctic science.

In the succeeding years, many professional and scientific groups have been concerned with international cooperation in arctic regions, and there have been a number of outstanding successful international arctic research programs. One direct descendant of the IPY was the International Geophysical year, (IGY), 1957-58, which established the scientific station at Ny Ålesund. There were in all, five stations established in Svalbard during the International Geophysical Year; I hope that they all did not present the environmental clean-up problems referred to yesterday by Dr. Prestrud in connection with the IGY station at Hornsund. (In defence of science, I should perhaps point out that the Hornsund building was used by trappers and others after the IGY was over).[1]

What about today, and the future? There is no doubt that the factors that inspired Weyprecht to insist on the need for cooperation between nations in arctic science are still as valid as ever. The natural phenomena — the weather, the migratory birds, the arctic seas and ice, magnetism, and aurora — must be studied over large parts of the polar region, without regard to political boundaries, if they are to be properly understood. Distinctive arctic geophysical and tectonic characteristics have to be studied in the Arctic wherever they are found, for reasons that only make sense in the context of the arctic regions or the globe as a whole. The Arctic is still an essential laboratory for investigation of biological and geological processes, studied without regard to national boundaries. Nations or companies undertaking industrial or economic development in polar regions encounter similar environmental problems and geotechnical conditions, and have much to learn from one another in development of technology, and in operational and management techniques. The social sciences, also, both those studies that have to do with traditional cultures and the influences and pressures of southern societies and governments on those cultures, as well as the studies of how persons from southern technical society can be adapted to and kept healthy and productive in the modern North, have much to gain from comparison and joint study of the many different "social development experiments" that are going on in different parts of the northern regions today. So, from all those aspects, the arguments in favour of arctic cooperation in science are as strong, if not stronger, today than they ever were.

But from another aspect, there are a number of disturbing and puzzling things about the outlook for international cooperation in arctic science. The changing economics and policies of northern nations are altering the role and nature of northern science. Some of these changes involve international arctic cooperation, and everyone who has an influence on the policies for arctic science should consider them carefully.

First, there is no doubt that the perception of the role of science among those who support it and direct its policies is changing profoundly. The success with which science and technology has contributed to economic and industrial advance in the past fifty years, and the central role that research has played in military and medical developments, has contributed to a deep-seated re-orientation concerning science, among those who support science and among the public. The change is from an earlier view of science as *the organized pursuit of knowledge* which was justified on the grounds that new knowledge was ultimately useful and therefore a good investment, to a present view that regards science as *a technical tool for solving national or economic problems*, or for supporting a domestic or foreign policy.

This re-orientation of the reasons for supporting science on a national basis is particularly noticeable in arctic science today. Dr. Willy Østreng pointed out this fact strongly at the beginning of this conference, and from international experience I can only agree with what he said. The change applies also to deliberate international cooperation in arctic science. You will remember that Willy stated that there were three principal reasons why governments today use public tax money to support arctic research [Østreng, W., 1984. Nordområdene i aktuell politikk. *Rapport fra Nordisk Vitenskapelig Konferanse om Arktisk Forskning*, Universitet i Trondheim Press, pp. 17-26.]:

1) Strategic, military, foreign policy
2) Economic
3) Territorial (within which I would include or add, social and cultural development).

You will also recall that Dr. Østreng identified three schools of thought about how science and policy are seen in relation to these three reasons, for their support. These schools are (and here I am interpreting Dr. Østreng's categories very freely):

(i) *a functional school* — which says "learn what we need to know — then use that knowledge to advance toward our objectives or defend our position"
(ii) *a pragmatic or "realistic" school* — which says "learn first in our areas of interest, then use that knowledge to see what the problems or opportunities are"
(iii) *an idealistic school* — which says that as much as possible should be studied and all knowledge is of interest — "study everything; because ultimately some of the information gained will be of sufficient value to pay back the whole investment".

What Dr. Østreng did not point out was that, at least in the circum-arctic world outside the Soviet Union, much more of the scientific activities in the Arctic in total are being paid for by industry using private funds than are sponsored by governments using tax-payers' money directly; and it is being done overwhelmingly for reason number 2 (economic), under a functional concept.

[1] The IGY building was used as the base hut by Mr. Ivar Rudd, a trapper who lived alone in this isolated area from 1967 until 1973, after which the area was created a wilderness reserve. Mr. Rudd's adventures during this period are eloquently recounted in "The Year-Long Day", by A.E. Maxwell and Ivar Rudd, published by Lippincott (1976) and Pocket Books (1977).

What does this situation mean for arctic science? It means that in most arctic countries, government science agencies have now less influence on arctic science than they had in the past, and are less responsible for its "freedom" or the directions it takes. Most governments now influence the major activities in arctic science indirectly through their energy and resource and territorial policies, their policies for northern development, environmental protection, devolution to home rule, etc.; instead of, as before, directly through funding from research councils or science foundations or grants to independent institutes on the basis of the science itself. This means, of course, that in the support of arctic research and the determination of its subject and scope, there is less emphasis on the quality of science as such, and more emphasis on what use will be made of the results. It does not necessarily mean that we now have poorer science, but it does mean a control of the kind of science according to its utility. This development is happening in all arctic countries — including the USSR if one compares the relatively small size of arctic activities of the USSR Academy of Sciences with the enormous arctic research program of, say, the Ministry of Oil Industry.

To see the importance of this development, even in the Nordic countries, I would ask you to look back over the program for this conference. See how the organizers divided up the field of arctic science. Review the research programs that were reported, or the studies that lay behind the excellent summaries that were made of marine and terrestrial atmospheric, and resources research. I ask you to think about who paid for that work and why they decided to support it, and where each fits into Willy Østreng's categories.

Such a change in the reasons why nations undertake arctic research has important implications for how international cooperation can be achieved, and what can be gained from such cooperation.

At this point, let me pause for a moment and ask you to reflect on what Dr. Østreng said and I have just said about the goals of the Nordic countries in undertaking arctic science today. These are good and necessary goals for democratic and scientifically advanced countries that are undertaking economic and social development in line with their arctic policies. But do you notice how very much these goals differ from the goals and principles for polar research set forth by Weyprecht one hundred years ago?

The Future?

Before we look at specific features of current and recent international programs, let us think about the future for a moment. Dr. Østreng presented us with a snapshot of the present, of a situation that has changed dramatically in the past fifteen years and is even now dynamically changing. One of the reasons for holding this conference is that the arctic science situation is changing rapidly, often because of factors we cannot control — like the price of oil in the Middle East or a change of government in one of the superpowers —, and it is important and timely to consider, together, what the Nordic countries can do to achieve the best arctic science, and contribute to their own national policies, in the uncertain future. One of the ways the Nordic countries will want to do this is to have beneficial cooperation in science with other northern countries. But whether we wish to state it bluntly or not, all such cooperation must lead to national benefit, as well as to good science.

No one, of course, should be foolish enough to try to say what future science policies or the future role of arctic science will be. But I think that there are two important aspects of arctic science in which the general directions are fairly sure, and which are worth thinking about in connection with future international arctic science programs. The first aspect has to do with changes in arctic science itself, and the second with some major factors, not connected with science or the Arctic, that are bound to affect arctic policies and arctic science in all countries.

The Changing Nature of Arctic Science

It is undeniable that the character and even the concept of arctic science, as an activity for acquiring new knowledge, is changing. This is true of science everywhere, of course; but like so many things in the arctic regions, the evidence and results of the change are dramatically apparent. There has been a swift transition from a stage where the arctic regions were largely "blank on the map" in a scientific sense and an unknown area where simple careful observation, in almost any subject, would be a real contribution to human knowledge, to a stage where, because of the relatively simple ecosystems and the clear evidence of the interactions between geophysical phenomena in the Arctic, there is unparalleled opportunity for sophisticated and advanced study of basic natural phenomena and processes that are critical to science in any part of the world. In this transition, studies of single phenomena or distinctive northern species are giving way to investigations of inter-relationships between phenomena, energy flows and feedbacks, resiliencies and stabilities of ecosystems. The boundaries between traditional scientific disciplines are changing and becoming indistinct, in the arctic regions perhaps faster than in studies in other parts of the world where the interrelationships are not so easily seen and the inertia of established compartmentalized knowledge is stronger. The very distinction between physical and biological sciences, as an approach to the study of nature, has all but disappeared from leading arctic research. And the involvement of social sciences into and with the natural sciences is rapidly increasing, driven by the exigencies of national social and economic needs in northern regions and by the obvious fact that human society in the Arctic is unavoidably more affected by a dominant and distinctive environment, and more obviously a part of the regional ecosystem, than most societies feel that they are in lower latitudes.

The increasing sophistication of arctic science means that its progress depends to an increasing extent on the direct involvement of specialists who are leaders in their field. At the same time, the evolving interdisciplinary and inter-related nature of arctic studies means that scientific success depends on how effectively diverse specialists can contribute to a team program or to the progressive accumulation of synthesized knowledge. This paradox, at the least, tends to lead front-rank arctic science away from being a spontaneous activity to being something "managed" and somehow integrated.

The progress of scientific knowledge about the Arctic is leading naturally to a need for field observations and experiments at all seasons of the year, or continued for several reasons. Accumulation of understanding, and of knowledge of key problems, in one area of study leads to calls for regional syntheses, or for comparisons between different locations of similar or contrasting environmental or geological setting. These logical and predictable developments are bringing all sorts of new factors into the established mechanisms and responsibilities for funding, organization, logistics support, and communication.

In nearly all areas of arctic research, the progress of science leads to an increased need for linkage with research in non-arctic areas. The distinctiveness or exclusiveness of arctic science as a subject or activity in its own right is becoming fuzzier. Does this lead to a questioning of the validity of an "arctic scientist" or the justification for institutions devoted to science in arctic regions? Those involved in research in the Arctic should at the very least not be surprised when others ask these questions.

It is dramatically evident that many of the new technologies of science, — from computers to satellite observation to remote sensing and data transmission to the ability to make gene transplants in the field — have particular application to arctic studies. One thing that these new technologies seem to have in common is that although they considerably increase the scientific productivity of the field work, especially in the arctic regions, they also considerably increase the research costs and required budget.

In sum, arctic research has progressed dramatically and rapidly from a state of rather simple science, of observation and data-gathering that supplemented the growing body of knowledge and understanding that was accumulating mainly in lower latitudes, to a position where many of the most advanced concepts in geophysics, marine and terrestrial and atmospheric environmental processes, and questions of biology and evolution can best be studied, or only be studied, in polar and sub-polar regions. In arctic regions today, science is asking questions of *why, how, what does it mean,* that apply to the whole planet, instead of, as previously, *what is there, where, how many,* in one or another particular part of the Arctic. All this means, for much of the leading arctic sciences today and in the near future:

— a team approach to research, involving specialists in different subject areas;

— careful coordinated planning (for example, to get arctic sensors or committed arctic observing schedules on a satellite, the proposal must be submitted, and approved, 5 to 8 years in advance) and appropriate institutional commitment;

— sophisticated equipment, and the means to maintain and upgrade it;

— flexible and comprehensive data systems that are compatible with or linked to established permanent data centres;

— the logistics ability to go where the science demands, and communicate as required by the science.

All this sounds perhaps overwhelming and discouraging to the old-time scientist or the eager young graduate who wishes to put a pack on his or her back and hike off to the Arctic to make a contribution to science. Many of us at this conference, myself included, are products of the time when the most important equipment needed to do good science in the Arctic was a keen eye, a strong back and legs, and perhaps a perverse ability to enjoy physical discomfort in glorious natural surroundings. These are still very important assets, but they are no longer sufficient to ensure a scientific contribution. There is still a place for the individual scientist who plans a careful but modest program, and even for the "science of opportunity" — that is for the scientist who hitches a ride on a boat or on aircraft going to the Arctic for some other reason, or who makes useful observations while engaged in some other activity —, but that place is not likely to be in the forefront of arctic science or to be significant with regard to international cooperation.

To be in the forefront of arctic science today, a country has to have the ability and the will to develop and maintain the expertise and facilities that will enable it to take part in world science, in those subject areas that relate to the Arctic that are important to its national needs. To do this on a sustained basis requires, as Dr. Øritsland stated so well for the terrestrial biological sciences, a balanced program that, within the national context as well as in the international scientific picture, gives attention to three main areas:

— development of theory, concepts, and mathematical modelling;

— field and laboratory work, ranging from inventory and evaluation, to process observation, monitoring, and experiments;

— development of equipment and technology.

If a country does not have the resources and determination to succeed in all three areas, it will be left behind in the advance of arctic knowledge and be dependent on the work of others for an understanding of its own arctic areas.

External Economic and Social Developments and Their Effect on Arctic Science

The scientific work done by each country in its arctic areas is necessarily and properly a component of its arctic policies.

Each country has its own arctic policies and its own science policies, and this review is not the place to discuss them. But it may perhaps be useful to note some factors, that appear to be affecting all arctic nations, that will be important to arctic policies of the future and which may have a profound influence on how each country supports, or directs its arctic science. These factors, shared in common between arctic countries may thus have an important influence on international scientific cooperation in the Arctic.

Countries at present spend public money on arctic research for perhaps five general reasons or purposes. The amount and proportion varies of course from country to country and from year to year, and the purposes are not independent or separate from one another; but in most arctic countries in the past few years the support has been for the following main reasons, with money spent in approximately the order shown:

(1) — in hope of contributing to economic development, and for eventual profit from exploitation of natural resources (it is necessary to say hope of economic development, because with the possible exception of Alaska, in no arctic region can it yet be honestly claimed that public expenditures on science have resulted in a net economic profitable return to the country concerned);

(2) — in support of national or territorial policy, defence, or international strategy (in some arctic countries, this category undoubtedly ranks first in national priority and possibly also in public expenditures on arctic science);

(3) — to contribute to local social or socioeconomic development, or to provide information in response to public demand and concern (including, in some countries, public concern over potential environmental consequences or effects on wildlife resources);

(4) — as a contribution to world science, and an aid to understanding of or possible solution to global problems (such as regional or global climate change);

(5) — as a contribution to intellectual and scientific knowledge for its own sake, and for educational and aesthetic reasons (although the amount of research supported mainly for these reasons is small, it is still a very important part of the science activity of every developed country and is an essential part of each country's image of itself and its sense of its own worth and future).

These reasons, and probably their order of importance, are not likely to change much in the medium term future. But some developments that have little to do with the arctic regions or with science are having an influence which is already being felt, and these may strongly alter the kind and emphasis of research that will be done in the Arctic for the various reasons noted above. For example:

(a) — continued high interest rates are altering the economics of exploiting northern resources in comparison to resources in lower latitudes. There are many inter-related reasons for this, ranging from the relatively greater advance capital investment needed in arctic areas to the necessity to have dedicated bureaucracies, "infrastructure" etc.; the net result seems to be that a continued high cost of money on the international market works to the comparative economic disadvantage of northern resources. High interest rates, perhaps even more than current or expected fluctuations in market prices for resources, have an effect on the long-term outlook for northern resources and thus on the government and industry investment in arctic science.

(b) — national policies concerning the operations of multi-national resource development companies, and the increasing ability of the multi-national companies themselves to shift their interests and activities to the Arctic, away from it and back again for their own political or economic advantage, tends to put both government-supported and industry-supported arctic studies on a stop-and-go basis. The effect of these fluctuations on both the effectiveness and the cost of science in arctic regions is relatively more serious than in lower latitudes, where there is usually a greater background of on-going related scientific activities to absorb the effects of any one decision — and a larger pool of scientific experts from which to draw during periods of expansion.

