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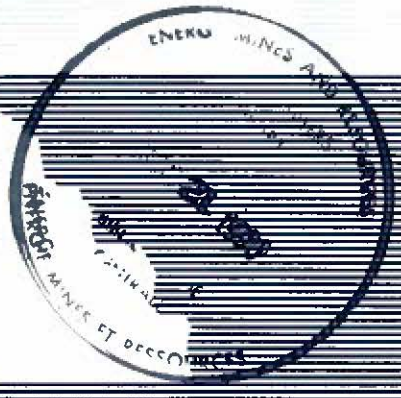
Polar Continental Shelf Project

Titles and Abstracts of Scientific Papers Supported by PCSP

No. 3

compiled by
G.D. Hobson and J. Voyce



1977

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PREFACE

Interest amongst libraries continues at a surprisingly high level for this bibliography through which one may stay abreast of the efforts of many individuals and agencies who conduct natural science research in the Canadian Arctic. There are very few government agencies or Universities (Canadian or foreign) conducting investigations in the natural sciences north of the mainland who do not make use of our facilities and expertise. "You are in good hands with P.C.S.P.!"

Unlike those agencies who can measure their output by the number of maps, papers and bulletins published, or by the number of miles flown or traversed, this publication has developed into one vehicle by which P.C.S.P. output may be perceived or evaluated. We, ourselves, are also convinced of its usefulness if the number of requests received are any indication of the desire by many people to know what is going on in the Arctic in the various disciplines of natural science.

Volume 3 contains 476 new items, at least 90% of which were published in 1975, 1976 and early 1977. This reflects the expanded level of scientific effort in the early and mid 1970's in the Arctic. We continue to solicit your support for this bibliography by asking you to continue passing copies of publications, internal and external, for inclusion in the next volume.

December 1, 1977

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ARCHEOLOGY

0916 APOLLONIO, S. - 1961
Report of the field leader, April-September 1961 in "The Devon Island Expedition"; *Arctic*, vol. 14, no. 4, pp. 253-254.

The main geophysical, glaciological and surveying work was done on a glacier that forms an outlet for the Devon Island ice-cap and enters Jones Sound at about 83°10'W.

In the geophysics program numerous depth and volume determinations were made on the glacier and ice-cap, using an electrical resistance measurement method described in more detail separately.

In August two visiting engineers from the U.S. Army attempted depth measurements on the glacier by a new method using radio altimetry, and the results obtained agreed generally with results obtained by the electrical resistance method.

0917 ARNOLD, C.D. - 1976
Archaeological site survey and excavations on Banks Island, 1976; *Polar Cont. Shelf Proj.*, internal report, 68 p.

A field programme of archaeological research was conducted during the summer of 1976 for the purpose of investigating the nature and extent of Thule Eskimo occupations along the south coast of Banks Island, N.W.T., from the region of the Masik River in the east to Cape Kellett in the west. Accordingly, a crew of four was put down by helicopter near the mouth of the Masik River on June 20 with the intent of conducting a foot and boat survey northwest along the coast. Plans in this regard were frustrated, however, as the sea ice in the research area failed to go out until the second week in August. A thorough survey of the areas within hiking distance was conducted during this period; the major part of the time, however, was spent excavating a site showing Pre-Dorset cultural affinities which was located a short distance southeast of the Masik River. By August 13 it was possible to resume the survey towards Cape Kellett, although this was effectively brought to a halt just short of Sachs Harbour when a resident of that community swamped his boat, losing much of the field equipment. Fortunately, no injuries were sustained and the loss in terms of excavation data was minimal. This report reflects a preliminary assessment of the data obtained, and as such will hopefully contribute to a more comprehensive understanding of the history and prehistory of Banks Island.

0918 CLARK, D.W. - 1976
A visit to the Engigstciak archaeological site, Northern Yukon Territory; *Polar Cont. Shelf Proj.*, internal report, 29 p.

During the late winter and spring months of 1976 the writer began to re-examine the collections from the Engigstciak site, NiVk-1, held by the Archaeological Survey of Canada, National Museum of Man (Clark 1976). It became apparent while I was attempting to reseriate them that a visit to the site, with limited test pitting, would be of immense value in helping me to understand and interpret the collections.

These were acquired through initial test pitting in 1954 and large scale excavations in 1955, 1956, and part of 1958 by Richard S. MacNeish (MacNeish 1956, 1959). MacNeish has seriated the collections into nine archaeological phases, some of which are primarily represented elsewhere on the arctic coast.

0919 McGHEE, R. - 1974/75
Late Dorset Art from Dundas Island, Arctic Canada; *FOLK*, vol. 16-17, pp. 133-145.

Dundas Island lies in the heart of the Canadian High Arctic archipelago (76°05'N, 95°W), several hundred kilometers to the northwest of the northern limit of Historic Eskimo occupation. It is a small island, only 10 km across, with barren gravel beaches and rocky hills rising over 200 m above sea level, surrounded by the semi-permanent open water and fog of a polynia in the ice-filled gulf between Grinnell Peninsula and Cornwallis Island. The first Europeans to see the island were probably the members of the doomed Franklin Expedition, who navigated this area during the summer of 1845. Some three or four centuries earlier the area was briefly occupied by Thule culture whale hunters, the remains of whose winter villages have been found on the adjacent shore of Grinnell Peninsula, but no traces of Thule settlement have yet been found on Dundas Island.

0920 McGHEE, R. - 1976
Archaeological excavations at Porden Point, Port Refuge and Brooman Point (Summer 1976); *Archaeological Surv. Can.*, internal report, 17 p.

The Queen Elizabeth Islands of Canada's high Arctic were beyond the age of Historic Inuit occupation, yet archaeological remains indicate that these far northern islands have been occupied at various times during the past 4000 years. The 1976 field season was an extension of work begun in 1972 and 1974, designed to trace the history of these early human occupations, and to assess their relationships to environmental changes over the past 4000 years.

0921 McGHEE, R. - 1976
Archaeological survey of Polar Bear Pass, Central Bathurst Island (Summer 1976); *Archaeological Surv. Can.*, internal report, 10 p.

0922 MULLER-BECK, H. - 1976
UMINGMAK - Eine steinzeitliche Moschusochsenjagerstation im Arktischen Archipel; *Antike Welt*, 7 Jahrg. 1976 Hef 4, pp. 40-47.
A stone age Muskox - hunting station in the Arctic Archipelago; *Antique World*, 7th year, 1976 Booklet 4, pp. 40-47.

0923 SNOW, E., BURNIP, M., LANE, P., and PARMENTER, C. - 1977
National Historic Parks and Sites Branch Salvage Archaeology in 1976; *Parks Can.*, Ind. and Northern Affairs, Nat. Historic Parks and Sites Branch Bull. No. 42, January 1977, 18 p.

ARCHEOLOGY

From 13 July to 15 August 1976 a preliminary survey of 12 sites in the Arctic was undertaken by the Historical Resources Impact Assessment Unit of the Archaeological Research Section as a result of reports describing unauthorized artifact removal and the despoilment of sites arising from the recent influx of people into the Arctic. Most of these sites were established by expeditions sent by the British navy during the 19th century to search for the northwest passage between the Atlantic and Pacific oceans. Sites surveyed in the 1976 season were associated with Sir John Franklin's ill-fated 1845 expedition and with the expeditions sent in search of him.