(c) — the degree to which popular concerns will affect the amount and nature of scientific activities carried out in northern countries will almost certainly increase. This development can affect arctic science in several ways that might be different from the effect on science in lower latitude, more populated areas. For example:

(i) In many northern democratic countries, one of the first and most common targets of public criticism has been increased government spending. In particular, popular disapproval is often expressed over government expenditures on activities that appear to go on for years without identifiable profitable results to voters in a particular constituency. Science in general has to contend with this problem, but arctic science tends to be particularly vulnerable. By its nature, arctic science is comparatively high cost, with the practical pay-off, if any, several years in the future; it is carried out in an area where there are no or few voters and where industrial development is almost always closely controlled by national policies rather than by local pressures; and the economic benefits, if they do materialize, or the policy benefits of arctic research tend to accrue to the country as a whole rather than to a particular public pressure group. For these and related reasons, in most democratic countries it has been very hard to maintain broad public support for long-term scientific programs in arctic areas; and arctic research has been often among the first of the areas of science to be cut during periods of fiscal restraint. Paradoxically, several countries have reduced their relative expenditures on arctic science even when those same countries have been actively pursuing policies of northern development or consolidation of their arctic territories.

(ii) Public demands for environmental protection and environmental information have played an important role — and in general a welcome and constructive role — in giving increased emphasis and focus to environmental and natural history studies of arctic regions. But such demands often place main emphasis on a current popular cause, or insist on quick and superficial conclusions that have newsworthy or political connotations. In many areas, it has been hard to get popular support for commitment to much-needed long-term basic studies or data gathering, or for research on problems that are very important to the arctic environment but which are not in the public news.

(iii) In arctic areas that are inhabited, however sparsely, there is a growing demand by the indigenous or resident people not only to participate more effectively in the decisions of government and industry that affect their economy, social development, and culture, but also to have an important or controlling say in what scientific studies should be carried out in their region. The residents are questioning the goals of arctic research and the availability, interpretation and distribution of the information that comes from that research. Most countries have national policies that encourage such action by northern residents, and the northern peoples themselves are developing both national and international communications and policy positions that, as an integral part, include a measure of control over arctic science and research.

Scientists in general can only welcome the emergence of an interest among the arctic people in modern scientific studies of their own land and adjacent waters. Over the years, it will undoubtedly be a great positive step, for science, and for the nations concerned as well as for the arctic peoples themselves, if arctic residents come to play a lead role in world-class science in arctic regions. But the transition period is bound to be turbulent and disruptive. Scientists and managers from southern institutions are having to find ways to re-orient their view of responsibility for science and the way in which it is used; and northern peoples are learning, sometimes with difficulty, that science done in a local context is not very effective, and that to be successful, even for contributing to the solution of local problems, it must be carried out in a broad regional or international perspective.

These examples show that the increasing influence of world economics and public concerns on the directions and control of scientific studies in northern regions tend to have an unsettling effect on the kind of planning, team approach, and institutional commitment that is necesary if front-rank and cost-effective science is to be pursued in arctic regions. It will be a test of the skill and dedication of science managers in all northern countries to use the volatility and immediacy of economic pressures and public concern as stimulants and justification for good and better science programs in the Arctic, rather than to let them be a hinderance and handicap. A very important part of the skill in turning these influences into positive forces for arctic science is the manner in which international science is carried out.

The Demand For Answers To Integrated Questions

Another aspect of the change of role of arctic science from one of pursuit of knowledge to one of a solver of national or economic problems, and which has important implications for international cooperation, is the growing degree to which scientific studies in the Arctic are seen by some as a means of providing ready-made solutions to very large and complex problems. Each of you is aware of the increasing extent to which both governments and the public expect the scientists, on the basis of their research, to produce not simply scientific information as such, but reliable answers to such complex and difficult questions as:

— what is the net cost, or benefit, of exploiting resources in a particular area?

— what is the relative significance of environmental change in a certain region due to natural factors, compared to the change caused by human activity?

There are many problems of this kind, legitimate in themselves and very real problems to the nations and people concerned but impossible to answer in purely scientific terms, which are being presented to those who are concerned with arctic science today. In few areas of science, in the Arctic or elsewhere, is there sufficient knowledge and understanding to answer such complex questions with any confidence. The pattern of national and international development in arctic regions, however, and the widespread acceptance that scientific studies in the Arctic are undertaken precisely to contribute to such questions, make it probable that arctic scientists will find themselves expected to answer such questions, based on whatever knowledge and information they may have.

To a degree somewhat greater than experienced by their colleagues in southern regions, arctic scientists find that the conclusions drawn from their research have political or policy consequences. To some extent this is a problem of the arctic scientists' own making, for they often have promised such conclusions in the attempt to get support for their research. But we are already seeing some unfortunate results of this situation, in the loss of credibility of arctic science and the reluctance of some of our best scientists, in several countries, to become involved in arctic research because of the risk that their work will be used, prematurely, for immediate purposes not compatible with good science. These kinds of problems have been felt particularly with regard to research in the social sciences, the studies of renewable resources, and international collaboration on the environmental and applied aspects of transport development.

Such problems bring up yet another facet of the question of international cooperation in arctic science. Because the arctic regions have physical and biological characteristics that are not familiar to governments, industry, or the general public in temperate latitudes, special studies, research, and engineering are needed. There is a call for proportionately "more science for each government or industrial decision" than is normal in lower latitudes. But arctic problems, and the information and research required to address them, are often circumpolar rather than national. In many respects there is more in common, in the scientific and socioeconomic sense, between the northern regions of different countries than between the northern and southern regions of the same country. Thus we have the peculiar situation of northern countries having to undertake cooperative international research in order to address their national arctic domestic problems and develop their national policies.

Taken all together, these developments and trends may mean that in the next decade or so it may be increasingly difficult to maintain vigorous arctic research programs on their own merits as "arctic studies". But at the same time, international studies of arctic regions and phenomena will be needed increasingly as an essential contribution to world knowledge and to major national policies and international relations.

Types of International Cooperation In Science In the Arctic

It may be useful to review some examples of different types or styles of international cooperation in arctic science to see how they relate, or accommodate to, the changes in arctic science that have occured. The examples tend to be, perhaps, mostly the larger international programs that have required some sort of formal organization between two or more countries. These have been selected because they are well known to most of you and because they are easy to refer to, and many have played an important role in the progress of arctic knowledge and the course of international arctic relations. But the importance of the informally arranged, modest, and often one-on-one cooperation and collaboration between individual arctic scientists or institutions must not be overlooked; it is a vital part of arctic science and will, we all hope, continue to do so. However, even the most informal and modest international program seems to fit somewhere into the following categories, with their respective strengths and shortcomings.

Regardless of scientific discipline or subject, there are several different ways in which scientists or institutions of different countries have come together to pursue their common interest in arctic science. For purposes of discussion I have identified seven different styles or variants of international arctic science cooperation, with some well-known examples, and some personal comments on their characteristics:

1. **Large, coordinated regional or circumpolar single programs.** The obvious example of this is the International Polar Year itself, from which much can be learned, even after one hundred years.

   Programs of this type have required a single detailed master plan that all participants agree to follow. Participation requires a surrender of some individual national or institutional priorities; in order to achieve a previously agreed goal or result. Such programs have proved to be very hard to get started (The Nansen Drift Station or Fram Strait Project proposals are recent examples), but once agreed to and properly launched, can be very effective. A successful modern example is perhaps the polar segment of the International Magnetosphere Study.

2. **The arctic component of complex and highly organized world-wide or global research programs.** The Tundra Biome project of the International Biological Program, or the POLEX-Polar Subprogram of the Global Atmospheric Research Program (GARP) are good recent examples.

   International arctic cooperation in programs of this type requires that nations share and agree upon the objectives, and means of exchanging data and information. But the work is carried out through separate national or regional activities, and the actual program may vary considerably from country to country. Cooperative programs of this type have good flexibility, and allow scientists in each country to make their own case for support according to the national priorities and the science support structure. But they have proved to be vulnerable to disruption because of failure or uncertainty of support from one or more participants and, sometimes, from lack of uniform control over the quality of the science.

3. **Scientifically focussed, wide-ranging programs to explore new concepts, gather data, or compare phenomena.** An early excellent example of this kind of study, involving the Nordic countries, was that undertaken by Professor H.W. Ahlmann fifty years ago to study the glaciation of the North Atlantic region. A more recent and equally successful example was AIDJEX (Arctic Ice Dynamics Joint Experiment) conducted in the Beaufort Sea 1969-1976.

   To be successful, programs of this type require a clearly expressed scientific concept, and then equal cooperation both from the scientific planners and the supporting agencies in all participating countries. The structure allows different countries or participating institutions to have different objectives, but some examples have experienced a history of tension or dispute, with harmful effects on the science, if balance is not carefully maintained.

4. **Programs where collaboration by a number of researchers or agencies in one good area, or taking advantage of an outstanding opportunity, will benefit many others.** A good example of this was the international participation in the Baffin Island Oilspill Study (BIOS) described earlier in this conference by Professor Eimhjellen. Other examples of different nature are the coordinated studies of arctic birch forests under the Northern Network of the Man and the Biosphere Program, or some of the engineering studies of ice-breaking forces (e.g. the Nutcracker Program) of the Arctic Petroleum Operators' Association. The promising PRO MARE program for the Barents Sea would appear to be of this kind.

   These types of programs seem to require planning initiative and usually major funding from one or two participants, who then invite others to join. Their successful operation requires a mechanism for participation by all agencies in both management and science decisions once the program is under way, so that those invited become true partners in the study. Because the various components tend to be independent in their authority and yet interdependent in the science, strong yet sensitive control or management is necessary.

5. **Studies that are so sophisticated or expensive that no one country can provide the expertise or facilities, so that international collaboration is essential.** Allied to this type are the programs where it may be politically expedient to have a number of countries or institutions participating, and the scientists are only too glad to have political support for the international cooperation that they would like to achieve anyway. The MIZEX (Marginal Ice Zone Experiment) is an example. So too were the Greenland Ice Sheet Program (GISP) referred to earlier in the conference and in which Dr. Dansgaard played a major role;

and the Arctic Drifting Buoy Program.

These kinds of studies require a common scientific plan, usually drawn up not only for scientists but in terms of the international management advantages. The obvious examples of such programs have developed a two-level management structure in their own defense: — a "board of directors" to justify the project to the various funding and decision agencies, and a committee of science and operational planners or managers who are concerned with the research program and operations, etc. The operational success of these programs obviously depends on assured funding and highlevel support. But the scientific success, while sometimes excellent, has sometimes been harder to ensure than operational success because the management and operation may be in danger of smothering the science.

6. **Programs designed to facilitate the sharing and exchange of experiences and knowledge, or to compare the results of similar studies.** An example of this kind of cooperation is that which it is hoped will come about through the recently signed Canada-USSR "Protocol of Consultations on Development of a Programme of Scientific and Technical Cooperation in the Arctic and the North". Another example is the regular sharing, comparison, and criticisms of individual medical studies and research programs in the Arctic, which take place through the periodic Conferences on Circumpolar Health. Even more informally, but productive scientifically, are the geological studies by scientists from three nations, working independently on a single widely recognized scientific problem — the structure and tectonic evolution of Nares Strait —, in which the researchers shared and built on each others' information, and finally held a conference that led to a joint publication which is a model of international arctic cooperation without the need for formal intergovernmental arrangements. I am interested to see brochures for that publication on display here in Ny Ålesund. [Dawes, P.R. and J.W. Kerr, 1982. Nares Strait and the Drift of Greenland: A Conflict in Plate Tectonics. *Meddelelser om Groenland*, Geoscience 8.]

Cooperative programs of this kind depend obviously on the willingness of each participant to share current scientific problems and results, good and bad, with one another. The emphasis must be on the sharing of information, not joint participation in activities, if questions of control and jurisdiction are to be minimized. Such programs appear to be most successful where the participants have about the same degree of scientific sophistication and level of arctic activity in the subject being shared. They are less successful where one country is the obvious leader in that field.

7. **Programs designed to combine data or information from several sources into a common format or synthesis that can then be useful to many countries.** A good example of this kind of international cooperation is that coordinated through the International Commission on Snow and Ice to compile the World Permafrost Map. Information from all circumpolar countries, often in different format and obtained in different ways, is synthesized by an international team into a common style and presentation. A similar example that comes to mind is the bathymetric map of the Arctic Ocean, produced in the GEBCO (General Bathymetric Chart of the Oceans) series.

Organization and coordination of this type of international cooperation seems to be done best by an established international professional body, supported by several countries, which can set the professional standards, and maintain the continuity, contacts, and influence necessary in each country. There are very few such bodies special to arctic or polar regions, so it is likely that successful international arctic cooperation of this nature will be accomplished mainly through the help of worldwide agencies such as those affiliated with the International Council of Scientific Unions or similar bodies.

Some Lessons Learned

The above quick review shows the wide variety of types and styles of international cooperation that have evolved to accommodate the changing needs and activities of science in the Arctic. Are there any general lessons to be learned from these experiences and experiments, that will help us achieve more effective international cooperation in the changing Arctic of the future?

It seems to me that there are a few characteristics that are important to nearly all successful international cooperation in arctic science, no matter how grand or how modest, how tightly organized or how informal it may be:

1. **The goals of the research should be clearly understood** by each participating country and institution. The goals of each participant may not always be identical (for example, I doubt if the reasons why Sweden supported its scientists in the MIZEX program were the same as those of the main U.S. agency that supported it); but if international participation is to be genuine, the reason for the participation usually has to be more than the professional interest of individual scientists.

I hope that no one will be offended if I venture to say that perhaps a reason why activities of the Man and the Biosphere Program have not been very successful in arctic regions over the past two decades is that the goals of the various activities that have been attempted have not been clearly formulated or understood.

2. **The programs should be clearly focussed,** scientifically and operationally. This does not mean that the studies need to be narrow, or be confined to previously defined problems; but if the international cooperation is to be successful, the intended scope and main emphasis of the activity must at all times be clear to all concerned. The best examples of international scientific arctic research programs seem to be those that focus on new discovery, or on problems and technologies not yet fully developed. Arctic science seems to benefit best from genuine international cooperation in subject areas that are still evolving. In activities where data gathering or confirmation of knowledge is the main objective, parallel rather than collaborative studies seem to work best, and studies to solve already identified scientific or engineering problems seem usually best done on a national basis.

3. A **cooperative, complex program** involving different kinds of scientists from different countries, playing different roles but contributing to the common theme or objective, should be undertaken as a *well-defined short-term project* with a scheduled termination date. Only for a short-term effort can various agencies in different countries make a committed effort to an activity that is outside their regular responsibilities or priorities.

4. **Long-term cooperative international scientific activities** in arctic regions — for example, like the obtaining of regional polar meteorological information or the magnetospheric studies along a polar geomagnetic meridian — have proven to be most successful if each participant plays almost exactly the same role, takes the same observations, etc., usually under the coordination of an international body (like the World Meteorological Organization, or the International Association of Geomagnetism and Aeronomy). An alternative for long-term continuing research studies is for one country or agency to take the lead and provide most of the funding and scientific initiative, while the other countries cooperate by providing a location and technical maintenance of the equipment, but playing only a minor role in the science. This is what has been happening in recent years to the magnetic meridian chain. Continuation of the international program then depends almost entirely on the initiative of one country, with more passive cooperation from the others.

Mechanisms for Achieving International Cooperation in Arctic Science

Several administrative and institutional mechanisms have evolved in the past few decades to bring about international scientific cooperation in arctic regions. Considerations of future international programs, or evaluations of those presently in existence, should take into account the characteristics of various mechanisms used by cooperating arctic countries. These range, as would be expected, from formal binding agreements to loose voluntary associations. The following are some of the more organized mechanisms that appear to be having an influence in shaping the present direction and vigour of several of the various types of international arctic cooperation discussed earlier, with examples.

1. **Inter-governmental or international agreements supporting and to an extent directing arctic science.** A well-known example of this type of mechanism is the International Agreement on the Conservation of Polar Bears. Although it is not specifically about research, the admission by all polar countries that they have, together, a shared concern and responsibility for a major arctic species that travels across political boundaries and is found also in international waters has made the Agreement, since 1974, an important vehicle for joint and cooperative research activities and sharing of information with regard to polar bears and their habitat.

For a number of years, there have been arrangements between Canada and Denmark, formalized by exchange of letters between the appropriate ministries of each country, which provide for cooperative work between agencies and scientists in west Greenland and the Canadian Arctic Islands and the adjacent waters. Cooperation under these arrangements has included scientists from one country joining the field parties of the other country, joint planning of surveys and research, the linking together of geodetic and hydrographic survey networks, the sharing of air photography and other practical technical work, as well as exchange of scientific information.