BATHYMETRY

0924 BORNHOLD, B.D., FINLAYSON, N.M., and MONAHAN, D. - 1976
Submerged drainage patterns in Barrow Strait, Canadian Arctic; *Can. J. Earth Sci.*, vol. 13, no. 2, pp. 305-311.

Recent detailed bathymetric maps of Barrow Strait enabled a reconsideration of the Tertiary fluvial erosion model used to account for the physiography of the Canadian Arctic Archipelago. Five distinct drainage basins were distinguished within Barrow Strait, including both dendritic and rectangular drainage patterns. The latter were controlled by normal faults along the Precambrian-Paleozoic contact in Peel Sound and Barrow Strait.

Several changes in the original model are proposed, including the placement of the main east-west drainage divide through Somerset Island and across Barrow Strait and southern Wellington Channel to Devon Island.

BIOLOGY

0925 ADAMS, W.A. - 1975
Light intensity and primary productivity under sea ice containing oil; Beaufort Sea Technical Report No. 29, December 1975, 176 p.

Field and laboratory work undertaken between July, 1974 and November, 1975 is presented. Field work was associated with an experimental discharge of 64 m^3 of crude oil under sea ice in Balaena Bay near the tip of Cape Parry (N70°02', W124°54'). The penetration of solar radiation through the water column was measured prior to freeze up in 1974 and below the ice cover during the spring melt period until open water in 1975. Water quality parameters, primary productivity, and microbiological abundance and identification studies were made on part of the bay exposed to the oil and compared to a control area. The open water in the bay was found to be stratified into a warm salty bottom water layer and a cold fresh upper water layer about 4 m thick in September, 1974. During the spring melt, the stratification was even more pronounced with a cold water mass having a salinity of 30-32 p.p.t. lying below a 2-3 m warmer fresh melt-water ice layer. The high transparency of the water mass in this bay as observed in September 1974, was again found during May and June, 1975, but lower light levels (approximately 50%) were found below the ice containing the entrapped oil. The diffuse attenuation coefficients (400-700 nm) of ice and water were found to be greater in close proximity to the oil discharge. However, despite the lower light levels, the primary productivity, as measured by ^{14}C uptake, was found to be slightly enhanced for stations close to the oil. The abundance and number of genera of phytoplankton (approximately 40) support the ^{14}C uptake results, indicating a slight enhancement of total abundance and a greater variety of genera present in the oil contaminated samples. Minor differences were observed in temperature, salinity and in the chemical analysis of the water below the oil discharge. The oil contaminated area was subjected to a clean-up procedure which involved igniting the oil when it formed pools on the ice surface. The airborne combustion products were observed to contaminate a wide area surrounding the spill. Melt ponds in this large area were found to contain a dense mixed algae population including some blue-green and several macrophytic algae, the latter which are normally attached benthic species. The oil contaminated area was free of ice about ten days prior to the remainder of the bay.

0926 ADAMS, W.A. - 1976
Environmental consequences of light penetration through snow and ice; *Ice*, no. 50, p. 13.

0927 ADDISON, J.A. - 1975
Ecology of collembola at a High Arctic Site, Devon Island, N.W.T.; unpub. Ph.D. Thesis, Univ. Calgary.

The ecology of the collembolan fauna was investigated at 3 sites on the Truelove Lowland, Devon Island, N.W.T. Since *Hypogastrura tullbergi* Schäffer and *Folsomia regularis* Hammer were the two most abundant species on the Truelove Lowland, much of the research centered on these species.

Population densities of Collembola, based on derived means were 4,700 Collembola/m^2 at the Meadow Site, 11,700/m^2 at the Beach Ridge Site, and 14,700/m^2 at the Transition Zone Site. Investigations into the population biology of *Hypogastrura tullbergi* indicated that reproductive activity was confined to a period of 2-3 weeks every season, and that individuals of this species were able to breed in up to 3 different years. Individuals of *Folsomia regularis* and *Hypogastrura tullbergi* were estimated to survive for up to 4 and 5 years respectively, and both species had flexible life cycles.

The most important factors influencing collembolan distribution on Devon Island were humidity and temperature. The macroflora was considered to affect collembolan populations indirectly, by modifying the microclimate.

In laboratory feeding studies, *Hypogastrura tullbergi* showed a clear preference for fungal substrates whereas *Folsomia regularis* selected decomposing organic materials. Analysis of the gut contents of field caught animals indicated that both species ingested mainly organic matter, although fungal materials constituted a higher percentage of the gut contents of *H. tullbergi* than of *F. regularis*. Growth rates of both *H. tullbergi* and *F. regularis* were low, and growth of *H. tullbergi* at field temperatures was found to be limited by diet rather than temperature *per se*. Maximum growth rates of adult individuals of *H. tullbergi* occurred at 10°C. The temperature response of growth rates in juvenile individuals of *H. tullbergi* differed from that of the adults, with juveniles showing measurable increases in weight at 2°C, and maximum growth rates at 15°C instead of 10°C.

At 10°C the respiratory rates of *Hypogastrura tullbergi* (222.7 µl O_2/g dry wt/h) and *Onychiurus groenlandicus* Tullberg (118.7 µl/O_2/g dry wt/h) were lower than those reported for cold-adapted Collembola, but the rate of respiration of *Folsomia regularis* (305 µl O_2/g dry wt/h) indicated some degree of adaptation to cold climates.

The rates of soil metabolism in experimental soil cores under field conditions were generally higher in the presence of Collembola than when these animals were excluded. Different species of Collembola enhanced soil metabolism by different amounts. At high densities in laboratory experiments, Collembola apparently caused a decrease in the rate of organic matter decomposition.

In conclusion, ecological adaptations, and the functional role of Collembola in a High Arctic Ecosystem were discussed.

0928 ADDISON, R.F., and SMITH, T.G. - 1974
Organochlorine residue levels in Arctic ringed seals: variation with age and sex; *OIKOS*, vol. 25, pp. 335-337.

Residues of p,p^1-DDT, p,p^1-DDE and PCBs were found in blubber samples of Canadian Arctic ringed seals *Pusa hispida* (Schreb.), at concentrations in the low ppm range. In males, residue concentrations increased with age: slopes of the curves relating p,p^1 -DDE and p,p^1-DDT to age differed significantly ($P < 0.01$) from zero, but the relationship between PCB and age was weaker ($P < 0.05$). In females, these relationships were absent: slopes relating residue concentration to age did not differ significantly from zero.

0929 APOLLONIO, S. - 1961
The chlorophyll content of Arctic sea-ice; *Arctic*, vol. 14, no. 3, pp. 197-199.

A number of observers, working in arctic and antarctic waters, have commented on the discoloration of sea-ice caused by unicellular algae, mainly diatoms, that are frozen into the ice. The discoloration is usually seen when the ice is broken and overturned, because it occurs principally on the lower surface of the ice and occasionally on its sides. The brown or greenish-brown colour is due to the chloroplasts in the algae and undoubtedly indicates the presence of a potential source of food in polar seas in addition to the phytoplankton and the benthic algae.

0930 APOLLONIO, S. - 1965
Chlorophyll in Arctic sea ice; *Arctic*, vol. 18, no. 2, pp. 118-122.

Further work was done in the Arctic on this subject in 1962 and 1963, and these results, together with some speculations, are presented here.

0931 BARRY, T.W. - 1976
Seabirds of the Southeastern Beaufort Sea: Summary Report; Beaufort Sea Technical Report No. 3a, December 1976, 41 p.

During the seasons 1972, 1974, and 1975, the Canadian Wildlife Service coordinated surveys of seabirds that use the southeastern Beaufort Sea. Various survey methods were employed to determine temporal and spatial distribution of seabirds. From several points along the coast we made counts of spring migrants. Aerial surveys were used to learn the distribution and concentration of seabirds using open leads in the ice and throughout the open water season. Aerial surveys were also used to sample the coastal breeding and molting species. Aerial surveys in the fall sought to locate concentrations in the littoral zone. Radar echoes from flocks of birds migrating past the Distant Early Warning site at Komakuk Beach gave information not available to visual observers.

0932 BECK, B., and SMITH, T.G. - 1976
"Seal Finger" -- An unsolved medical problem in Canada; *Fish. Mar. Serv.*, Res. Dev. Tech. Rep. 625, 7 p.

Seal finger, an infection caused by contact with the blood or blubber of seals, remains unrecognized by Canadian medical authorities. Because of our close and frequent contact with many species of marine mammals, we have learned to identify and effectively cure the infection using tetracyclenes. Four case histories of recent infections are documented. Suggestions are made for research which would identify the causative organism and quantify the incidence of the infection in wild seal populations.

0933 BECK, B., and SMITH, T.G. - 1976
Seal finger: an unsolved medical problem in Canada; *CMA Journal*, vol. 115, July 17, p. 105.

0934 BRAKEL, W.D. - 1977
The socio-economic importance of wildlife resource utilization in the Southern Beaufort Sea; Beaufort Sea Technical Report No. 32, March 1977, 91 p.

This study considers the socio-economic importance of fishes, beluga or white whales, seals, white fox and polar bears to Inuit, Metis and Indians living adjacent to the Beaufort Sea. Factors considered as 'socio-economically important' include the level and distribution of local and export sales, domestic uses of wildlife harvests, employment and income.

Neither sociological changes nor the cost of compensating for any environmental changes caused by industrial activities are considered in this analysis.

There is a mosiac of socio-economic and marine wildlife utilization for two separate and distinctly different economies. The Mackenzie economy encompasses the settlements of Aklavik, Inuvik and Tuktoyaktuk (known as Tuk) and is closest to the current drilling operations in nearshore and offshore waters of the Beaufort Sea. For this and other reasons, this economy exhibits a highly developed level of industrial and commercial activity. Fishes and whales are the most important species of marine wildlife and their resource use is largely domestic. Their socio-economic importance, however, is overshadowed by commercial and industrial activities.

The Rim economy includes the settlements of Holman, Paulatuk and Sachs Harbour, and lies to the east of the Mackenzie economy. Here, the level of industrial activity is minimal, and export sales of furs is a major commercial activity. Seals, white fox and polar bears are primary sources of income in the Rim economy. For example, over half of the income earned in Paulatuk is from the sale of marine furs and commercial fishing. There is extensive domestic use of fish and of other marine resources, which is reflected in the low levels of income.

Fishes and white whales are the most important forms of marine wildlife to the Mackenzie economy. The domestic or subsistence use of these animals supplements wage or salary income. The export of white fox and polar bear furs from Tuktoyaktuk is the main commercial use of marine wildlife.

Each settlement has an individualized pattern of specialization in the harvesting of marine wildlife. Fishing and whaling are prominent activities in Aklavik, Inuvik and Tuk. In the Mackenzie economy, Tuk hunters monopolize the harvest of marine fur-bearers, such as foxes, polar bears and seals. Marine furs are more important in the settlements of the Rim economy. In particular, seals are critical to the Holman economy, while Sachs Harbour depends primarily on white fox. Paulatuk is the least specialized community since all fur-bearers and fishes are utilized.

These patterns of specialization reflect the relative socio-economic importance of marine wildlife. The importance of hunting, trapping and fishing declines, however, when wage employment and increased imports accompany decreased domestic and commercial utilization. This explains the greater socio-economic importance of marine wildlife in the Rim economy, where there is little commercial and industrial activity beyond fisheries and fur export.

0935 BUNCH, J.N., and HARLAND, R.C. - 1976
Biodegradation of crude petroleum by the indigenous microbial flora of the Beaufort Sea; Beaufort Sea Technical Report No. 10, March 1976, 52 p.

Despite unusually heavy ice conditions, microbiological samplings were conducted in the south Beaufort Sea during the summers of 1974 and 1975. One metre water from stations occupied during the open-water season produced total viable counts ranging from 1.0×10^6 to 3.0×10^7 CFU/litre of seawater in almost all instances. Incubation of replicate samples at different temperatures demonstrated that this heterotrophic flora was predominantly psychrophilic.

Oleoclastic or petroleum-degrading microorganisms appeared to be ubiquitous to the waters and nearshore but not offshore sediments of this region and were relatively abundant when compared to ocean bodies at more southerly latitudes. Mixed cultures produced by an enrichment procedure demonstrated an ability to degrade Norman Wells crude at 0.0°C. The presence of psychrophilic cell-types was evident within some mixed cultures in that optimum rates of degradation occurred at 20.0°C or lower. The probability of biodegradation in the south Beaufort Sea is suggested by these data. However, the nutrient requirements for *in situ* biodegradation remain inconclusive as a result of time constraints.

A baseline study of heterotrophic turnover of dissolved organic material by bacteria in the Beaufort Sea has been undertaken by this laboratory. A natural extension of this study was to determine the effect of petroleum upon this activity. Mineralization of glutamic acid by the indigenous heterotrophic flora was generally unaffected, or in some instances, was enhanced by the presence of weathered or unweathered crude. This suggests that *in situ* activity of non-oleoclastic heterotrophs might not be affected by a moderate influx of petroleum in the Beaufort Sea ecosystem.

0936 De MARCH, L., De MARCH, B., and EDDY, W. - 1977
Limnological, fisheries and stream zoobenthic studies at Stanwell-Fletcher Lake, a large high arctic lake; *Dept. Fish. & Env.*, internal report to Arctic Is. Pipeline Proj., 84 p.

Stanwell-Fletcher Lake was found to be a large cold monimictic true polar lake. At the end of winter (June) there was an ice cover of 2 to 2.5 metres with a snow cover varying from 0 to 100 cm. Some years the ice leaves the lake completely (August 26, 1975) but in other years it does not (1976 - 1 m of ice 90% cover). Freezeup occurs in September.

Average water temperatures in the lake remain below 2°C. The heat budget was calculated to be between 14×10^3 and 22×10^3 calories cm^{-2} with over 70% accounting for the latent heat of fusion of ice.

Light transmission by the water was high but ice and snow limited the amount entering the water column to between 0.5 and 30% of incoming radiation.

Chemically the water was very pure. The lake was low in salts, with a specific conductance of 67. The nutrient elements N and P were also present in only small amounts. Oxygen concentrations were high at all depths at all times.

Primary production rates were extremely low.

The 4.8 g C m^{-2} lake area planktonic primary production is as low as has been measured anywhere. The low production rates results from low nutrient supplies, low light levels and possibly low temperatures.

The most common benthic invertebrates in the lake were the Chironomidae. The species found were typical of other high Arctic lakes. Their numbers fluctuated between years. Because of this fluctuation it would take a number of years (approximately 10 years) to obtain adequate data to define baseline data for the lake.