Another example of a mechanism formally arranged between governments is the protocol for a programme of scientific and technical cooperation in the Arctic and the North signed recently between the USSR and Canada. The protocol provides for joint or cooperative study and exchange of information in twenty-six identified program areas having to do with arctic earth sciences, resources, environment, construction, and ethnography and education over a two-year period.

The Svalbard Treaty is, of course, a special case of an inter-governmental arrangement that has had implications for cooperation in arctic science. I shall not discuss it here, except to point out that, although the Treaty does not mention science or research as such, the provision of "equal liberty of access or entry for any reason or object whatever to the waters, fiords and ports" has been the basis of establishment within the archipelago of scientific programs by many nations. In practice, it appears that the Treaty has had little effect on whether these various studies by different nations have been independent from one another or closely cooperative; and it has fallen to other mechanisms to determine whether the researches on Svalbard by different countries have been carried out in separate and parallel fashion, or whether there has been international coordination and collaboration.

2. **International scientific organizations** are playing an increasing role as vehicles for achieving scientific cooperation in arctic regions. Some of these are specifically arctic in their scope, as for example the Circumpolar Health Conferences already mentioned. But more common, and often taking a leading part in stimulating international arctic science today, are arctic components or activities of organizations that have a global mandate. Examples well known are the Scientific Committee on Oceanic Research (SCOR) whose Working Group 58 on the Arctic Ocean Heat Budget has provided the scientific basis for a number of international arctic studies and proposals; the mechanisms established by the International Biological Programme (IBP) that have led to comparative studies of tundra ecosystems, and movements toward Biosphere Reserves and other specially protected sites in arctic areas; the International Commission on Snow and Ice, responsible for obtaining funding, mainly from UNESCO, for the World Glacier Inventory; the UNESCO-sponsored Man and the Biosphere Program, with its recently formed "Northern Network" to encourage and facilitate international coordination of arctic MAB projects; and many others. Few international scientific professional organizations have established separate arctic bodies; but the need for specific attention to arctic science and its international coordination is felt so strongly by some scientists that in 1983 a formal motion was placed before the general assembly of the International Union of Geodesy and Geophysics (of the International Council of Scientific Unions) that consideration be given to the formation of a new International Union or Association for Arctic Studies.

3. **Initiative by one agency or institution, which draws up general plans, secures basic funding or support commitments, then invites specialists from other countries or organizations to join** has proved to be an effective and widely used method of achieving international participation or co-operation in arctic science. In these cases, international cooperation has been most successful when the partners bring some resources or support with them. An excellent example of first-rate international scientific collaboration developed through this mechanism is the YMER expedition 1980; others are the LOREX and BIOS studies referred to earlier. The PRO MARE studies have potential for achieving effective inter-institutional and perhaps international participation in this way.

A variant of this mechanism, often used in America but apparently less successful elsewhere, is one in which a group of knowledgeable scientists draw up a scientific work plan and arguments to justify support of the work, and circulate these widely for open discussion before commitment to support has been secured. The intent is that open discussion among scientists will not only produce the best scientific plan and help identify the most qualified and interested scientists, but that broad scientific consensus and support will help influence decisions to support that particular project over others that might be competing for the same funds or facilities. Examples of use of such a mechanism are the Greenland Ice Sheet Project, the now abandoned Fram Strait Project, and the current Air-Sea-Ice Interaction research proposals. While such a mechanism is an excellent way of producing a good scientific plan and, when in operation, consistently good science, it has obvious drawbacks when support must be obtained from and coordinated between different countries and institutions with different priorities and decision-making procedures.

4. **Mechanisms for continuing support, planning and coordination** of arctic science activities have evolved in all northern countries. In each case, these have developed to serve national needs and priorities, but most have made provision for participation by scientists from other countries or for joint projects with other institutions and nations. The activities of the Norsk Polarinstitutt, many of which are coordinated through the station here at Ny Ålesund; of the Commission for Scientific Research in Greenland; and of the Canadian Polar Continental Shelf Project, are examples. Each is dominantly designed and funded to facilitate research by its own nationals in its own territories, but each, in practice, has developed a degree of internationality in its program, with a door open to scientists and programs from other nations under fairly liberal conditions. The activities coordinated by the Swedish Committee for Polar Research are similar; for example, in the past few years, almost 50 per cent of the scientists and stu-

dents working at the Abisko Scientific Research Station have come from abroad.

In each country it has seemed to be the experience and conviction that the inclusion of an international component within the mechanisms for coordinating and providing continuing support to on-going national arctic programs has enriched and strengthened the national programs, as well as aided international cooperation and the progress of science itself. It is likely to be through this mechanism that the main continuation and growth of the informal, modest, one-on-one or professor-and-his-student type of international arctic cooperation, which was noted above to be valuable and essential, will take place. In the experience of each country, the scientific and management problems of this kind of cooperation appear to be minor; the main difficulty lies in convincing the authorities of each country that it is in the nation's interest to spend public money to help support research by scientists from other nations.

5. **Mechanisms for international planning and appraisal of arctic research** have had a varied history, and there have been some interesting recent developments. The *International Polar Commission*, formed in 1879 to organize what became the International Polar Year and which then took on the responsibility for assembling the observed data and publishing the results, was perhaps the first, and set an admirable pattern. Its members were directors, presidents, or senior officers of the institutes or academies that took part in the IPY, and each acted as a representative of his country. Its work done, the International Polar Commission disbanded in 1891.

Nothing quite like the International Polar Commission appears to have appeared in arctic science until, nearly forty years later, discussions about a second international polar year led to the establishment in 1929 in Copenhagen of a *"Commission for the Polar Year 1932-33"*. This commission was of a rather different character. Largely as a result of the first IPY, international professional organizations had become the vehicles for international coordination of science. Thus the new Commission included a mixture of representatives of participating countries, and the presidents of international commissions or unions of the scientific subjects to be studied (at that time, the Commission for the Réseau Mondial and Polar Meteorology, Commission for Terrestrial Magnetism and Atmospheric Electricity, Commission for Investigation of the Upper Air) and it established a special liaison with the International Union of Geodesy and Geophysics. In all major subsequent international programs, (IGY, IHD, IBP, IQSY, GARP, WCRP, etc.) the planning and coordination for the arctic programs have fallen naturally to the established international organizations; and specific arctic or polar bodies for this purpose have been absent or inconspicuous.

There have been some spontaneous moves to create international mechanisms to plan and coordinate arctic research. The *Arctic Institute of North America* was formed in 1945 as a bi-national or tri-national institute, incorporated in the United States and Canada with at least one member of the board of governors from Denmark or Greenland. It had the express purpose of encouraging, coordinating, and supporting arctic research and making available scientific information about the arctic, as much as possible regardless of international boundaries. For several decades it was very effective in these roles. The activities of the Arctic Institute of North America had a lot to do with the fact that in all arctic countries and not just in North America, by the time of the renewed interest in national issues and resources in arctic regions, there was a much greater body of knowledge and pool of arctic experts than there otherwise would have been. But the evolution of Arctic research programs within government agencies and the enormous broadening of the base of arctic studies in both universities and industries, plus the difficulties of supporting a bi-national or tri-national institute have in recent years greatly reduced the role of the Arctic Institute of North America as a stimulator and coordinator of international studies in arctic regions.

Several other arctic-oriented or polar-oriented institutions in other countries have made efforts from time to time to serve as vehicles for international cooperation in the Arctic. Those that have survived have become rather narrow or specialized in scope, or have become basically national institutes and instruments of their country's northern or polar policy. However, some, like the Scott Polar Research Institute of the United Kingdom, have been able to maintain a truly international scientific information role.

Nevertheless, the need for some means of dealing with arctic science on an international basis is strongly felt in many quarters. Periodically in nearly all northern countries the question has been raised as to why there cannot be an arctic equivalent to SCAR, the Scientific Committee on Antarctic Research; or proposals have been made for some country to take the lead and call yet another international conference on arctic research, which would set international scientific priorities and establish better means of communication and coordination in arctic science. These questions and proposals come at all levels — perhaps more often from politicians or from news media and the public than from experienced arctic scientists, who are caught in the middle and aware of the difficulties. The difficulties and impracticalities of a direct simple arrangement for broad international cooperation in the Arctic are usually easy to explain; but the persistence and sincerity of proposals for better coordination and planning of arctic science on an international basis shows that the feeling of need is real, and widespread.

There have been some attempts at establishing better methods of coordination and exchange in planning and appraisal of arctic science. At Norway's initiative, a quiet meeting was held at the Polarinstitutt early in 1972, of senior arctic research directors from USSR, USA, Norway, and Canada, to explore the possibilities for joint arctic research. A meeting was held shortly after the UN Conference on the Human Environment in Stockholm, also in 1972, to discuss whether it would be practical to set up an international mechanism to undertake the studies recommended by the Stockholm conference as they applied to arctic regions. And many here will remember *CHARLIE* — the Committee for High Arctic Research, Liaison and Information Exchange — an informal association of arctic scientists who were frustrated by the difficulties and lack of means of getting together to plan, and obtain coordinated support for, arctic science programs that were of high scientific value and in the national interest of each country but could not be accomplished by any country alone. CHARLIE's newsletter, issued from Copenhagen on a purely voluntary basis, was not only a useful exchange of information but it also helped to weld interested scientists into a feeling of arctic community, and it brought to the attention of several governments the essential international dimensions of arctic science.

However, none of these activities resulted in the emergence of any substantial mechanism for international planning or coordination of arctic science. A new development came when Prince Rainier III of Monaco invited twenty-six persons from ten countries engaged in arctic research to an International Symposium on the Polar Seas, held in Monte Carlo, February 1979. Out of the intense and hard-headed discussions at that small but high-level meeting came an agreement to create, on a genuinely international basis, a non-government body that would nevertheless be in a position to be listened to by governments, to be concerned with arctic science and its role in world affairs. After a few planning meetings, the *Comité Arctique International* was formed. Its members, as most of you know, are nearly all persons with senior responsibility in arctic science and activities, and they come from universities, industry, and government. The first clause of the objectives of the Comité Arctique International reads:

> "To improve knowledge and understanding of Arctic areas and to that end promote research in different fields on an international and multidisciplinary basis."

While the Comité Arctique International is a non-governmental body and each member participates in an individual capacity, persons from all circumpolar countries have taken part in its activities, and governments of some countries have provided direct financial support and recognition.

It is too early to assess what will be the effectiveness of the Comité Arctique International in facilitating the planning and coordination of arctic research or improving international arctic cooperation. The Comité has made one serious attempt at assessing arctic scientific priorities and planning an international research program. After reviewing assessments of research needs in many fields of arctic science, a study of the exchange of water mass and energy in the passage between Greenland and Svalbard was chosen as an important research project which would provide a substantive contribution to many other fields of science and also provide information of practical value to the northern resource development activities in both eastern and western hemispheres. It was also a scientific problem that could only be attacked successfully if experts and facilities of several nations were involved. A proposal to study this problem became the Fram Strait Project. After three years of preparation, and the obtaining of considerable support from four countries, it became apparent that it would not be possible to secure adequate financial commitment to enable the proposed seven-year study to take place. So the Project was terminated. Although the Fram Strait Project was not carried out, the Comité Arctique International appears to have played a useful role in coordinating the planning of a major arctic scientific initiative, and in facilitating international consideration of its merits and practicability. The future activities of the Comité in the research area, as well as its already established role in organizing international conferences and providing contacts and information, will be watched with interest.

Many of the attempts that have been made to achieve international planning and coordination of research have been very successful in producing a coordinated or integrated scientific plan in which specialists from each country are to play mutually supportive roles, and in which it is proposed that optimum use be made of the special facilities or equipment of various countries. But it has frequently been the experience that, even though it has been agreed by the authorities that the project is very important from the standpoint of science and the interests of different countries, and although the project may be practical from an operational aspect, it has not been possible to put the international plan into operation because of the need to get favourable decisions, individually but all at about the same time, from science support agencies in different countries, when each of those agencies has different science and policy priorities.

The problem of getting coordinated decisions from support agencies in different countries for an international scientific activity has been particularly difficult with regard to oceanographic research in sub-arctic and arctic waters. A number of major research studies in the Arctic Oceans and northernmost Atlantic will come to mind — CAGE and JASIN in the more temperate parts, Greenland Sea Project, MIZEX, Fram Strait Project, the FRAM programs, Nansen Drift Station proposal, and others as one goes farther north. Each of these had effective international input into the scientific planning, but each, for its execution, depended upon independent but simultaneous favourable decisions or commitments from national agencies in three to five countries to provide research ships, special aircraft, or other support according to a schedule that sometimes had to be decided several years in advance. This was very difficult for the support agencies who also had to meet their own national responsibilities and commitments to other priorities. And there was no doubt that those promoting particular arctic research programs were tempted to play one support agency against another.

As a result of this situation, the need for a more senior-level mechanism to provide international review of proposals for arctic oceanographic research programs had been recognized for some time. After several years of discussion and a couple of preliminary meetings, in May 1984, a body was formed known as the *Arctic Ocean Sciences Board.* Members of the Board are not scientific researchers as such but representatives of principal institutions or national organizations supporting arctic ocean sciences. At present, Canada, Denmark, Federal Republic of Germany, Iceland, Norway, and USA are represented on the Board. The formal objective of the Arctic Ocean Sciences Board is:

> "to advance scientific knowledge of the Arctic Ocean and adjacent seas by bringing together resources into cooperative programs where these are essential to achieve desired scientific objectives."

Note that the emphasis is not on science program planning but on the bringing together of resources — financial, research support, and scientific. The Board will develop working arrangements with established scientific oceanographic organizations, and intends to provide a means for international scrutiny, development, and support decisions on proposals and plans for scientific study of arctic oceanic areas.

The formation of the Arctic Ocean Sciences Board is a very interesting development in the complex story of mechanisms to achieve international coordination and cooperation in arctic science. In some ways, it has a structure, protocol, and potential influence similar to that of the original International Polar Commission of 1879. Whether it will be able to achieve its intended purposes, and whether it will prove useful only for subject areas such as international oceanography which by their nature tend to be "big budget science"; or whether it will be a model for increased international coordination at the support level as well as the scientific level in other subject areas, of course, remains to be seen. But it does appear that in one subject area at least, another significant step has been taken in the organization of international cooperation in arctic science.

Conclusions

The nature and sophistication of arctic research and related scientific activities, and also the mechanisms for its support and management, have changed radically in recent years. These changes have been due to advances in science and knowledge, but equally to evolving national, international, and economic issues affecting the Arctic. In some respects the changes in arctic science have had a character different from the changes that have taken place in science in more temperate latitudes.

The scientific and practical reasons for international cooperation in arctic science are as strong as they ever have been in the past, and perhaps are even stronger as arctic science becomes progressively more integrated with world science as a whole, and as significant arctic studies require information of equal sophistication from circum-arctic regions. At the same time, the increasingly direct linkage between national policies and the support or direction of arctic research in all countries involved in arctic science makes it necessary that international cooperation in arctic science be justified on the basis of the national interests of each cooperating country, as well as being of benefit to science.

The inescapable involvement of arctic science in policy questions in all parts of the Arctic today, no matter how "pure" the science or how modest the program, need not make international cooperation less effective, and in fact may facilitate cooperation.

But it does require greater awareness by scientists of why their research is supported, and more international contact between science support agencies, than perhaps has been usual in the past. Successful international cooperation also requires an awareness of the various kinds of cooperative arrangements that have been found to be successful in arctic areas, with the advantages and problems of each as they apply to a particular kind of study; and a careful selection and use of the mechanisms for achieving participation of scientists and institutions from several nations to their mutual advantage and the general increase of knowledge of the arctic regions.

There are some, perhaps pessimists, who feel that the Golden Age of Science is over. They feel that the spirit of free inquiry, of the unfettered pursuit of knowledge wherever it may lead, with its findings openly available for use by all Mankind, cannot survive in today's nationalistic and competitive world. Whether or not one accepts this judgment, it is undoubtedly true that the role and nature of science itself, and not only the state of knowledge, has changed importantly within the working lifetime of most of the senior scientists living today. This change has been particularly evident in the arctic regions.

The Golden Age, if such it was, of international science lasted just about a century. Its first clear expression came from arctic science. But the principles of international cooperation and open self-examination of scientific information which were developed through arctic science had an effect on the whole world. The polar regions have played a leading role in science because in those regions, physical and biological systems are comparatively simple, interrelationships and the effects of variations are often more clearly apparent, and the linkage between cause and result can often be traced more directly than in other parts of the world where complexity results in fuzziness and the effects are not as dramatic. Thus it is not strange that arctic science has played an important role in developing not only the knowledge and techniques of science, but also its philosophy.

Perhaps the arctic regions can once again lead the way. For not only are relationships between physical and biological phenomena comparatively clear and dramatic in the Arctic, but so are the relationships between science and human affairs. Perhaps arctic research, based in national policies but undertaken in the spirit of free inquiry and international and cooperative in its outlook and practice, can usher in a new era where the sciences are more integrated and closely connected to the major social, economic, and international problems of tomorrow. If this can be done, the Golden Age of Science will not be behind us, but ahead of us.

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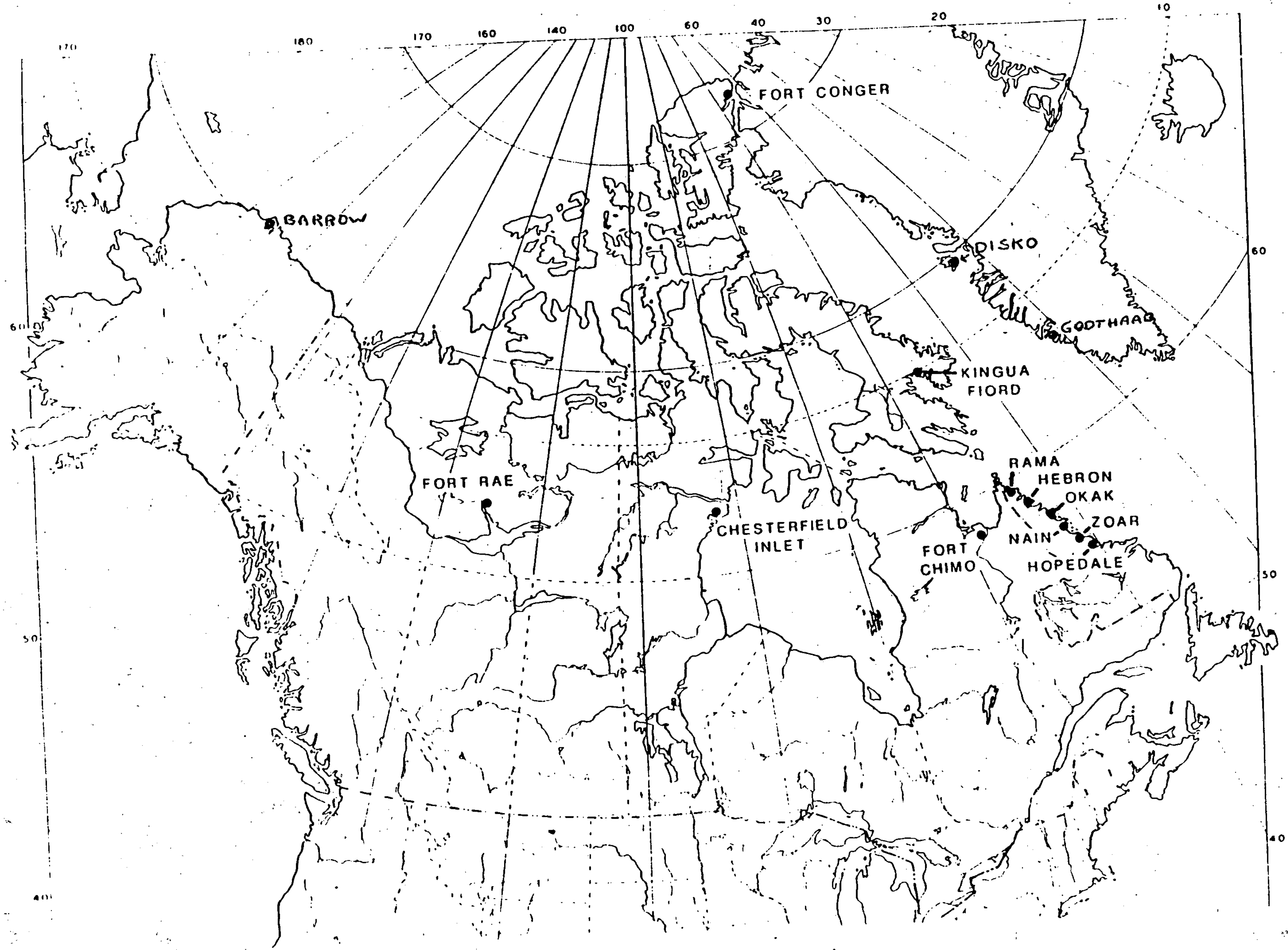

Map showing First and Second International Polar Years localities.

ATTACHMENT No. 2

COOPERATION IN ARCTIC SCIENCE - BACKGROUND AND PROSPECTS

E.F. Roots

Department of the Environment, Canada

Keynote Address to the Meeting on

International Cooperation in Arctic Science

held at
The Royal Swedish Academy of Sciences
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COOPERATION IN ARCTIC SCIENCE- BACKGROUND AND PROSPECTS

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1. Introduction

In nearly every scientific subject or field of activity, careful research and data-gathering in arctic regions has an important international component.

Most science in northern regions today is carried out for domestic or national reasons, even though some is the arctic part of national participation in global or international activities. Nevertheless, it is a characteristic of studies in high latitudes, both in pure science and applied sciences and engineering, that they are in many ways more closely linked to and dependent on scientific activities of other countries in similar latitudes than is the case for most science in temperate and tropical regions. There are many reasons for this; perhaps the principal one is that arctic geophysical and environmental characteristics and processes are distinctive and related on a circumpolar basis, but are in many ways different from those in lower latitudes. Thus, despite strong national interests, scientific activities of all kinds in the arctic, including resource development and environmental studies, take on a "polar" rather than a national character. There is in addition a very important human reason; - the cultures and societies of arctic regions have connections and entities that are not confined to present national boundaries but are boreal or circumpolar in nature, so that any careful study of arctic peoples and their development even within a single nation, has many international aspects. Also, simple polar geography, bringing arctic nations today closer together than many of them felt they were before the advent of modern technology, has led to a shared need for applied and pure sciences connected with circumpolar and trans-polar communications, transportation, weather and space phenomena, and oceanography.

It is obvious that the arctic nations share many problems that require research and scientific data from other arctic regions. In fact, in many fields of study important to arctic countries, there is more in common between the arctic regions of different nations than there is between the arctic and more southerly parts of each respective nation. Therefore, it is no surprise that many arctic countries have taken a similar or common approach to arctic science, and that many arrangements and practices have developed through which countries share or co-operate in arctic scientific work.

Arctic research is difficult, both physically and scientifically or intellectually. It requires specialized techniques and equipment, much of which is of little use in other parts of the world except the Antarctic; and it is very costly, both in money and in terms of the amount of effort and organization that needs to be expended for a given amount of data or new scientific results. But the scientific results of arctic research are increasingly of vital importance, nationally, internationally, and to the northern people themselves.

For all these reasons, there is a strong incentive to achieve increased international and circumpolar co-operation in many fields of arctic science.

Experience has shown, however, that the established mechanisms for international scientific co-operation, which have been developed through the growth and pursuit of modern science in other parts of the world, do not operate very well for achieving cooperation in arctic research. The difficulties are of many kinds - political obstacles, reasons of national policy and differing priorities, problems of cost and availability of research facilities and ice-going research ships, and also reasons related to the nature of modern science itself. During this meeting, we will want to look at some of the scientific and managerial difficulties that stand in the way of effective international arctic scientific co-operation.

Although there have been many examples of effective international co-operation in specific areas of arctic science, the lack of a means to foster continued international communication and co-operation on a broad basis has been seen by many as increasing the cost and decreasing the value of arctic researches and data-gathering in the modern context. The absence of effective international co-operation presents a handicap, especially to the smaller countries, in their pursuit of arctic science and technology. It also makes more difficult the inter-relation between modern science and the contributions that indigenous northern societies can make to the social, cultural and economic development of their respective countries.

A further factor making co-operation in arctic science activities necessary is that the advance of science itself has greatly increased the global and international importance of arctic research. In this context, the value to science of arctic research is measured by its benefit to the whole world, not only by the benefit to the nation where the research was done or who did it. And yet science in the arctic will in nearly every case be undertaken by national agencies, for purposes that are of importance to the sponsoring nation. International co-operation and co-ordination is necessary if separate national studies are, together, to produce scientific results of global importance.

Another important factor that brings us together is that, taken overall, despite its importance to many countries and to world science, arctic research constitutes only a small and specialized fragment of total world research; the volume of science and scientists engaged in arctic studies is just too small to maintain, automatically, the vigorous flow of information, criticism, and interchange of scientists that is essential for healthy scientific progress, using the institutions and mechanisms that are in place for most of world science. Many of us are here today in the conviction that intellectually as well as operationally or managerially, arctic science will benefit if there can be put in place an imaginative yet practical scheme for improving international cooperation.

Therefore, there have been repeated expressions from scientists, from administrators, and from those concerned with arctic policy, of the need for improved co-operation, liaison and communication between arctic countries on topics related to arctic science and research.

It is to discuss how, in the light of these problems and opportunities, we can achieve improved co-operation, liaison and communication in arctic science that we are gathered here today.

2. Historical Setting

The issues of co-operation and sharing of knowledge of arctic regions, of international rivalry and protection, and international schemes for working together, are not new. They have had a long history of ups and downs, and there have been times in the past when those concerned with arctic investigations have faced opportunities and frustrations not unlike some of those that lie before us today. It may be useful to note briefly some incidents in the history of co-operation in arctic investigation and knowledge, as a background to our own discussions.

When, about the year 860 AD, Othere of Halagoland made the first recorded voyage into the Arctic Ocean, and sailed around North Cape "to find what lay beyond the wasteland", he started a pattern of exclusive possession of arctic knowledge and information that has left traces with us today. For several generations, after his first voyage, only Othere's family knew how, or had the right to sail around the Kola Peninsula and into the White Sea and extract tribute from the Finns; although in 895 Othere made a business trip to England to bargain with King Alfred the Great and exchange his secrets of sailing directions to White Sea in return for a portion of trading rights to Britain (Blom, 1984). King Alfred welcomed him but firmly refused. Thus, from an early date, the sharing of arctic scientific and technical knowledge was mixed up with national priorities, international relations, and economics.

The fullest expression of the **Mare Clausem** or closed sea approach to arctic knowledge was seen in the Royal Proclamation, or Bann, issued by the King of Norway in 1294, which forbade any foreign ship to sail north of the latitude of Bergen without the King's permission or the King's emissary on board. The Bann appears to have been surprisingly successful for a couple of centuries; and the main force in ensuring its success appears to have been that the Bergen pilots had exclusive knowledge of how to pass safely through the reefs and whirlpools, and how to avoid the terrifying sea monsters and the threatening mountains of ice that beset the minds and the ships of northern travellers in those days.

Suppressed information will, however, escape; and in 1360 a book was published in Italy entitled "De Inventione Fortunata" that took more than a century to circulate, and then forever altered the international aspect of arctic knowledge. The book was attributed to Nicholas of Linne "a Minorite from Oxford", and bore the sub-title **"qui liber incipit a gradua 54 usque ad polum"** ("which book begins in the description at latitude 54 degrees and goes as far at the Pole"). No copies are known to exist today; but for the next two centuries this book was widely quoted, often at length, and it was the acknowledged source of information about the geography of the arctic ocean region. It was used by cartographers of the day in several countries - Rysch (1508), Mercator (1539, 1569), Ortelius (1570), etc. in compiling national and international maps and atlases. Although the details of the geography, apparently derived from old Scandinavian and British sailors' stories and legends, were in many respects fanciful, the international spread of the information from "De Inventione Fortunata" and many maps that incorporated it were important elements in the development of a uniform geographic information system for all of Europe. From the beginning of the sixteenth century there was developed, in effect, the start of an international arctic data base. Even rival countries and opposing interests worked thereafter from, and added information to, this integrated data base.

In 1494, the Treaty of Tordesillas, given international sanction two years later by a Papal Bull, divided the right of exploration and acquisition of the unknown world into two domains. The portion west of a line 470 leagues west of the Azores was granted to Spain, and all unknown areas east of this line were assigned to Portugal. Although the treaty extended from Pole to Pole, it excluded lands already in possession of a Christian power, and did not prevent northern nations from exploring the coasts of lands that they already claimed (Theutenberg, 1984b). Holland and Britain, and to a lesser extent France, Sweden and Denmark, concentrated their efforts on exploration of the arctic regions, searching for northeast and northwest passages to circumvent the Portugese and Spanish restrictions. The Treaty of Tordesillas thus gave indirectly a strong political incentive, from outside the arctic regions, for the increase of arctic knowledge and to the intentional sharing, even among rival countries and companies, of arctic geographical and technical information (Weber and Roots, in press).

In the enthusiasm that characterized the sixteenth century regarding sharing ideas about arctic regions , not all the information was correct. Christopher Columbus himself subscribed to a then current notion that sea ice could only form near coastlines and could not cover the polar ocean, and in 1500 he wrote to his patron proposing a voyage to China by way of the North Pole. This misconception about sea ice, and the erroneous ideas about Arctic Ocean geography with four central islands and mythical straits joining the North Atlantic and North Pacific that were derived from De Inventione Fortunata, persisted for nearly three centuries and cost many lives and fortunes in failed and tragic expeditions.

The open sharing of arctic scientific information and practical knowledge received a further stimulus when, during the seventeenth century, the concept of **Mare Liberum**, that the world's oceans away from the coastlines were free for access and travel by all countries, came to be generally accepted. Except for the closing of the North Pacific by Russia 1824 - 1870, all countries engaged in arctic science have since followed the principle of "the freedom of the seas" in arctic regions in peacetime, and most information has been freely exchanged. In recent years, however, the principle has been challenged by various mostly unofficial but influential statements of the "sector principle" for the Arctic Ocean (Theutenberg, 1984a). Also, legal jurisdictional issues have arisen in recent years related to use of the sea ice for travel, hunting, and temporary occupancy (Cook and Van Alstine, 1984). Whether these developments will have an influence on the control and exchange of arctic scientific information remains to be seen.

One of the most interesting examples of the tradition and benefits of international co-operation in arctic scientific research is provided by the expedition of Constantine John Phipps in 1775. This was perhaps the first major arctic expedition with scientific research as its primary goal. Because discovery of new lands, a new trade route or other overt national advantage was not its primary purpose, Phipps' expedition has been largely ignored by geographers and historians; but it provides many insights into the differences between scientific research and national exploration in arctic regions. The expedition had a genuine international background. The plan was proposed by the French round-the-world explorer de Bougainville, who presented it to the Academie Royale de Sciences. The French Academy turned it down, so de Bougainville took it to the Royal Society of London, of which he was a member. After considerable discussion and influenced strongly by the urgings of the eminent Swiss geographer Samuel Engel, the Royal Society accepted the proposal for "a voyage made towards the north-pole to be of service to the promotion of natural knowledge" (Royal Society, 1782). In the preparations for this multi-disciplinary expedition, authorities in many fields were consulted throughout the scientific world. A senior scientist and officer of the Royal Society, Joseph Banks, himself went to the Netherlands to interview Dutch sea captains and obtain detailed information on ice conditions and ocean currents north of Svalbard - information which was freely given and which turned out to be quite accurate. Similarly, the results of this scientifically fruitful expedition were reported throughout the specialist scientific literature, and not simply treated as appendices to the story of an exploration. In this instance, at least, international communication on arctic science worked very well.