Stanwell-Fletcher Lake was found to be similar to Char Lake, the only other intensively studied eastern high Arctic lake. The similarities were in nutrient budgets, physical factors, chemistry, benthic species and primary production. What differences there were could be explained by the differences in geology, size and depth of lakes and size of drainage basin.

Only two species of fish were present, fourhorn sculpin, *Myoxocephalus quadricornis* and Arctic char, *Salvelinus alpinus*. There appeared to be two groups of char, namely anadromous and lake dwelling.

The anadromous population was estimated at 9 x 10^4 fish with a biomass of 7 x 10^4 kg. Char over 500 mm in length could be divided into two groups, one group growing faster than the other. There was a strong correlation between the faster growth and the utilization of polar cod (*Boreogadus saida*) as a food source. Other char in the sea fed heavily on Amphipoda as well as other types of invertebrates. Lake dwelling char fed primarily on Chironomidae.

Migration times for the char were at ice out (sometime in June) for the seaward migration and August for the return from the sea. During both runs the cahr are caught by Inuit from Resolute Bay. In 1976 the total catch was approximately 5550 kg. A lowering of the mean age of the population and a decrease in the percentage of fish over 500 mm from 1962 to 1975-76 suggests that this level of utilization might not be supported by the population.

0937 DUSZYNSKI, D.W., SAMUEL, W.M., and GRAY, D.R. - 1977
Three new *Eimeria* spp. (Protozoa, Eimeriidae) from muskoxen, *Ovibos moschatus*, with redescriptions of *E. faurei*, *E. granulosa*, and *E. ovina* from muskoxen and from a Rocky Mountain bighorn sheep, *Ovis canadensis*; *Can. J. Zool.*, vol. 55, no. 6, pp. 990-999.

Oocysts of *Eimeria moschati* sp.n., *Eimeria oomingmakensis* sp.n., and *Eimeria ovibovis* sp.n. are described from muskoxen (*Ovibos moschatus*) in the United States (Alaska), Canada (Alberta, Northwest Territories, Quebec), and Norway. Oocysts of *Eimeria faurei* (Moussu and Marotel, 1902) Martin, 1909, *Eimeria granulosa* Christensen, 1938, and *Eimeria ovina* Levine and Ivens, 1970 are redescribed from muskoxen and from a Rocky Mountain bighorn sheep, *Ovis canadensis*, from Montana. Ellipsoid oocysts of *E. moschati* are 17-25 x 15-21 (20.5 x 17.4)µm with ovoid sporocysts 9-12 x 5.7 (10.8 x 6.1)µm. A micropyle, micropyle cap, multiple polar bodies, Stieda bodies, and sporocyst residua are present. Oocysts of *E. oomingmakensis* are ellipsoid, 38-61 x 28-38 (47.5 x 33.7)µm with ellipsoid sporocysts 18-23 x 9-12 (20.4 x 10.5)µm. A micropyle, Stieda and substieda bodies, and sporocyst residua are present. Ellipsoid oocysts of *E. ovibovis* are 20-25 x 16-21 (22.9 x 18.8) µm with ellipsoid sporocysts 11-15 x 5-7 (12.7 x 6.0)µm. A micropyle, Stieda bodies, and sporocyst residua are present. Similarities between these six species and all other *Eimeria* spp. from ruminants are discussed.

0938 FULLER, W.A., MARTELL, A.M., SMITH, R.F.C. and SPELLER, S.W. - 1975
High Arctic Lemmings (*Dicrostonyx groenlandicus*) I. Natural History Observations; *Can. Field-Naturalist*, vol. 89, no. 3, pp. 223-233.

Greatest density (533.3 per hectare) of burrows of collared lemmings (*Dicrostonyx groenlandicus*) in a high arctic setting occurred in peat polygons which occupied well under 1% of Truelove Lowland, Devon Island. Raised beaches occupied more than one-quarter of the lowland and had a burrow density of 115.4 per hectare largely associated with frost cracks. Meadows were much less densely settled. Winter nests were found in areas of deepest snow accumulation and were subject to 11.6% predation by *Mustela erminea*. Subnivean temperature in a meadow site fell gradually to about -25°C, where it remained for at least 11 weeks during the winter of 1972-73, when the population was in increase phase. Four species of plants, *Dryas integrifolia*, *Saxifraga oppositifolia*, *Salix arctica*, and *Pedicularis* sp. predominated in the autumn diet. Presence and calorific values are given for plants in winter habitats.

0939 FULLER, W.A., MARTELL, A.M., SMITH, R.F.C. and SPELLER, S.W. - 1975
High-arctic lemmings, *Dicrostonyx groenlandicus* II. Demography; *Can. J. Zool.*, vol. 53, pp. 867-878.

Captures of *Dicrostonyx groenlandicus* on northeastern Devon Island peaked in 1969 and 1973, were higher than expected in 1971, and were minimal (5 per 1000 trap-nights) in 1970 and 1972. Captures declined from July to August in at least five of seven summers and may have declined in a 6th year (1973). No change was detected in 1972. Body size was maximal in 1973 for mature and immature males and females and for all pelage (=age?) classes. Sexual maturity was delayed, at least in males, in 1973. Wintering females conceive under the snow in May and the litter is weaned at the normal time of snowmelt. Two other summer cohorts are produced by surviving old females and early maturing females of the first litters. None of the late summer cohort matures before the onset of winter. No female examined bore more than two summer litters. Mean summer litter size was 5.7 with no significant variation between years. Mean sex ratio was 50.3% male. It is suggested that density-related effects ought to occur in winter, rather than summer, but evidence on this point

is equivocal. Arctic adaptations of *D. groenlandicus* are discussed.

0940 GERACI, J.R., and SMITH, T.G. - 1975
Functional Hematology of Ringed Seals (*Phoca hispida*) in the Canadian Arctic; *J. Fish. Res. Board Can.*, vol. 32, pp. 2559-2564.

Hemograms from 20 netted and 6 shot ringed seals (*Phoca hispida*) were studied. Changes in red and white cell values in netted seals offer evidence for functioning sympathetic and adrenal-cortical stress pathways. The very high blood oxygen carrying capacity of ringed seals suggests that the animal is capable of deep or sustained dives. A technique for blood sampling from the vertebral "extradural" vein is described.

0941 GERACI, J.R., and SMITH, T.G. - 1976
Direct and Indirect Effects of Oil on Ringed Seals (*Phoca hispida*) of the Beaufort Sea; *J. Fish. Res. Board Can.*, vol. 33, pp. 1976-1984.

Ninety-six ringed seals (*Phoca hispida*) were taken from nets at Brown's Harbour, Northwest Territories in the fall of 1974. Comparison with two other net samples from 1971 and 1972 revealed a lower proportion of young-of-the-year and a lower mean weight of seals in all age-classes. Six seals immersed in Norman Wells crude oil for 24h at the field netting site suffered only transient eye problems and minor kidney and possibly liver lesions; no permanent damage was observed. Three seals transported to the University of Guelph all died within 71 min after oil was introduced into their pool. Hematologic and blood chemical studies indicate that death was caused by oil superimposed on the stress of captivity. Six, 3-4 wk-old wild whitecoat harp seal (*P. groenlandica*) pups at the Magdalen Islands, Quebec, were coated with crude oil. No significant differences in core body temperatures were noted and no deleterious effects were observed. Five captive ringed seals at Guelph were subjected to a cumulative dosage of Norman Wells crude oil fed with their fish food. High dosage (75 ml) and low dosage (25 ml) of crude oil were also fed to two groups of six harp seal pups. No significant lesions or behavioral changes were noted. These experiments were of an acute nature and reflect the effects of a brief contact with oil only. Effects of longer contact as would probably be the case in an offshore oil well blowout situation are discussed. Possible effects of large-scale offshore oil fields are also considered.