The clearest expression of the benefits of international co-operation in arctic sciences, and also one of the most successful examples of international scientific co-operation that the world has yet seen, took place a little more than one hundred years ago. Arctic science, and arctic international relations, owe a great debt to Karl Weyprecht. Weyprecht was a physicist and an officer in the Austro-Hungarian navy with special interests in studies of magnetism and the aurora. When co-leader of the German North Polar Expedition of 1872-73 he became convinced that simple geographical exploration should be replaced by international scientific research carried out according to a plan. Weyprecht launched a campaign throughout academies and scientific institutions in Europe, stating that the arctic regions offered opportunities unparalleled anywhere on the planet for scientific studies of the Earth's physical and natural processes. He promoted the concept that co-operation between nations was essential to the successful accomplishment of research in the arctic (Heathcote and Armitage, 1959; Roots, 1984).

Weyprecht made the first strong statements of the need for international co-operation in arctic science. Some of his arguments apply with equal force today. He said:

-- "The Earth should be studied as a planet. National boundaries, and the North Pole itself, have no more and no less significance than any other point on the planet, according to the opportunity they offer for phenomena to be observed."

-- "Science is not a territory for national possession."

-- "Small nations must be able to take part in arctic research."

-- "Uncoordinated observations can have only relative significance"

-- "Scientific knowledge of lasting value can result from coordinated and co-operative studies undertaken according to an agreed plan, with the results of the observations freely shared without discrimination."

Weyprecht's ideas were radical for their time, but persuasive. They gradually become endorsed by leading institutions concerned with the study of natural history and the physical phenomena of the Earth. They led to the creation in 1879 of the International Polar Commission, and then to the International Polar Year, 1882-83.

The International Polar Year was one of the greatest steps forward, in any subject or any part of the world, toward international communication and co-operation in science. Not only did eleven nations sponsoring 14 simultaneous polar research expeditions and 39 permanent observatories in 25 countries co-operate in a detailed circumpolar and global research programme, but the observations and data were reported to a central commission and made available to the whole world. This example also led to broad acceptance that the standards of accuracy and objectivity in science must be set through review by scientific peers and not through political favour or personal prestige. The freeing of scientific results from political influence, which has meant so much for the progress of science for the past one hundred years, has come in important degree through the achievement, by the International Polar Year, of international co-operation in arctic science.

The International Polar Year was followed by a marked advance in world-wide scientific co-operation. Aided by advances in communication technology, geophysical observatories developed global networks of co-ordinated observations, weather observations became synchronized and tidal readings harmonized. Fifty years later, in 1932-33, the Second International Polar Year marked another co-ordinated international study of high-latitude phenomena. Twenty-five years later still, in 1957-58, geophysical sciences were ready to spread the concept of co-ordinated study over the whole world, with the International Geophysical Year, or IGY. IGY was truly global, but paid particular attention to the polar regions, arctic and antarctic, and brought them for the first time into the mainstream of international world science. Many of us here at this meeting took part in the IGY, and I am sure that its success has influenced our subsequent thinking on the needs for and benefits from international co-operation in science. Nowhere was this more evident than in the arctic.

The International Council of Scientific Unions, which was responsible for the organization of the International Geophysical Year, gave careful consideration to the best way to achieve international co-ordination of scientific activities in polar regions. At the 1957 meeting of ICSU in Bruxelles a proposal was made for a scientific committee for arctic and antarctic research - dubbed SCAAR -, which would serve as an international centre for communications and joint planning for arctic and antarctic researches. Several countries were in favour of a SCAAR; but because several northern countries already had institutions concerned with arctic research and were already involved in arctic studies and the need for co-ordinated scientific planning was obviously greatest in the Antarctic, it was agreed to be easier and more logical to form a special committee for the Antarctic first. Therefore in 1958, the Scientific Committee on Antarctic Research (SCAR) was created as a Scientific Committee of ICSU, and has functioned since as a body for international communication and co-ordination of scientific activities in southern polar regions.

3. International Arctic Science Co-operation since the International Geophysical Year

The success of the International Geophysical Year, not only in advancing scientific knowledge but in demonstrating the advantages and feasibility of large-scale international cooperative scientific endeavours, led naturally to a number of somewhat similar programmes in other fields of scientific enquiry. Within a few years, the International Hydrological Decade, the International Biological Programme, the International Upper Mantle Study were under way, each global or planetary in scope but with important specialist attention to the arctic region. Other international programmes were direct offshoots of specific IGY researches, to investigate particular phenomena whose study in different parts of the arctic was essential: - the International Year of the Quiet Sun, and the International Magnetospheric Study are examples.

All of these developments showed the circumpolar unity of arctic science, and the essential linkage between science in the arctic and science in lower latitudes. At this stage, there was little "nationalism" in the leading scientific researches in arctic regions, and indeed in many areas the scientific leadership in arctic research was taken not by scientists from arctic countries but by scientists and institutions who were not from arctic countries but who were leading in global research.

While the large integrated research programmes achieved a remarkable degree of international co-operation and sharing of results related to arctic regions in the period 1958 - 1972, international developments of a different nature also affected science and technology in arctic regions. Advances in communication and instrumentation, and a better understanding of the science involved, led to greatly improved high-latitude circumpolar networks for weather observation and reporting, radio transmission, and magnetic observation. The management and co-ordination of these networks led to the refinement and increased importance of international scientific and technical organizations whose principal role was the co-ordination of technical activities and the exchange of technical information. The importance of international professional organizations in facilitating co-operation of on-going specific technical activities in arctic regions led to a desire in some quarters for an effective international body to enhance co-operation in arctic research in general.

During the same period, developments in three other areas have had a profound effect on the directions taken by international scientific co-operation in the Arctic:-

(i) Advances in technology made the arctic regions, on land, in the sea, and in the air, accessible in a new way. The repercussions of the new technologies were profound. Arctic natural resources (petroleum, metals) became potentially important in world commerce and in geopolitics, and led to new national policies about northern development in most arctic countries. But these developments also led to international or multi-national sharing of many arctic technologies, and to the development of transpolar transportation and communication. The role of arctic regions in defence and military strategy was profoundly changed.

Technological developments have had a mixed effect on arctic science co-operation. Distance and a harsh environment are no longer a barrier to research; but neither do they provide national safety or protection. There is now little exclusiveness in scientific knowledge in arctic regions; rival technologies, both civilian and military, rapidly converge. There is a great increase in shared information, but little systematic way of sharing it. At the present time in all northern countries, most national policies concerning the arctic are based strongly on the state of scientific knowledge and technology, but the knowledge and the development of technology are rarely controlled nationally.

(ii) Environmental concerns have emerged as among the most important arctic issues, politically and with the public. The issues concern both northern residents, and large numbers of people who live in more southerly regions. The concerns are in part economic, in part related to heritage and the need to preserve a vulnerable and valuable land for the future, and in part are related to what arctic regions can tell us about the condition of the planet as a whole. The nature and substance of these concerns depends directly on scientific knowledge and the communication of that knowledge; and on the scientific ability to detect trends and predict changes in the natural environment.

The arctic environment is vulnerable to change, not only from natural causes and activities in the arctic itself, but from causes originating in other parts of the planet. Anticipated changes in climate will be greatest in arctic regions, and will affect the natural environment and renewable resources of arctic regions more than in more southerly latitudes. These questions have obvious international and national dimensions.

Environmental issues are increasingly a part of national policies of all northern countries, but the issues themselves are rarely national; they are mainly circumpolar or world-wide in nature. This situation has resulted in an intensified importance for international co-operation in arctic science.

(iii) Social and political developments in arctic regions have altered the demand for scientific knowledge and exchange of information. The northern regions of all arctic countries have experienced profound socioeconomic and educational changes. The indigenous people, whose culture and heritage are not restricted to national boundaries, have in many parts of the arctic a more circumpolar outlook than most of the public in the countries of which they are citizens. Increasingly, the aspirations and activities of northern peoples focus on the local or practical application of the results of research and technological development, on resource management, environmental protection, the construction of settlements, or the improvement of transportation and public services. The need for incorporation of modern international science into educational programmes in the arctic is widely recognized. Local or national socioeconomic questions increasingly provide policy and economic justification for national investment in arctic science. However, the science undertaken to study these issues must often be international in scope.

4. Mechanisms for Co-operation in Arctic Science

A wide variety of mechanisms and arrangements have been developed in the past three decades to facilitate international co-operation in research, data-gathering, and technological development in arctic regions (Roots, 1984). Some of the more important that should be kept in mind during considerations of what is needed for the future, are noted below:

(i) Multi-lateral intergovernmental agreements. There are few if any multi-national intergovernmental agreements dealing directly with arctic science. Some international treaties and agreements lead directly to shared research; an obvious example is the 1974 International Agreement on the Conservation of Polar Bears. Some other treaties, e.g. the Svalbard Treaty, do not mention science but have been used to open the door to equal access, thereby facilitating international co-operation if the countries concerned wished it.

(ii) Bilateral intergovernmental agreements. There are a large number of bilateral intergovernmental agreements between northern countries, or between arctic countries and non-arctic countries that have arctic interests. Some of these, such as the USSR/Canada Agreement for Co-operation in Science in the Arctic and the North, or a similar agreement between Norway and the USSR, are focussed directly on arctic science. Others, such as the co-operative agreement between the United Kingdom and Canada or that between the USSR and the USA, are broader than the arctic in scope but contain specific clauses dealing with the arctic. The range of subjects covered by these bilateral agreements is very wide, from the upper atmosphere to medicine to environmental protection.

(iii) International Scientific Organizations and Programmes. There are a number of international scientific organizations whose principal purpose is to provide communications and exchange information directly related to arctic science:- the International Union for Circumpolar Health, the International Permafrost Association, the Comité Arctique International, the Arctic Ocean Science Board are examples.

More common, and on the world scene perhaps more influential, are international scientific organizations that are global in scope, but with specific units or programmes dealing with arctic topics. Most of these have a fairly well-defined disciplinary focus, and many represent the arctic component of the global interests of the parent body. Prominent among these are the numerous organizations of the International Council of Scientific Unions. Typical examples from among many such bodies are the International Commission on Polar Meteorology of the International Association of Meteorology and Atmospheric Physics, and the Northern Research Basins Network of the International Association of Hydrological Sciences (both these Associations are components of the International Union of Geodesy and Geophysics); or Working Group 82 of the Scientific Committee on Oceanographic Research, which deals with "Polar Deep Sea Palaeo-environments". Other examples, outside the ICSU family, are the Northern Science Network of the UNESCO Man and the Biosphere Programme, or the Polar Sub-programme of the World Climate Research Programme.

(iv) International participation in nationally-organized arctic research activities. Several of the best examples of international arctic scientific co-operation in recent years have been activities sponsored or organized primarily by one country, but in which scientists or institutions from other countries took part. Well known recent examples of national arctic studies in which scientists from several countries took part include the Swedish YMIR expedition, the Norwegian PRO MARE programme, the U.S. MIZEX and FRAM researches, and the Canadian LOREX and CESAR studies. The success of these studies when they have gone well, and also the great effort required to plan and achieve genuine international co-operation for a single expedition, has been one of the principal motives for the repeated desire that there should be a continuing, formally recognized international mechanism to facilitate co-operation in the future.

5. The Lessons Learned

The different recent examples of international co-operation in arctic science reviewed above, and many others that have been noted and reviewed elsewhere (Roots, 1984), prompt us to ask some searching questions:

- How successful have the present mechanisms for co-operation been?
- How well have they served science?
- How well have they served national interests of the participating countries?
- How well have they served the cause of international relations in general? Has international and multi-national science in the arctic regions been a positive factor, a difficult obstacle, or a passive victim in the development of arctic bi-national and international relations and in

defining the role that the Arctic plays in world issues?

It is necessary to ask these questions and to try to answer them frankly - not all answers will be the same - before considering the questions that have brought us this meeting:-

- <u>Do we need something else?</u>

and then:-

- What can be devised or constructed in the modern context, that can succeed where the present mechanisms have failed to serve either science or national interests?

We are here to search for an international mechanism that would not displace or discredit the various bilateral and specialized arrangements for arctic co-operation that presently exist; that truly represents varied national and international interests and can be supportive of national policies; and which still meets the needs for effective co-ordination of important science and keeps it at arm's length from political interference. To accomplish this will not be easy, but I think that we are all here in the belief that it can be done.

6. Parallel developments

During the past decade, while the various arrangements for international involvement in arctic research programmes referred to above have been evolving, there have been developments in other areas that have a bearing on the need for, and likely political acceptability or scientific usefulness of an international mechanism for arctic scientific co-operation. Some of these may be noted, as background to our discussions:

* Developments in Antarctica related to regimes for resource management (living resources and minerals), tourism, and the challenges in the United Nations General Assembly that the Antarctic Treaty was too "exclusive", have led to much discussion and clarification of the relationship between intergovernmental policy and positions (dealt with through the Treaty) and non-governmental but government-endorsed scientific co-operation (dealt with by SCAR) in polar regions;

* Developments related to international co-operation in studies of the World Ocean and Regional Seas, consequent upon national and international discussions of the ratification of the Third United Nations Convention of the Law of the Sea (UNCLOS III), have similarly had important implications for the relationship between national and international policies and international co-operation in research. Involved in these discussions are not only United Nations bodies dealing with science - UNEP (Regional Seas), UNESCO (Intergovernmental Oceanographic Commission)-, but independent intergovernmental organizations (International Council for the Exploration of the Seas), informal international groups of agencies supporting arctic science (Arctic Ocean Sciences Board), and non-governmental scientific members of the ICSU family (Scientific Committee for Oceanographic Research, and others). Many of the principles and arrangements being developed in these discussions will apply directly to international co-operation in arctic regions of which the Arctic Ocean is a vital and central part. In addition, like the discussions of the co-operation in Antarctica and in space research, the evolving arrangements for co-operative oceanographic research are relevant also in a broader sense in illustrating the problems, trends and possibilities for international co-operation in research in areas that are politically sensitive and of economic and

environmental importance to all nations.

It is very important to ensure that any arrangement for international scientific co-operation in the Arctic, which includes research on the Arctic Ocean, is compatible with arrangements or mechanisms for co-operation in oceanographic research.

* On the social sciences side, important international developments include the influence of the Inuit Circumpolar Conference (ICC) and its growing recognition by governments of several arctic countries as a legitimate voice for the concerns and the knowledge of northern peoples. The ICC has become an active promoter of international scientific research on social issues, history, and heritage, economic planning and arctic political sciences. Its concerns and activities have found support in much of the scientific community and in policies of several arctic nations, and will undoubtedly (some will say belatedly) influence the future character and style of international co-operation in arctic science.

* There is a new wave of global-view scientific programmes, international in nature and participation, that necessarily include the arctic regions as a normal but essential part of their activities. The Geosphere-Biosphere Programme of ICSU, the World Climate Research Programme of the World Meteorological Organization; the World Ocean Circulation Experiment, are examples and there are several others. Such global-scale studies include international co-operation as an essential element, and this must be extended to arctic regions. Any specific mechanism developed for co-operation in arctic science must be compatible with the co-operation necessary for these major global programmes.

* Several countries, including some that do not possess arctic territories (for example, Germany and Japan) have responded to the newly-recognized importance of arctic science and polar sciences generally by revising their policies with regard to the arctic or by strengthening their facilities and resources for arctic research.

Most of the countries represented at this meeting have recently given national attention to the adequacy of arctic science as seen from their own national perspectives. While the emphasis and focus has differed from country to country, one feature that has been common to all has been the recognition that enhanced international co-operation in arctic science is in the national interest of each arctic country. A brief reminder of current and recent developments in our own countries will show that we are all in the same boat in this respect:

Canada - The recently completed study "Canada and Polar Science" stresses the importance of international participation in polar science and the need for Canada to improve its organization.

Denmark - a recent series of studies on the possible need for a Danish Polar Institute lays stress on the need to provide for an international dimension. Also, discussions connected with the establishment of a Greenland University and research centre at Nuuk have been carried on in an international context.