0942 GRAINGER, E.H. - 1975
Biological productivity of the southern Beaufort Sea; the physical-chemical environment and the plankton: Beaufort Sea Technical Report No. 12a, December 1975, 82 p.

The south Beaufort Sea, immensely modified by the outflowing Mackenzie River, consists of a layer of low salinity water of Mackenzie River origin overlying one of higher salinity, of offshore, Arctic Ocean origin. The variable balance between these elements determines the extent of the river plume, and therefore the basic biological composition of the south Beaufort Sea. A changing sea-ice cover influences undersea light and provides a surface for the ice flora which supplies a primary food source for what appears to be an important trophic series. Undersea light is also influenced by particulate material in the water. Light penetration is shallow in the inshore plume waters, because of the high sediment load carried to the sea by the outflowing river. Nutrients, mainly nitrate and silicate, are added to the sea from the river. Levels remain high near shore, where consumption by plants is consistently low. Outside the plume, nitrate is probably the major factor limiting phytoplankton production; within the plume it is probably light, inhibited by river-contributed turbidity. A low annual primary production rate is indicated for all waters of the region, and especially for the area of the river plume. A low secondary (zooplankton) production is also indicated, and standing stocks are generally low by world standards.

The two-layered, estuarine structure of the inshore waters is expected to encourage rapid spread of pollutants through the system, either from offshore, from inshore or from terrestrial or river locations. Much of the character of the system is determined by river influences, so much so that quantitative changes in the river will be expected to alter the biological composition of the south Beaufort Sea. Even temporary elimination of the plume would wipe out the estuarine fauna and flora. Qualitative changes would also be expected, and pollutants from the river would quickly spread at least to the limits of the plume. The primary and secondary producers provide the basis of a food structure which supports fishes and mammals, both in the water column and in association with the sea ice cover. Relatively short food chains represent areas of the system of potentially great vulnerability to oil.

0943 GRAINGER, E.H., and GROHE, C. - 1975
Zooplankton data from the Beaufort Sea, 1951 to 1975; *Fish. Mar. Serv.*, Res. Dev. Tech. Report No. 591, 54 p.

Zooplankton collections, made during 7 years in the south Beaufort Sea, are described quantitatively. Copepods are the largest group, with 40 species, followed by amphipods with 15, then hydrozoans with 11. There are at least 92 species in all.

0944 GRAINGER, E.H., LOVRITY, J.E., and EVANS, M.S. - 1977
Biological oceanographic observations in the Eskimo Lakes, Arctic Canada. Physical, nutrient and primary production data, 1961-1975; *Fish. Mar. Serv.*, Tech. Report No. 685, 108 p.

Tables of physical and chemical data from 128 station occupations in the Eskimo Lakes include information on temperature, salinity, dissolved oxygen, phosphate, nitrate, nitrite, silicate, chlorophyll a and carbon.

0945 GRAY, D.R., and COCKERTON, D.F. - 1974
Muskoxen at Bathurst Island; *The Beaver*, Winter 1974, pp. 32-39.

The National Museums began a study of muskox behaviour on Bathurst in 1968 and this project, along with other behavioural and ecological studies, continues today. The proposal to study the winter ecology and behaviour of muskoxen during the winter of 1970-71 was developed in hopes of filling the obvious gaps in the knowledge of the muskox. Evidence of a limited die-off during the winter of 1967-68 and a proposed muskox hunting program by the Inuit of Resolute Bay made such a study even more desirable.

0946 GREENDALE, R.G., and BROUSSEAU-GREENDALE, C. - 1976
Observations of marine mammal migrations at Cape Hay, Bylot Island, during the summer of 1976; *Fish. Mar. Serv.*, Res. Dev. Tech. Report No. 680, 25 p.

Marine mammals were observed and counted at Cape Hay, Bylot Island, from 21 June to 31 July 1976. Narwhals, harp seals, belugas, walruses, bowhead whales and bearded seals were recorded as they migrated westward on the south side of Lancaster Sound.

Although bad weather limited observation severely, a total of 6,145 narwhals was recorded during the survey. Extrapolating for fog and other adverse weather factors, the number actually passing was estimated at 8,000 to 10,000. Groups of adult males for the most part headed the migration. Mixed groups and young animals were most frequent in mid-July and females with newborn calves occurred at the end of the migration. The number of narwhals seen passing was about the same as in a survey made at the same site in 1957.

Beluga whales probably passed through for the most part before the survey began. A total of 183 belugas was recorded between 24 June and 5 July. After that only 3 animals were seen.

Harp seals were still passing when the survey ended and only 16,000 were seen as compared with 132,000 in all in 1957. The migration of this species was evidently later than in 1957.

A definite movement of bearded seals occurred in the last week of July when 164 seals were seen passing at Cape Hay.

Walruses were observed regularly throughout the survey, in groups never exceeding 4. Some feeding took place at the base of Cape Hay cliffs in Lancaster Sound.

Only 3 bowhead whales were observed in 1957. The number had increased to 23 in 1976. Most of these animals were seen between 12 and 17 July. On 15 July, a group of 3 bowheads, 2 adults and a younger animal, was observed.

0947 HAY, K., and McCLUNG, R. - 1976
Observations on beluga and narwhal in the Canadian High Arctic, Summer 1974; *Fish. Res. Board of Canada*, Arctic Biological Station Manuscript Report Series No. 1385, unpub. manuscript, 55 p.

0948 HAY, K., and SERGEANT, D.E. - 1976
Interim Technical Report, Arctic Whale Project; Envir.-Social Prog., Northern Pipelines, *Dept. Env. Can.*, internal report, 41 p.

Exploitation by Inuit hunters and potential environmental disturbance due to fossil fuel developments in the Canadian eastern arctic have helped to arouse great interest in the narwhal and the status of its populations. The purpose of this research is to determine population sizes, migration routes, dynamics and general biology of this relatively unknown species.

Helicopter surveys on June 3, 5, and 6 revealed only about 100 narwhals and 1000 white whales in the vicinity of the ice edges in Lancaster Sound and northern Prince Regent Inlet. Although little accurate information on populations and migrations was obtained, much interesting whale behaviour was observed. More radical technology must be developed and applied to adequately census dispersed arctic marine mammals.

The main emphasis of the 1975 field season was upon sampling of narwhals from the Inuit hunt near Arctic Bay and Pond Inlet. During the period from late July until the end of August, samples were obtained from 65 narwhals, including 35 females and 30 males. The material which was collected, including teeth and bones for ageing and ovaries and testes for reproductive studies, will enable determination of the life history parameters and population dynamics of this species.

0949 HSIAO, S.I.C. - 1976
Biological productivity of the southern Beaufort Sea: phytoplankton and seaweed studies; Beaufort Sea Technical Report No. 12c, March 1976, 99 p.