Finland - The creation in November 1987 of a Finnish Polar Committee, whose membership includes persons from ministries concerned with foreign affairs and international trade. The planning for the proposed Arctic Science Centre at Rovaniemi has envisaged participation by foreign scientists as an integral part of its activities.

Norway- Both the parliamentary review of the Norsk Polarinstitutt and the approved programme of the Norwegian Research Council (NAVF) which supports important arctic researches, refer to the essential international nature of Norwegian polar science.

Sweden - The enlarged and supported mandate of the Polar Research Secretariat charges it with maintaining liaison and co-operation with other countries in polar research, and states specifically that "Polar research ... calls for collaboration, often in an international setting".

U.S.A. - The U.S. Arctic Research and Policy Act defines international co-operation in science as one of the goals in arctic research, and charges the U.S. Arctic Research Commission to see that this is accomplished. The U.S. Arctic Research 5-Year Plan includes a section on international co-operation.

U.S.S.R. - In a speech delivered at Murmansk on 1 October, 1987, General Secretary of the CPSU, M. Gorbachev stressed the importance of international co-operation and arctic science, and referred to it again during the Washington Summit meeting on 13 January, 1988.

7. An "Arctic SCAR"?

The most common question that is raised in discussions of the feasibility of establishing a comprehensive and multi-nation circumpolar arrangement for improving scientific co-operation is: "Why cannot we establish an arctic equivalent to SCAR?" In my own experience, such a suggestion has been put forward at about five-year intervals since 1960.

A little reflection and examination has nearly always led to the conclusion that, at least in recent decades, the geophysical, national policy, and research support situation in the Arctic is sufficiently different from that of the Antarctic that an international committee patterned directly after SCAR does not seen feasible for the Arctic, unless (which has seemed politically most unlikely) there was an intergovernmental political instrument equivalent to the Antarctic Treaty that could provide some sort of policy umbrella. (We should recall, however, that SCAR was established as a non-governmental international scientific body of ICSU before the Antarctic Treaty came into existence; and so initially it did not have the benefit of the Treaty to help keep it clear from policy entanglements.)

In full realization of the different situation in the Antarctic and the Arctic, a number of serious proposals nevertheless have been made recently to re-examine the question of whether an "arctic SCAR", in the ICSU sense would be useful and feasible. In 1986, during the SCAR Meeting in San Diego, U.S.A., an informal meeting was chaired by Dr. Zumberge, who is with us today and who was at that time simultaneously the chairman of SCAR and the chairman of the U.S. Arctic Research Commission, to reconsider this question. Representatives of several countries at that meeting felt that the time was propitious, in the light both of the international political situation in the Arctic and the needs of science; and it was decided to explore the issue further.

8. Preparation for the Oslo Meeting

The Norsk Polarinstitutt in Oslo offered to host an informal meeting of persons from arctic nations who were familiar with the complex history of scientific co-operation in the arctic and with national policies and international relations, to discuss the feasibility of a new and forward-looking mechanism for international co-operation that would take into account modern realities. The undersigned was asked to prepare a discussion paper for the meeting; Mr. Rogne commented on it and graciously consented to let his name be attached to it.

In our review of the points to be taken into consideration with regard to the need for feasibility of and possible role of a mechanism for improving international co-operation in arctic science (Roots and Rogne, 1987), we stressed the following (I have re-worded some of these in the anticipation of our forthcoming discussion):-

(i) Caution - It was important not to become carried away with the enthusiasm of the moment, and to avoid making a decision that a new international arctic science committee is needed and feasible, before looking carefully at all the angles and implications. With such a rich history of attempted and occasionally successful examples of co-operation in the past, why is something new needed and why have the previous attempts not developed into a lasting mechanism?

(ii) Issues - We identified four main issues that had to be dealt with:

(a) different countries have different domestic priorities and different international priorities, and all had a science component;

(b) the arctic interests of arctic states often differed from the arctic interests of non-arctic states, and this influenced their approach to arctic science; - yet the scientific knowledge base was for the most part shared and non-national;

(c) to an increasing extent, in several countries, the kinds of scientific information most needed by government or industry on a short term calls for research quite different from the research that is most important from the point of view of major scientific questions in the arctic, or the needs of world science. The degree of desired international involvement and collaboration may also differ.

(d) the level of scientific or political authority at which international co-operation is most effectively organized needs to be carefully considered - (scientist-to-scientist, institution-to-institution,programme-to-programme,government-to-government).The problem will be to retain desired flexibility and yet have sufficient control and influence to achieve true co-ordination.

(iii) Comparison with the Antarctic - In the Antarctic, the continued success of international co-operation in research is facilitated by the clean separation of political and policy issues from the issues of science (Polar Research Board, 1986). Is this same separation possible or desirable in the Arctic? If not, to what degree is the SCAR model appropriate for the Arctic today?

(iv) Recent experiences - What lessons can be learned from the experiences of different organizations that have been involved in international scientific arctic activities, in planning, evaluation, operation or communication? Among the most valuable are:

- Comité Arctique International
- Arctic Ocean Science Board
- Committee for High Arctic Research Liaison and Information Exchange (CHARLIE)
- Man and the Biosphere Northern Science Network

- Polar related ICSU bodies.

(v) "Sticky" problems - that are not major conceptual issues but which will have to be dealt with, or they may become major obstacles:

(a) What countries will be included? What will be the "qualifications" for membership?

(b) How will a balance be kept between "big science" (the global and regional programmes), "modest science" (the facilitation of co-operation or teamwork between individual scientists or universities on small projects) and "national science" (mission-oriented science according to national priorities)? Is a "balance" necessary or desirable?

(c) How will the desired range of disciplines or subject areas be enhanced through international co-operation? In particular, how will the mechanism promote or achieve co-operation in the area of human and social sciences?

(d) Will the mechanism facilitate the arctic component of international global scientific programmes? If so, will there be a risk of conflict of interests and procedures?

(e) How will the mechanism deal with commercial science and military science, much of which is already characterized by co-operative participation, but not on the same open terms as public science?

The paper made some suggestions, that are repeated here, because I believe that they are relevant to our present discussion:

(i) To achieve effective international co-operation in arctic science, it is necessary that there be continuing consultation or communication at various levels:-

- between scientists;
- between science managers and administrators;
- between ministries or those responsible for arctic policies.

How, and whether, to bring these together or keep them separate will determine the nature and the success of any international arctic science committee.

(ii) Any body or mechanism created to facilitate international co-operation in arctic science must support, and not weaken or supplant, the bi-lateral and multi-lateral mechanisms already in place.

(iii) The practical results of an international co-operation mechanism will depend upon the resources and interest that can be sustained. Therefore, the question of continued support must be carefully considered before any decision is made to form a new body.

(iv) Full co-operation or partnership between all circumpolar countries in any field of research is at this time an unrealistic expectation. It is necessary to start with practical goals in a few areas, where there is already circumpolar agreement.

(v) Despite its complex ramifications, the idea of a means to achieve improved international co-operation in arctic science needs to have a simple and clear description and identity, so that it can be widely discussed in all northern countries, before there is commitment to its establishment.

9. The Meeting in Oslo

The meeting held in Oslo on 13 February, 1987 was an historic one. It was the first time that senior people from all countries with territories north of the Arctic Circle had come together expressly to discuss co-operation in science.

After discussion of many of the points noted above, the meeting concluded:

- that there is a firm consensus of a definite need for an international organization or body devoted to facilitating international co-operation in science in the arctic;
- that it was premature to decide on a specific organization. The organization would have to be carefully planned and structured to avoid pitfalls;
- that any structure formed must have continuity and reasonable hope for a long life. Eventual association with ICSU would appear to give it the best chance of survival;
- that it should focus on science and not be a creature of political agencies. However, there must be parallel or supporting political understanding, communication, and policy guidance. Scientific co-operation in the arctic cannot be expected to last if it is superimposed upon, or if it must weave its way between, the present haphazard intergovernmental contacts on arctic matters;
- that a successful organization for international co-operation in the arctic will be a union of organizations or nationally representative institutions, not of individuals.

At the close of the Oslo meeting, a working group comprising O. Rogne, J. Taagholt and E.F. Roots was appointed to draft a proposal embodying the above conclusions. Sweden offered to host a subsequent meeting to discuss this proposal.

The Working Group immediately determined that it was competent and authorized to make a proposal for a purely scientific body only, and that it was not authorized to consider policy matters. It could make tentative suggestions only, to policy authorities, on matters related to policy aspects of scientific co-operation.

10. Subsequent Developments

While the Working Group (the RRT Group) was drafting its proposal paper, a number of events occurred that changed the background against which the future need for and prospects of international arctic science co-operation must be discussed. These include:

- submission to the President of the United States of a Five-Year Plan for Arctic

Research, and its subsequent publication;

- establishment on a stronger continuing basis of the Swedish Polar Research Secretariat within the Royal Swedish Academy of Sciences;

- creation of the Finnish Polar Committee, with representatives from 8 government departments and agencies, with responsibilities for co-ordinating Finnish scientific activities in the Antarctic and the Arctic;

- enlargement of the polar research programme of the Federal Republic of Germany;

- acceptance by the Canadian Minister of Indian Affairs and Northern Development of a recommendation to establish a Canadian Polar Science Commission;

- statements at the highest political level, in the USSR, of the importance of arctic research and the need for international co-operation in arctic science;

- establishment of a polar research programme within the European Research Foundation;

- reinvigoration of the Northern Science Network of the UNESCO Man and the Biosphere Programme;

- organization, within the developing International Geosphere-Biosphere Programme of ICSU, of **ad hoc** international bodies giving specific attention to plans for research in the arctic;

- specific focus on high latitude phenomena and research by international bodies (WCRP, UNEP, ICSU) studying climate change and its effects;

- confirmation of the global significance of the decrease in stratospheric ozone over the Antarctic, and concern whether a similar phenomenon was occurring in the Arctic, bringing sophisticated polar science into the forefront of international political and environmental issues;

- re-organization of major science programmes in the U.S. and elsewhere to provide "global" science mandates (Global Geosciences; Earth System Sciences; Interdisciplinary Earth Studies) that include arctic regions;

- establishment of programmes of Long-Term Ecological Research and Biogeophysical Observatories that will obtain sophisticated reliable information on what is happening to the Planet over time periods of decades to centuries. Such programmes are necessarily international, and global in scope, including the Arctic. Because the arctic regions are sensitive to change, and because changes in high latitudes have important global effects, particular attention in these studies is being devoted to arctic research;

- release of the report of the United Nations World Commission on Environment and Development, which draws attention to the need for international co-operation and sharing of knowledge from all parts of the Planet, and to the need for use of international scientific knowledge to protect the world environment and the indigenous societies that live in the harsher, less populated parts of the world.

It is against this dynamically changing background of arctic science and world concerns that the RRT group develped its paper on "International Communication and Co-ordination in Arctic Science - A Proposal for Action". The paper was distributed on 17 November 1987. It is against this background also that the Royal Swedish Academy of Sciences has invited us here, as an informal group of scientists from arctic nations, to discuss the proposal.

Mr. Rogne will outline the proposal. Thank you.

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ATTACHMENT No. 3

МЕЖДУНАРОДНАЯ
КОНФЕРЕНЦИЯ
ПО КООРДИНАЦИИ
НАУЧНЫХ
ИССЛЕДОВАНИЙ
В АРКТИКЕ

CONFERENCE

OF ARCTIC COUNTRIES ON COORDINATION OF RESEARCH IN THE ARCTIC

(Leningrad, December 12-15,1988)

GENERAL SUMMARY

THE CONFERENCE OF ARCTIC COUNTRIES ON COORDINATION OF RESEARCH IN THE ARCTIC (LENINGRAD, DECEMBER 12-15,1988)

The Conference of Arctic Countries on Coordination of Research in the Arctic held from December 12 to 15, 1988 in Leningrad, as suggested by M.S.Gorbachev in his speech in Murmansk, considered a wide range of scientific questions concerning this region. The research on the Arctic serve to enhance understandings of a number of fundamental problems of geosphere, biosphere and the near space. Considerable renewable and non-renewable resources are concentrate in the Arctic. At the same time Arctic regions are extremely sensitive environments, so when using them we must be very careful. Consideration should also be given to the interests of population living there.

In the Arctic, the interests of different countries are closely interrelated. The Conference reinforced the need to strengthen mutually beneficial international cooperation and coordination of the activity of different countries in the matter of studying the natural environment, hydrometeorological processes and climatic changes, as well as for developing the region's resources, providing for its balanced economic development and creating a system of international ecological safety.

Scientific studies in the Arctic have been carried out over a long period of time and produced substantial results. This Conference in Leningrad is one more important step in improving cooperation and strengthening communication among scientists and specialists of different countries. It provided a favourable forum to explore further joint research opportunities and promoted a better understanding of the important tasks of socio-economic and cultural development of the indigenous peoples of the Arctic region. At the Plenary Sessions, at the Sessions of six Sections, and during Round Table discussions, the participants of the Conference had a fruitful exchange of ideas on a wide complex of arctic problems. Special attention was paid to the prospects and forms of international cooperation in research concerned with the Arctic. The following fields of international cooperation in the Arctic research are recommended as realistic by the Conference:

Upper atmosphere and near space:

- the study of the influence of changes in Solar activity on terrestrial processes and the improvement of methods for forecasting these changes by means of a further development of observations within the frameworks of coordinated programmes;
-the working out of methods for diagnosing space perturbations in the areas of cusp, auroral oval and Polar cap with the use of rocket, air-borne and onland observations coordinated with satellite missions.
- the definition of the physical and chemical regime of ionosphere and of middle atmosphere and of changes in the content of ozone and minor constituents during the expected intense solar maximum in the early 1990s.

Arctic ecosystems:

- the study of adaptations of organisms to the conditions of high latitudes, of the structure, functioning, natural dynamics and anthropogenic transformation of terrestrial and marine ecosystems;
- the study of evolution of biocenoses and paleoecology and the biogeographical regionalization of the Arctic region;
- the study of the biological diversity on population, species and ecosystems levels, the creation of cadasters and of the "Red Book" of plants, animals and ecosystems of the Arctic;
- the study of regularities in population dynamics, changes of numbers and migrations of marine and terrestrial mammals and birds, of biological processes on the shelves of seas and of possibilities for creating mariculture;
- the working out of recommendations on the rational use, renewal and protection of biological resources, as well as of approaches towards optimisation of the network of protected areas and principles of ecological monitoring.

Interaction between ocean and atmosphere; Arctic climate change

- the study of energy and mass exchanges between ocean and atmosphere and of its role in the formation of the global climate;
- the working out of mathematical models of "air-sea-ice interaction";
- the study of the physics of climate froming processes, applied aspects of climate, thermodynamic processes, circulation of atmosphere, ice and Polar waters, water and ice exchange of the Polar Ocean with the adjacent oceans;

- the creation of a system of monitoring of Polar atmosphere, ocean and sea ice, including observations from sputniks, drifing stations, automatic drifting buoys and other observation platforms

Geology, geocryology and glaciology:

- the working out of a geodynamic scheme of the Arctic with the account of the drift of lithospheric plates and stratigraphy of the sedimentation mantle;
- the study of the deep structure of the Earth's crust under the bottom of the Polar Ocean;
- the creation of a model of the oceanic lithosphere's evolution;
- the study of natural hydrocarbon gases;
- the clearing up of the conditions of existence, temperature regime and fluctuations of permafrost in the Arctic;
- the reconstruction of the glacial and climatic history of the Arctic for the last glacial-interglacial cycle, including deep drilling through the inland ice sheets;
- the carrying out of coordinated observations of the mass balance and fluctuation of existing glaciers.