Standing stock and *in situ* primary productivity of the southern Beaufort Sea phytoplankton were determined during the summers of 1973, 1974 and 1975. Average cell numbers were 10 times greater at inshore stations than at offshore stations at corresponding depths while the rate of primary productivity was 2 to 8 times greater at inshore stations. Cell numbers ranged from 2.0 to 4802.0 x 10^3 cells /l, while integrated productivity values averaged 47.45 mg C/m^2/h for inshore stations and 8.82 mg C/m^2/h for offshore stations. Possible reasons for a greater standing stock and primary productivity at inshore stations are discussed.

The largest group represented was the Bacillariophyta with 64 species, followed by the Pyrrophyta with 5 species, the Chrysophyta with 3 species, the Chlorophyta with 2 species and the Euglenophyta and Cyanophyta with 1 species each. There were at least 87 species identified.

The phytoplankton community consisted mainly of diatoms and flagellates. Diatoms dominated the inshore stations and flagellates were more abundant at offshore stations. Possible reasons for this unique distribution are discussed.

Diatoms were more sensitive than flagellates when they were exposed to crude oils, Corexit

and crude oil-Corexit mixtures. The toxicity of crude oil-Corexit mixtures on algal photosynthesis and growth was greater than crude oil or Corexit alone. Possible long-term ecological consequences of such differential sensitivity and selective toxicity are discussed.

Primary production of seaweed was severely inhibited by all types of crude oil at relatively low concentrations.

0950 HUBERT, B. - 1974
Estimated Productivity of Muskox (*Ovibos moschatus*) on Northeastern Devon Island, N.W.T.; unpub. M.Sc. Thesis, Univ. Manitoba.

The productivity of muskox was studied on the Truelove Lowland of northeastern Devon Island, N.W.T. between May 1970 and August 1973. The number of muskox occupying the 44 km^2 lowland ranged from zero during the spring melt and runoff to 114 in March 1973. These muskox were part of a population totalling approximately 275 whose range extended from Sverdrup Inlet east to Sverdrup Glacier. The total range area below 200 meters is 301.4 km^2.

A growth curve for wild muskox based on weights of domesticated muskox and wild muskox is proposed. Energy requirements of domesticated muskox were determined and were used to estimate the energy requirements of free-living muskox. Based on the proposed body weight and estimated energy requirements of wild muskox a predicted 20.8 percent of the available forage was harvested from areas grazed during the period of snow cover. Examination of areas grazed in winter showed that an average of 23.6 percent of the forage had been removed.

The net biomass increase for the population in the year ending 30 April 1973 was 12 percent. The growth of calves contributed 53 percent of this increment.

Calves account for only 5.1 percent of the total forage removal by muskox grazing. The significance to the productivity of this muskox population of the Truelove Lowland appears to be an abundance of forage which is readily available in the season when forage is most difficult to obtain.

0951 JONKEL, C.J., GRAY, D.R., and HUBERT, B. - 1975
Immobilizing and marking wild muskoxen in Arctic Canada; *J. Wildl. Manage.*, vol. 39, no. 1, pp. 112-117.

During 1970-72, 26 wild muskoxen (*Ovibos moschatus* Zimmermann) were captured on Bathurst, Devon, and northern Ellesmere islands, NWT, Canada, using helicopters and Cap-Chur drugging equipment. Animals were immobilized with a mixture of 60 to 100 mg of succinylcholine chloride and varying amounts of promazine hydrochloride. Dosages were based on estimated body weight (1 mg/3 kg). Muskoxen were marked with paint, plastic and metal eartags, plastic streamers fastened to the horns by metal hose clamps, and numbered radio collars. Disturbance by the helicopter appeared to be a potential hazard through disruption of herd cohesiveness. Muskoxen should not be immobilized and tagged where predators are numerous or when young calves are present.

0952 KENDEL, R.E., JOHNSTON, R.A.C., LOBSIGER, U., and KOZAK, M.D. - 1975
Fishes of the Yukon Coast; Beaufort Sea Technical Report No. 6, December 1975, 114 p.

The purpose of this study was to collect baseline information regarding the inshore fisheries resource and the aquatic environment of the western coastal Beaufort Sea, and to identify areas that could be critically affected by a major oil spill.

We present data collected from April 1974 to September 1975. The study area included the coastal sea out to 7 km offshore, lagoons, bays, and estuaries, bounded by the Blow River delta on the east and by Welles Point, Herschel Island, on the northwest.

Of 21 species of fish recorded within the study area 6 species represented 95% of the total catch in 1974. These were least cisco (*Coregonus sardinella*), Arctic cisco (*Coregonus autumnalis*), Arctic char (*Salvelinus alpinus*), fourhorn sculpin (*Myoxocephalus quadricornis quadricornis*), boreal smelt (*Osmerus eperlanus*), and humpback or lake whitefish (*Coregonus clupeaformis*). Of these only the fourhorn sculpin is considered a marine species, the remainder being anadromous species.

The Mackenzie River is thought to be the major contributor to coastal fish populations. This is indicated by the relatively high abundance of anadromous species in the east, excluding Arctic char. Tag recovery data helps to confirm this for Arctic cisco.

Seasonal movements of the anadromous species can be generalized as an upstream migration of mature individuals into river systems prior to spawning time and a subsequent downstream post-spawning migration to coastal waters. Fry spend variable amounts of time in the river systems before moving down to deltas and coastal waters.

The movements of marine species are not clear, however, there are indications of migrations of some species into sheltered coastal waters at the time of spawning.

The areas of highest density and species diversification were Mackenzie Bay and Phillips Bay. Along the open coast and to a lesser degree inside bays and lagoons fish were noticeably shore-oriented. In most cases nets set nearshore caught fish while those set offshore were either empty or showed reduced catches.

Some of the life history information is presented along with a discussion of the available literature for each species. Age-length relationships, sex ratios and age at maturity are also presented for the most common species.

The feeding habits of coastal fishes vary both with species and area. Crustaceans, insects, other fish, pelecypods and miscellaneous items comprised the diet of most fishes, however, some species such as fourhorn sculpin and inconnu appeared to be more selective. Generally, increased feeding activity, as indicated by lower incidences of empty stomachs occurred in adult fish west of Kay Point. Fry, on the other hand, fed more extensively

throughout most of the regions of capture, utilizing the smaller forms and life stages of crustaceans and insects.

Results from chemical and physical measurements show an extremely complex system. Surface and nearshore waters are fresh to brackish with temperatures above 10°C during the summer months.

Some concerns related to offshore drilling and the potential effects of an oil spill on the fisheries resources of the study area are discussed. Of foremost concern is the apparent lack of knowledge pertaining to the behaviour of oil under ice, the direct and indirect effects of crude oil on the aquatic resources and the efficiency of clean-up techniques for spilled oil in the Arctic environment.

0953 KINOSITA, S. - 1975
General outline of joint studies on physical and biological environments in the permafrost, Alaska and North Canada, June to July, 1974; *in* Joint Studies on Physical and Biological Environments in the Permafrost, Alaska and North Canada, June to July, 1974, Inst. Low Temp. Sci., Hokkaido Univ., Japan, pp. 1-32.

A scientific expedition in permafrost regions of Alaska and North Canada was carried out by seven scientists of the Institute of Low Temperature Science, Hokkaido University, Sapporo, JAPAN (Chief: Prof. Kinosita), from the middle of June to the end of July, 1974. The main attention of the expedition was directed to the role of the active layer on vegetation and soil invertebrates in permafrost areas.

Areas for studies were selected as follows: Alaska - Fairbanks: forest zone, Barrow: tundra zone; North Canada - Tuktoyaktuk: tundra zone, Inuvik: forest zone; Churchill: forest-tundra transition boundary.

The group was divided into three sub-groups according to their research subjects: (1) frozen ground (Prof. Kinosita, Ass't Prof. Suzuki, Messrs Horiguchi and Fukuda). (2) vegetation (Prof. Sakai and Dr. Yoshida), and (3) soil invertebrates (Dr. Tanno).

0954 KNOWLES, R. - 1975
Nitrogen fixation in Arctic marine sediments; Beaufort Sea Technical Report No. 9, December 1975, 44 p.

Nitrogen fixation was measured in grab and core samples of sediments from the Beaufort Sea and Eskimo Lakes. The indirect assay involving the reduction of acetylene to ethylene was used. Very low rates, of the order of 25 mg N/m^2. year, were detected in untreated sediments. Activity was markedly stimulated by addition of glucose, sucrose, lactose, mannitol and malate, much less by acetate, and negligible activity was supported by N-acetylglucosamine, the chitin monomer. There was no consistent effect of the presence or absence of oxygen and evidence suggested that anaerobic and facultatively anaerobic bacteria were responsible for the observed activities. Nitrogen fixation potentials in glucose-supplemented sediment samples showed large variation between stations, between samples from the same station, and between depths within single cores down to 18 cm. Consequently experimental reproducibility and replicability was poor.

Denitrification of nitrate to the gaseous products N_2O and N_2 was not detected in untreated sediments but was potentially very active when sediments were supplemented with organic carbon and nitrate. Reduction of the nitrate followed the sequence $NO_3^- \rightarrow NO_2^- \rightarrow N_2O \rightarrow N_2$.

Weathered Norman Wells crude oil, decane, dodecane and hexadecane had no effect, stimulatory or inhibitory, on nitrogen fixation, denitrification or carbon dioxide evolution. Hexane caused partial inhibition of denitrification but not of nitrogen fixation, and 1,2,4-trimethylbenzene caused complete inhibition of both nitrogen fixation and denitrification but only partial inhibition of CO_2 evolution. There was no evidence of utilization of any of the hydrocarbons tested during periods of over 30 days under the experimental conditions employed.

0955 LEGAULT, J. - 1976
Wilderness, Ordeal in the jaws of the white bear; *Outdoor Life*, April 1976, pp. 69, 150, 152, 154, 156.

It seemed a bad dream, but then I realized the polar bear was going to crush my skull and I would die.

0956 MacDONALD, S.D. - 1976
Phantoms of the polar pack ice; *AUDUBON*, vol. 78, no. 3, May 1976, pp. 2-19.

Sculptured by summer's melting, gilded by the early winter sun, grounded ice floes near the shore of Seymour Island not only provide perches for adult ivory gulls but form protected pools where young birds can swim and feed.

0957 MacDONALD, S.D. - 1977
An Arctic Oasis; *Nature Canada*, July/September, pp. 4-6.

Twenty-seven sites for ecological reserves have been identified in the High Arctic. None of them yet has the status of a protected area. This is a plea for ecological reserves in northern Canada.

0958 MACPHERSON, A.H., WATSON, G.H., HUNTER, J.G., and HATFIELD, C. - 1972
Potential effects on social values in wildlife and fisheries resources; *in* Proc. Can. Northern Pipeline Res. Conf., Feb. 2-4, 1972, Nat. Res. Council Can., Assoc. Com. on Geotech. Res., Tech. Memo No. 104, pp. 79-90.

We foresee four kinds of potentially deleterious effects on the social values in fish and wildlife resources arising from the construction of pipelines or, for that matter, any other massive and extensive engineering works. These are: 1) Alteration of habitat lowering its ability to support particular fish and wildlife resources; 2) Activity or terrain disturbance deflecting fish and wildlife from important migratory paths or routes; 3) Improved access to certain fish and wildlife populations facilitating unprecedented harvest

rates; and 4) Injudicious siting of oil pipelines with respect to pollution hazards.

The kinds of information required to avert the above threats to northern wildlife and fish resource values include: (a) estimates of the comparative value of the various habitat units, lakes, rivers and landscape units, along the route, to the various fish and wildlife resources; (b) economic and social values of fish and wildlife resources of these units to local and to other Canadian people; (c) behavioural characteristics of fish and wildlife in relation to disturbance and obstruction; (d) performance of particular northern fish and wildlife populations under increased harvests; calculation of sustainable yields; and (e) effects of crude oil on northern fish and wildlife environments and populations.

Studies in progress by Canadian Wildlife Service, Canadian Fisheries Service and Fisheries Research Board of Canada include: surveys of proposed and alternate routes in order to provide advice to granting and regulatory agencies on the best alternatives; characteristics of the northern fauna, again to provide advice concerning planning and technique; and establishment of a data baseline by which to assess future environmental changes.

0959 MALTBY-PREVETT, L.S., BOYD, H., and HEYLAND, J.D. - 1975
Observations in Iceland and Northwest Europe of Brant from the Queen Elizabeth Islands, N.W.T., Canada; *Bird-Banding*, vol. 20, no. 2, Spring 1975, pp. 155-161.

Extensive ornithological surveys were initiated in the summer of 1973 on those islands in the Canadian High Arctic that are likely to be affected by well drilling and pipeline routes resulting from explorations for natural gas and oil. One of the projects involved a thorough investigation of the numbers and distribution of Brant (*Branta bernicla*) on Melville Island and adjacent territory known collectively as the Queen Elizabeth Islands. To obtain data on the distribution of these Brant on their wintering areas, a number of geese were banded. This involved the capture of flightless young and molting adult geese by setting up a portable net corral and driving the birds into it with a helicopter (Heyland, 1970). In 1973, only standard numbered aluminum leg-bands were used, but in 1974 painted aluminum neck-collars were also placed on the birds. The collars were yellow with black lettering as developed by C.D. MacInnes et al (1969). Table 1 records the extent of banding in 1973-74, and the numbers of Brant leg-banded by Heyland in 1971 and 1972.

0960 MANSFIELD, A.W., SERGEANT, D.E., and SMITH, T.G. - 1975
Marine Mammal Research in the Canadian Arctic; *Fish. Mar. Serv.*, Tech. Report No. 507, 23 p.

This report is a summary of research carried out on marine mammals in the arctic by the staff of the Arctic Biological Station. Continuing programs and plans for future research are also described.

0961 MANSFIELD, A.W., SMITH, T.G., and BECK, B. - 1975
The Narwhal, *Monodon monoceros*, in Eastern Canadian Waters; *J. Fish. Res. Board Can.*, vol. 32, no. 7, pp. 1041-1046.