Environmental conservation:

- the study of the pollution of air, water and land in the Arctic and of the processes of pollutants transfer and transfromation and the creation of corresponding models;
- the study of ecological consequences of the impact of toxic substances and of oil spills in the ocean; the estimation of an assimilation capacity of Arctic ecosystems;
- the study of exchange of hydrochemical elements and pollutants between the Polar Ocean and the adjacent oceans;
- the development of joint programmes of monitoring and simulation for the study of distribution of Arctic ozone, Arctic haze, chlorinated hydrocarbons and other trace components;
- the working out recommendations on the weakening of anthropogenic impacts when developing natural resources and rehabilitating disturbed ecosystems of the Arctic.

Socio-economic, educational and cultural problems of the indigenous peoples of the North; the problems of Polar medicine

- the study of the cultures of northern peoples, their history and development, especially under the present-day conditions of the growing inter-regional and international economic, educational, and cultural interaction;

- the study of medical-demographic and genetic aspects of the health of both indigenous and non-indigenous population of the North;
- the definition of a rational combination of modern and traditional sectors of the economy;
- socio-economic problems of non-indigenous population of the North
- the improvement of the methods for designing and constructing residential and industrial buildings in the North;
- the creation and introduction of machinery, materials, and technologies adapted to the northern conditions;
- the study of long-term development of the North and Arctic under the conditions of growing complexity of economic and ecological situation.

The above fields of international cooperation in the Arctic are presented in more detail in recommendations worked out by the Conference Sections.

The Conference considers very important the exchange of ideas about the role of Arctic research in different global programmes (The International Geosphere-Biosphere Programme, the UNESCO "Man and Biosphere" Programme, the World Climate Programme, the Solar Terrestrial Energy Programme,etc.), which helped reveal general approaches and create prerequisites for further joint action in different fields of international cooperation in the Arctic. The Conference supported the idea of creation of the International Arctic Science Committee, which is called for to become a vital and active body in the field of coordination of research on the Arctic,of organization of joint work and exchange of the results of research.

The success of the Leningrad Conference demonstrated that important positive changes inthe international situation have recently occurred, which open increased prospects for international cooperation in the Arctic. The participants of the Conference noted the strengthening of the links between scientists and their important contribution to the solution of Arctic research issues that range from the natural sciences to economic, social, educational, medicinal,and cultural ones. The Conference provided a unique opportunity to promote and enhance understanding between countries, which should strengthen peace and international security.

This Conference is the first forum on such a wide scale and broadness of scope of scientific problems. Over 500 scientists and specialists from Arctic and non-Arctic countries took part in the Conference. Its work was carried out in a friendly atmosphere and all the questions were considered without prejudices in the spirit of new thinking. Another achievement of the Conference was the establishment and broadening of personal contacts among the participants and acquaintance of many of them with the activity of Leningrad scientific institutions. The participants of the Conference believe it expedient to hold such Conferences in future on a regular basis and hopefully under the International Arctic Science Committee.

FOREIGN MINISTRY OF FINLAND

ATTACHMENT No. 4

WORKING PAPER

1. The ecosystem of the Arctic is very fragile. Due to the extreme climatic and ecological conditions the flora and the micro-organisms in this area can only very slowly be renewed or - after disturbances of the arctic equilibrium - be revived. The adverse impact of human activities has, however, considerably increased in the Arctic, especially during this decade, so that the area has become exposed to danger. No comprehensive protection measures have been undertaken so far to safeguard the natural heritage of arctic resources. Therefore, the Government of Finland is convinced that urgent measures to protect the Arctic environment are necessary in the nearest future.

2. The most important threats to the Arctic environment today are constituted by climate change, pollution of the marine environment and exploitation of living and non-renewable resources. These threats have a direct impact on the well-being, traditions and cultures of the Arctic peoples.

The consequenses of the climate change to the Arctic environment need to be acknowledged. The emissions of certain air-polluting compounds releas ed from the territories of the States boardering the Arctic evidently have adverse effects on this region. In addition, long-range transboundary air pollution poses an increasing risk both to the land and sea areas in the Arctic.

The ecological equilibrium, resources and legitimate uses of the marine and coastal environment are threatened by pollution and by insufficient integration of environmental concerns into the development process. Effective measures are needed to enhance protection of the Arctic sea areas and to prevent them from pollution caused by shipping, oil and gas drilling, mining and from pollution from land-based sources including rivers, estuaries, outfalls and pipelines. Attention should also be paid to pollution caused by dumping of wastes and other matter into the sea and to the protection of polynyas where both human activities and wildlife are concentrated. A particular problem is caused by pollutants transported along sea currents from the Atlantic and the Pacific ocean.

The value of the arctic living resources needs to be acknowledged. It is therefore important to seek to ensure that resource development shall be in harmony with the maintenance of the unique environmental quality of the region and the evolving principles of sustained resource management.

The development of the arctic living resources should be based on the principles of the World Conservation Strategy.

It is important to include in the protection programme of the living resources both marine, coastal and archipelagic ecosystems, ecosystems in estuaries, mountains as well as tundra and north boreal forests including peat bogs.

The whole Arctic region could also be affected by radioactive contamination caused by emissions from nuclear power plants, nuclear fuelled vessels or reprocessing plant or by nuclear accidents.

3. Effective protection of the Arctic region requires development of intergovernmental co-operation, scientific research and monitoring of the ecosystems of the Arctic region. It is important to further develop and implement scientific programmes as well as to co-operate with the relevant existing scientific organisations. The Arctic States should facilitate the conduct of scientific activities in the Arctic, and coordinate their scientific work.

Specific intergovernmental measures should be undertaken for the establishment of criteria and standards concerning human activities having an impact on Arctic environment. Furthermore, effective notification and consultations systems should be developed for dealing with situations where the marine environment is in imminent danger of being damaged by pollution.

4. Existing multilateral and bilateral agreements which have a bearing on human activities having an impact on the Arctic environment may be grouped into four.

First, there is a group of global conventions which are applicable in respect of the Arctic. These include the four Conventions on the law of the sea of 1958, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention, 1972), the Convention for the Prevention of Pollution from Ships (MARPOL and MARPOL Prot. 1973), the Convention on the Law of the Sea (Montego Bay, 1982, not yet in force) and the Vienna Convention for the Protection of the Ozone Layer (1986).

Second, a group of regional Conventions regulate activities with an impact on the Arctic. These include the Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft (Oslo Convention, 1972), the Convention for the Prevention of Marine Pollution from Land-Based Sources (Paris Convention, 1974) Convention on Protection of the Marine Environment of Baltic Sea Area (The Helsinki Convention, 1974) and the Convention on Long-Range Transboundary Air Pollution (Geneva Convention, 1979).

Third, a group of agreements aim at protecting Arctic Wildlife, namely whales (1946), polar bears (1973) and North-Atlantic seals (1957, 1971).

Fourth, certain agreements regulate fisheries in the North-Atlantic waters. Due to the extension of national jurisdiction, however, these agreements have lost much of their importance.

In conclusion, it can be observed that there exists no comprehensive régime concerning the conduct of human activities having an adverse impact on the Arctic environment or its resources.

5. On the basis of the above the Government of Finland deems it necessary to initiate an intergovernmental process with the view of elaborating coordinated and concerted action for the protection of the Arctic environment. This process could lead, for example, to a declaration, convention or other multilateral arrangement exclusively dedicated to the protection of the environment of the Arctic.

6. Such action should

- be taken by the eight countries which possess sea or land areas north of the Polar circle;
- not contradict existing multilateral or bilateral agreements covering human activities affecting this area;
- not affect ongoing negotiations on boundary lines of economic, fishery or other zones in the area or take stand to such negotiations;

On the other hand, such action could, as a first step, include an expression of general, political willingness to undertake concrete measures in protecting the environment of the Arctic.

7. In order to thoroughly address all aspects of a possible international action, the Government of Finland suggests that a Conference on the Protection of the Arctic environment be convened in Helsinki in the near future.

Representatives of Finland will submit this Working Paper to the Ministries for Foreign Affairs of Canada, Denmark, Iceland, Norway, Sweden, the Union of Soviet Socialist Republics and the United States of America. Finland will welcome any opinions and proposals relevant to this matter.

The Government of Finland hopes that its representatives will have an opportunity, in a suitable context later on, to consult with representatives of the Governments of the countries concerned on the opinion of these countries of the idea of arranging such a Conference and of the elements and nature of the final document of the Conference.

The Government of Finland will carefully follow developments in this matter and consider the possibilities of taking further action.

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DOE NORTHERN SCIENCE SEMINAR
JUNE 8-9, 1989
TALKING POINTS FOR FISHERIES AND OCEANS

BY

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1. DFO Mandate on the Arctic.
2. Brief Description of Science Programs by Sector and Institute.
3. Policies and Principles that Guide DFO Science on the Arctic.
4. A Model for Environmental Science in Support of Management Decision Making.
5. A Response Strategy for Future Environmental Uncertainty.
6. References

1. DFO MANDATE ON THE ARCTIC

The Minister of Fisheries and Oceans has legislative responsibility, as established by the Constitution Act, and as outlined in the 1979 Government Organization Act, for:

- sea coast and inland fisheries
- hydrography and marine science
- fishing and recreational harbours
- the coordination of policies and programs for oceans

The Fisheries Act provides the legislative base for the enactment of all regulations governing fisheries in the provinces and territories. The responsibilities of the Minister include the conservation, protection and management of fish and waters frequented by fish, as well as the provision of economic and social benefits to fishermen, industry and Canadians. The direction and extent to which these responsibilities are exercised has been determined by judicial interpretation, by the evolution of public policy, and by agreements with provinces (some provinces have been delegated certain administrative responsibilities, in varying degrees).

The Minister has retained full authority over all fisheries matters in the Yukon, Northwest Territories and Northern Labrador inland, tidal and marine waters. In Northern Quebec, DFO retains responsibility for marine and anadromous fish in marine and tidal waters; administrative responsibility for freshwater fisheries has been delegated to the provincial government. Freshwater fisheries responsibilities have been recently delegated to the Yukon Territorial Government and talks have recently begun with the Government of the Northwest Territories as well.

The Department of Fisheries and Oceans is organized into six sections, each headed by an Assistant Deputy Minister. These are: Science Sector, Atlantic Fisheries Sector (AFS), Pacific and Freshwater Fisheries (P&FF), Policy and Program Planning (P&PP), Corporate and Regulatory Management, and International. Each of these is engaged in Canada-wide activities, and coordination is provided by National Headquarters in Ottawa. National Headquarters as a whole is responsible for policy development, national planning, and the monitoring of program and policy implementation.

There are six regional offices located through Canada to administer fisheries management, research and infrastructure programs. Pacific Region office is located in Vancouver, Central & Arctic Region office is in Winnipeg, Quebec Region office is in Quebec City, Gulf Region office is in Moncton, Scotia-Fundy Region office is in St. John's. With the exception of the Gulf Region, each of these has certain northern interests and responsibilities, administered by Regional offices and various research institutes. The Central and Arctic Region is responsible for NWT fisheries including all territorial waters. Thus, it has the major DFO Arctic responsibilities.

2. DESCRIPTION OF SCIENCE PROGRAMS

The Science Program is divided into biological science, physical and chemical sciences, and hydrography. Biological programs such as ecology, migration patterns and habitat improvement techniques help in the management of fish and marine mammal stocks and habitat. Physical and chemical programs study contaminants and toxicology and help understand our oceans by studying waves, tides, currents, ice, the interaction of sea and air, carbon and oxygen cycles, organic and inorganic materials. The hydrographic program surveys and charts all of Canada's navigable coastal and inland waters, and publishes additional charts and maps for pleasure craft, the fishing industry, national defence and offshore exploration.

Basic and applied Arctic science activities are carried out from several different research laboratories. The laboratories are multi-disciplinary and work on many aspects of fisheries and oceanography as well as Arctic problems. The following sections describe some of the activities of the major laboratories involved in Arctic fisheries and oceanographic research.

Institute of Ocean Sciences - (PACIFIC REGION)

The Institute of Ocean Sciences (IOS) is located at Sidney, British Columbia. Marine scientists at IOS concentrate their efforts on the coastal waters of British Columbia, the North Pacific Ocean and the western Canadian Arctic, where particular emphasis is given to the Beaufort Sea. Work is also undertaken towards the definition of engineering and design criteria to ensure safe operations in the Arctic environment. Current Arctic studies have been designed to help predict ice break up; to measure ocean currents; and to estimate ice drag forces.

Freshwater Institute - (CENTRAL AND ARCTIC REGION)

The Freshwater Institute is located in Winnipeg, Manitoba. The Institute is responsible for research relative to freshwater, freshwater fisheries, and Arctic marine fish and mammals and associated ecosystems. Studies are carried out in extensive laboratories at the Institute, as well as in field stations throughout the Arctic. Northern freshwater research has emphasized fish habitat problems such as hydro-electric reservoir development. Research in the Arctic Ocean is currently being undertaken on Arctic char, whitefish, white whales, narwhal, walrus and seal populations throughout the Arctic; on marine and freshwater habitats, especially the ecology of food chain components; and on organic and inorganic contaminants in fish and marine mammals.

Maurice Lamontagne Institute - (QUEBEC REGION)

Inaugurated in June, 1987, the Maurice Lamontagne Institute, located near Mont-Joli, Quebec is the latest Government of Canada organization involved in fisheries and ocean research. It is different from other Departmental institutions because the working language is French. Its research programs include studies on fisheries stock assessment, marine mammals, biological oceanography, fish habitat, chemical oceanography and physical oceanography. The Institute has a satellite laboratory in Montreal, Quebec - the Arctic Biological Station. The Arctic research activities of the Institute covers northern Quebec, and parts of Hudson and James Bays and Foxe Basin.

Bedford Institute of Oceanography - (SCOTIA-FUNDY REGION)

The Bedford Institute of Oceanography (BIO) is located in Dartmouth, Nova Scotia. As one of the world's major oceanographic research institutes, the BIO's mission is to contribute to the knowledge and understanding of the marine environment and its resources, principally those of Canada's Atlantic seaboard and in the eastern Canadian Arctic. Research in fisheries and biological sciences, physical and chemical sciences and hydrography is conducted in support of short as well as long-term projects relating to resource development and environmental management. Areas of study include the impact of airborne pollutants on marine ecosystems; eastern Arctic physical and chemical oceanography; the distribution of sea ice meltwater in the Arctic; and heavy metal contamination of sediments and suspended matter on the Greenland shelf.

Northwest Atlantic Fisheries Center - (NEWFOUNDLAND REGION)

The Northwest Atlantic Fisheries Center (NAFC) is located in St. John's, Newfoundland. The Center's northern responsibilities include the protection, conservation, enhancement, and overall management of fish and marine mammal stocks and habitats of northern Labrador, David Strait, and Baffin Bay. Biological, ecological and stock assessment studies are carried out on groundfish, pelagic species, shellfish, anadromous species, and marine mammals. The information gathered ensures the best current estimate of stock abundance for prediction of yield and setting of quotas.

3. POLICIES AND PRINCIPLES THAT GUIDE DFO SCIENCE IN THE ARCTIC

Canadian Arctic Marine Conservation Strategy

The AMCS is a government wide strategy to "ensure the future health and well-being of Arctic marine ecosystems, thereby enabling Canada to fulfill its national and international responsibilities in the Arctic and provide for the sustained utilization of marine resources, in particular, use by Arctic peoples."

The development of the strategy was initiated in 1984 and a discussion paper was released in 1987. The basic principles are:

- Sovereign Rights
- Conserve and Protect Renewable Resources
- Maintain Essential Ecosystems

- Integrated Management of Renewable and Non-Renewable Resources
- Sustainable Utilization of Resources
- Inuit Rights and Responsibilities
- Knowledge and Understanding
- Consensus Decision Making
- Use Existing Institutions
- International Cooperation

Science serves as the fundamental basis for the formulation of resource management policies, strategies and procedures and will influence significantly the development and implementation of Arctic Marine Conservation. The first implementation strategy of the AMCS is to "plan, develop and coordinate research programs necessary for the development and implementation of policies, strategies and procedures in support of Canada's Arctic Marine Conservation Strategy."

Other implementation strategies of the AMCS are:

- Shared Management

- Integrated Resource Planning and Management
  - Planning and Management
  - Sustainable Development
  - Integrate Renewable and Non-Renewable Resource Developments
  - Environmental Impact Assessments

- Marine Environmental Quality
  - Arctic Marine Environmental Quality
  - Protected Areas

- Public Knowledge

- International Considerations

DFO Arctic Fisheries Principles

The Arctic Fisheries principles apply to all Canadian waters north of 60°N including all of Ungava Bay, Hudson Bay and James Bay and parts of northern Quebec and Labrador. In the East, it applies to all marine waters north of the NAFO 2J Divisional boundary (northern) to the 200 mile limit north along and the boundary between Canada and Greenland.

The objective of the principles is to provide for the conservation, development and sustained economic utilization of Canada's Arctic fishery resources and their habitats for those who derive their livelihood or benefits from these resources, in particular Arctic peoples.

The principle for science states:

- DFO planning and management decisions for management and protection of fish and marine mammal stocks and their habitats will be on the basis of scientific knowledge, information and understanding, of the highest international standards. In particular:
    - Scientific advice will serve as a basis for the formulation of fisheries management policies, strategies and procedures.
    - A broad program of investigatory activities including qualitative and quantitative assessments and surveys, desk analysis, experimental management and experimental research on fish and marine mammals and their habitats will provide the basis knowledge, data and understanding for planning, and decision-making.
    - DFO will ensure high quality of scientific advice for Arctic resource management decisions through its scientific advisory committees.
    - Local and industry knowledge and experience will form part of the inputs to the ongoing science process.

In summary, the other principles are as follows:

<u>Clients</u>

- DFO will recognize all legitimate users of Arctic fisheries resources and in particular will recognize the special rights and responsibilities for the management and use of traditional fishery resources of northern native people as defined through ongoing constitutional and aboriginal land claims negotiations.

<u>Co-operative Management</u>

- DFO recognizes the importance of increasing the understanding, participation and accountability of client groups, territories and provinces in the management and development of the Arctic fisheries resource.

<u>Fisheries and Habitat Management</u>

- Decisions respecting the management of Arctic fisheries will be guided by resource conservation objectives and will be pursued within a framework of sustained resource utilization.

<u>Integrated Resource Planning</u>

- DFO will participate in and encourage integrated resource planning for management of fish and marine mammal resources and non-renewable resources in the Arctic.

Environmental Quality

- DFO will promote the protection and maintenance of essential ecological components, processes and ecosystems in the Arctic aquatic environment.

Delegation

- DFO supports the federal government priority of devolving certain responsibilities to the territorial governments. DFO will seek agreements that transfer administration of the non-anadromous freshwater fisheries to the governments of Yukon and the Northwest Territories.

International Considerations

- DFO will maintain and promote international cooperation on the conservation of Arctic fisheries resources and their habitat.

Public Knowledge/Communication

- DFO recognizes that awareness of the benefits of fisheries conservation and sustainable use and its relevance, enables policy makers and clients to see the need to achieve conservation objectives. In particular, DFO recognizes the benefits of good communication between the Department and the client groups by exchanging information and promoting understanding of fisheries concepts and management strategies.

Relationship to Other Policies and Priorities

- In the Arctic, DFO will operate in accordance with other relevant governmental and Departmental policies, programs and priorities including (inter alia) delegation to the territorial governments, DFO's Policy for the Management of Fish Habitat, Canada's Oceans Strategy, Canada's Policy for Recreational Fisheries and Canada's Arctic Marine Conservation Strategy.

4. A MODEL FOR ENVIRONMENTAL SCIENCE IN SUPPORT OF MANAGEMENT DECISION MAKING

Setting research priorities for Arctic environmental science is a difficult task. The Westwater Research Center, in Vancouver, (Dorcey and Hall, 1981) has developed an interesting model which has been used to relate ecological research to resource management priorities. Their approach gives directions for future knowledge generating activities.

I will not attempt to describe the process completely but refer those interested to Dorcey and Halls' (1981) report. The following sections basically describe some aspects of the model.

Dorcey and Hall divide the types of information used in resource-management decision-making into "descriptive knowledge" and "functional knowledge". The latter goes beyond description of the elements of the environment to specify the cause-effect relationships between them. Descriptive and functional knowledge can be considered as the two ends of a spectrum of knowledge. The investigatory activities or research used to generate the new knowledge can be categorized and located on this spectrum in positions that reflect their present use in resource management decision making (Figure 1).

The five investigatory activities and examples of specific Arctic environmental projects from DFO are as follows:

Inventory

- Tissues and organs of marine mammals across Arctic analyzed for contaminants
- Test fisheries for Arctic char, scallops, Greenland halibut etc.
- Biological oceanographic survey of Beaufort Sea
- Hydrographic surveys

Monitoring

- Periodic assessments of commercial and recreational char fisheries
- Native harvest studies of fish, whale and seal harvests
- Monitoring of Mackenzie River whitefish and burbot for hydrocarbons
- Annual studies of coastal water chemistry

Desk Analysis

- Contribution to the development of the Mackenzie Delta Beaufort Sea Regional Land Use Plan
- Development of strategies to respond to climate change

Experimental Management

- Analysis of distribution and abundance of seal populations in response to harvesting
- Analysis of response of narwhal and beluga to vessel traffic
- Analysis of growth rates of char, scallops and halibut under fishing pressure
- Effect of artificial islands on ice break-up and movement

Experimental Research

- Biochemical genetic analysis of fish and marine mammals for stock identification
- Investigation of long range transport of air pollutants
- Development of walrus tagging methods
- Investigate the behavior of narwhal using satellite tags

- Methodology for trace metal analysis

Figure 1 illustrates how all management activities are inter-related in the use of knowledge. Dorcey and Hall contend that:

1. "New functional knowledge will only result when the data produced by inventorying and monitoring are used to test an hypothesis.

2. If inventorying and monitoring are not part of a specific experimental design for testing an explicit hypothesis then it will be by chance and good luck that new functional knowledge results.'

In the future if management of the Arctic environment is to be improved it must become more proactive rather than reactive i.e. decision making must be integrated and part of the planning process not ad hoc (Figure 1). Integrated decision-making depends more on functional knowledge then descriptive knowledge. This suggests that future research needs are to the functional end, or right, of the knowledge spectrum and that all research activities should be shifted to the right if management is to become more proactive (Figure 2).

5. A RESPONSE STRATEGY FOR FUTURE ENVIRONMENTAL UNCERTAINTY

The previous section summarizes how investigatory activities in general must be designed to contribute to more functional knowledge if environmental managers are to become more proactive in the future. This section describes a more specific response strategy. It is a strategy for environmental research in response to what is seen as the major environmental problem of the next few decades namely the environmental changes/degradation that will result from long range transport of air pollutants and climate warming as an outcome of increased CO_2 in the atmosphere.

My primary assumption is that both unpredictability and the likelihood of extreme events will increase as the climate changes and atmospheric transport of pollutants increases and the but and most feasible responses of managers to these events are not yet apparent.

An aquatic environmental research program in response to climate change and increased atmospheric contamination should address three issues:

1) management of uncertainty;
2) sensitivity of species and ecosystems to climate change and contaminants; and
3) early detection of pollution and of significant climate change.

During climate transition, as biological communities adjust, uncertainty will increase at all scales from years to centuries. Greatest increases in annual temperature and toxic pollutants are expected to occur in the arctic. Researchers will be trying to model climate responses in a biosphere which is also being subjected to other stresses e.g. decreasing ozone, toxic rain, etc. Such changes will also include the impact of man's response to that climate. Clearly, despite the best efforts, there will be a residual uncertainty, and our ability to respond to and manage that uncertainty may well be the greatest test presented by climate change. To meet it, researchers should explore a range of possible mitigative and adaptive responses, and must not be satisfied with simply offering future scenarios. Fundamental to concern about climate change is our understanding of the sensitivity of organisms, processes and ecosystems to climate. Convincing data, theory, and mitigative and adaptive technologies will have to be produced to effect needed change in our socio-economic policy and planning. These changes will not occur singly or in isolation, and we must recognize this. Researchers will need to factor toxic compounds and decreasing ozone into the assessment of biological effects of climate change. Once aquatic environments are shown to be sensitive to climate, there will be a need to assess and evaluate the risk that fisheries are facing from changes in climate and species composition. These data will indicate what is changing, and how fast it is changing. Flexible risk assessment processes or models should be developed to define the future environmental, economic and social risks and opportunities incumbent in climate predictions. Time series data, monitoring and surveys, coupled with a global and regional ocean monitoring and modelling strategy will be essential for the early detection of climate change. The earliest possible detection of significant climate change will be an important negative feedback into public policy and may induce the behavioral modification required to forestall further change.

In closing, it should be noted that current resource management policies such as the Arctic Marine Conservation Strategy were developed without consideration of the possibility that significant environmental changes will occur. They were developed with the underlying assumption that, in the long term, the environment (and generally the economic and social environment as well) is relatively stable, except for selected interventions such as fishing, hunting, habitat disruptions, etc. With this premise, general environmental policies, as a rule, provide little in the way of explicit guidance for management actions in response to a warming shift in climate and may even specifically prohibit actions that might be desirable as the natural system begins to adapt to climate change. The full process for major conservation policy development could take 15-20 years from initiation to implementation (The Arctic Marine Conservation Policy was initiated in 1980. The first evaluation is not scheduled till 1996). This length of time is similar to the minimum climate time scale required to detect whether change is occurring projected from models. Clearly the time to begin developing new environmental research programs for the Arctic is now not some time in the future.

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IN SUPPORT OF NORTHERN SCIENCE
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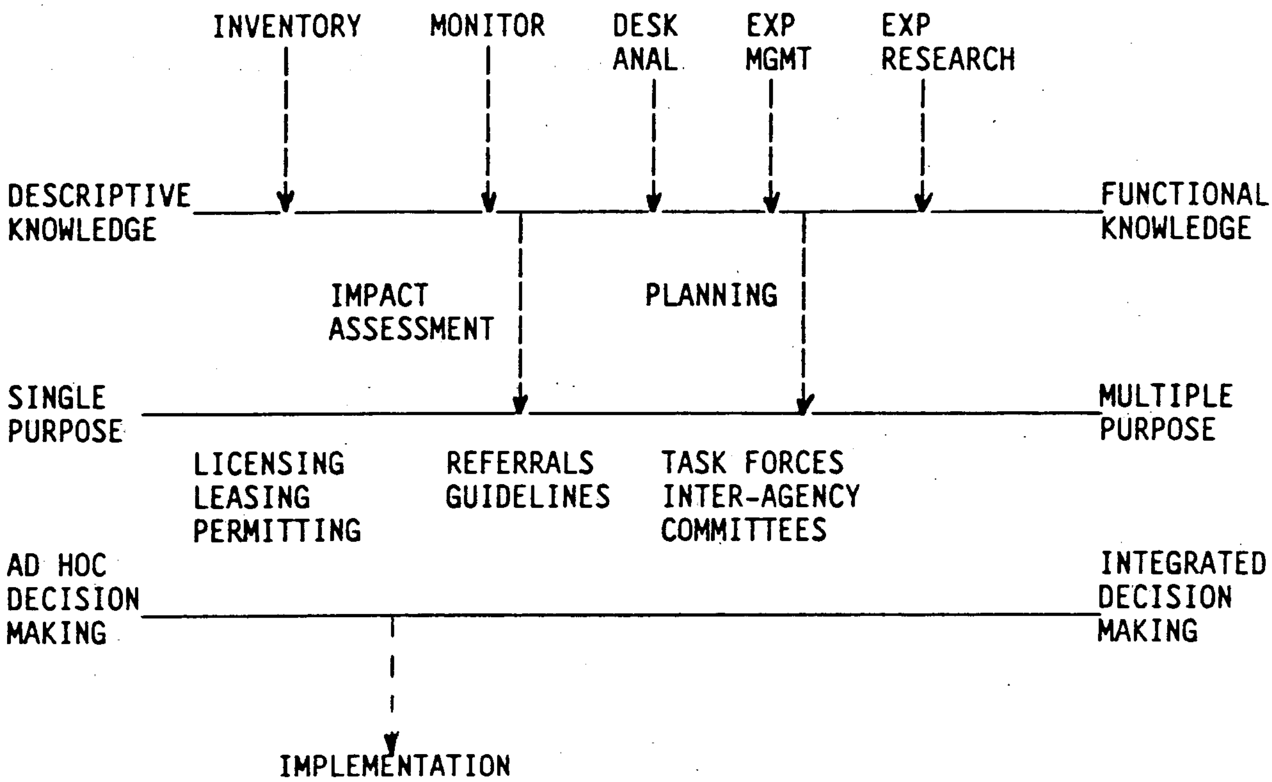

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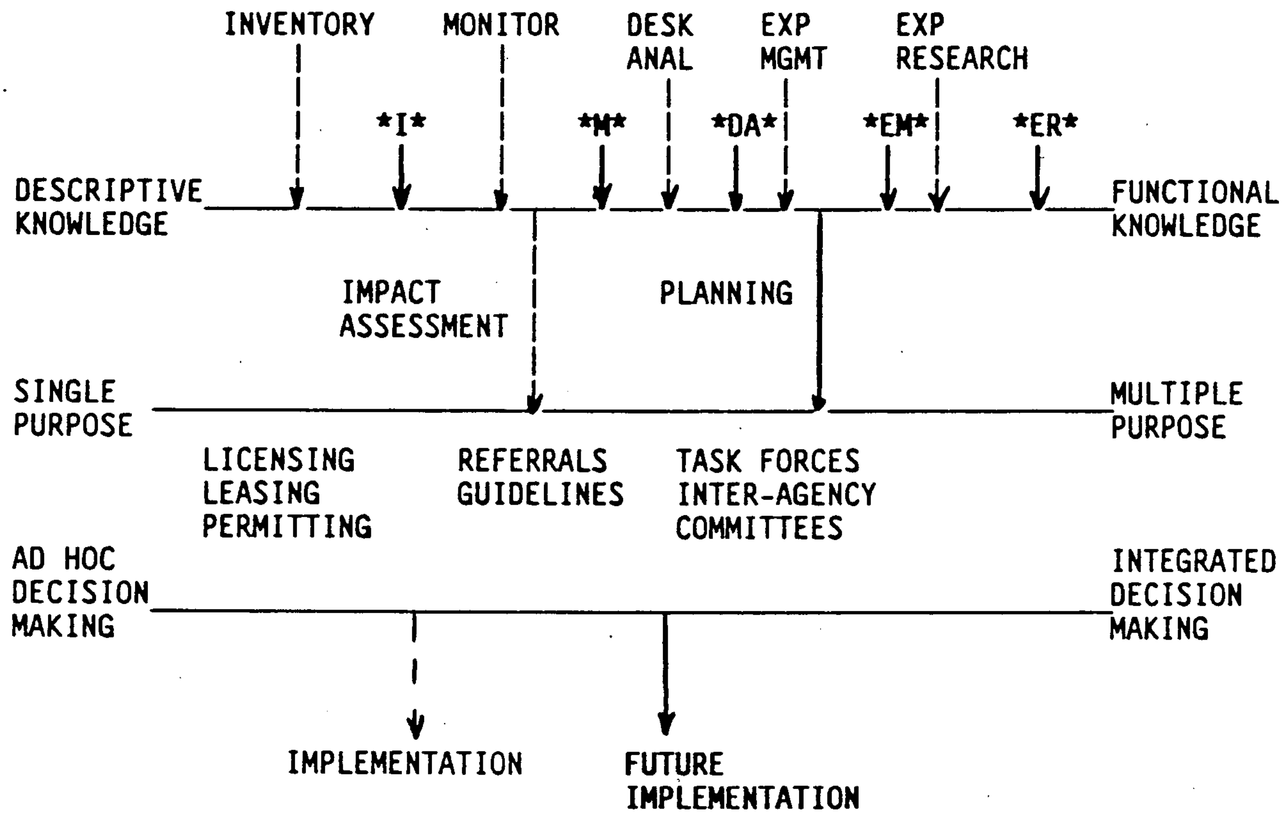
MANAGEMENT DECISION MAKING

FUTURE RESEARCH



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