In the Pond Inlet area of Baffin Island in 1963-65, 62 narwhals (*Monodon monoceros*) were caught in nets and examined. Growth layers occur in both the extruded tusk and in the embedded tooth. The few identifiable food remains in stomachs were of squid and Arctic cod. At birth, the calf measures about 160 cm in length and weighs just over 80 kg. Fully grown females attain a length of 400 cm and a weight of 900 kg. Males reach 470 cm and a weight of 1600 kg. Calving is assumed to occur about once in 3 yr. A conservative estimate for the narwhal population of Canada and northwestern Greenland is approximately 10,000. Although the birth rate is unknown, it is assumed to be similar to that calculated for the closely related white whale; that is, about 9%. The maximum potential annual catch, based on the highest reported Canadian catch of 442 narwhals in 1957, combined with the Greenland catch of 135 and an assumed sinking loss of 50%, is about 1154. This is above the estimated annual production of 900.

0962 MILLER, F.L., and RUSSELL, R.H. - 1976
Distributions, movements and numbers of Peary caribou and muskoxen on Western Queen Elizabeth Islands, Northwest Territories, 1972-74; *Env. Can.*, Can. Wildl. Serv. Report CWSC 2045, 493 p., unpub. manuscript.

We flew three late winter and three summer surveys of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) on the western Queen Elizabeth Islands 1972-74. We flew standard "transect census" strip surveys at mainly 25% coverage using strips 1.6 km wide. Technical and weather delays prevented uniform coverage of the survey area. The results are comparable for Peary caribou but not for muskoxen with a previous survey in 1961. Peary caribou have decreased since 1961 between 87% and 100% on all islands surveyed in 1972-74. There appeared to have been an increase in numbers of muskoxen between 1961 and 1973 with recolonization of Prince Patrick Island. In winter 1973-74 there was high mortality of muskoxen with an overall loss of 35%. Eastern Melville Island especially the Dundas Peninsula is the heartland for caribou, some of which move to Prince Patrick to winter. We used aerial dye-spraying and subsequent locations of marked animals to document the inter-island movements. Southwestern Melville Island especially the Bailey Point area is the heartland for muskoxen. In summer 1974 more than 25% of all Peary caribou and muskoxen estimated were on the Dundas Peninsula and Bailey Point areas respectively. The two areas are 6% and 1% of the landmass of the western Queen Elizabeth Islands respectively.

On large islands caribou moved to high, dry sites on coastal areas in early spring and late summer: in the interior they showed a preference for drier sites intermediate in elevation. Muskoxen showed a year-round preference for well-vegetated sedge (*Carex* spp.) meadows and

willow (*Salix* spp.) slopes on Coastal sites at low elevations. Summertime movements to the interior were usually restricted to shores of watercourses and adjacent drainage slopes. Caribou group sizes were influenced by forage availability: relatively large aggregations form in summer with favourable forage conditions but break up into small groups and singles in winter. For muskoxen under average conditions the pattern of group sizes is opposite of that observed for caribou, but under severe nutritional stress the large winter groups split up. Most single muskoxen occur during the summer.

The marked decreases in numbers are attributed to a combination of high winter mortality in some years and an overall low rate of births and recruitments between 1961 and 1974 for caribou, and at least 1972-74 for muskoxen. We believe a series of years with unfavourable snow and ice conditions made forage unavailable and restricted, and thus caused the decreases in numbers of both species. Currently numbers of both Peary caribou and muskoxen are dangerously low on the western Queen Elizabeth Islands--their conservation and preservation must be considered.

0963 MILLER, F.L., RUSSELL, R.H., and GUNN, A. - 1976
The Recent Decline of Peary Caribou on Western Queen Elizabeth Islands of Arctic Canada; *in* Proc. 10th Intern. Polar Meeting, German Soc. Polar Res., Zurich, Switzerland, April 6-8, 1976, pp. 17-21.

The numbers and distributions of Peary caribou (*Rangifer tarandus pearyi*) on western Queen Elizabeth Islands, Northwest Territories were determined by aerial surveys based on a standard census strip method. Surveys were flown in March-April and July-August periods in 1972, 1973, and 1974. Comparison of the 1973 and 1974 surveys with those results of a comparable survey in 1961 showed an overall decline of 89% in numbers of caribou between 1961 and 1974. Percentage reduction of caribou numbers from 1961 to 1974 followed a west-east gradient on the three major islands. Prince Patrick 72%, Melville 87%, and Bathurst 92%. The marked decrease in numbers of caribou is attributed to a combination of high winter mortality in some years and an overall low rate of births and recruitment from 1961 to 1974.

0964 NETTLESHIP, D.N., and SMITH, P.A. - 1975
Ecological sites in northern Canada; Can. Comm. I.B.P. Panel 9, Nettleship & Smith, eds. 331 p.

This volume includes a listing of 71 biologically important areas in the Canadian North which the members of CCIBP-CT Panel 9 feel should be given a high level of consideration for protection, special management, or study. Although these sites have not all been reviewed in consultation with the development companies and the native groups which have given their approval in principle to the concept of an Ecological Sites system for the North, they do represent the present views and efforts of a diverse group of scientists, experts, and leaders who make up the Panel membership, and of the many individuals and organizations who have been consulted. The bibliographies provide more detailed documentation and comprise the most extensive source of references in existence on these biologically important areas.

The general purpose of this volume, therefore, is to assist in land-use planning on the national and territorial levels. While development continues throughout the North, biological and conservation interests have not always been adequately represented. Even planners and developers have complained that up to now little or no relevant, factual information on northern renewable resources was on hand and, where data were available, planners usually found them incomprehensible because the writing was too technical or full of scientific jargon.

Consequently, our main purpose was to collect all the pertinent references and unpublished data on sites identified by the CCIBP-CT as being representative of the Arctic, and to summarize the information on a local basis and in a form usable by land-use planners and other decision makers, both public and private.

A second important purpose was to suggest preliminary guidelines for the protection of specific sites and to develop broader guidelines that would indicate potential problems and options which would be valuable in the selection of alternate areas by other legitimate users of northern resources. We hope that these guidelines may curtail excessive or unnecessary destruction of valuable and unique biological communities and ecosystems.

In essence, this book is an attempt to *aid* developers and development-oriented agencies in their planning, as well as to provide a program for habitat preservation in northern Canada. It will provide a means by which conservation planning and thinking can enter easily into land-use decision-making processes in arctic regions, and will ensure that renewable resource conservation is no longer considered of secondary importance, or not considered at all.

0965 NETTLESHIP, D.N. - 1976
Census techniques for seabirds of arctic and eastern Canada; *Env. Can.*, Wildlife Service Occasional Paper No. 25, 33 p.

This paper reports on the various census techniques that have been used and tested during a lengthy study of the breeding and pelagic distributions of seabirds in the western North Atlantic and adjacent parts of the Arctic Ocean by the Canadian Wildlife Service's program "Studies on northern seabirds". Emphasis is on census techniques used to estimate population size and monitor changes in bird numbers at colonies of individual species within the families Procellariidae, Hydrobatidae, Sulidae, Phalacrocoracidae, Laridae, and Alcidae. The methods employed for gathering quantitative information on bird numbers at sea are also briefly reviewed.

The immediate purpose of this manual is to attempt to standardize census procedures used

by investigators in the study region, in the hope that the techniques will be sufficiently precise to measure *real* changes in numbers within individual colonies and be sufficiently rigid to reduce observer error to a minimum, thus making the data more valuable in identifying substantial numerical changes and geographical shifts of species populations. The methods described are group-specific, not species-specific, in that the census procedures outlined can be extended to species breeding in similar situations or habitats in other geographic areas.

0966 NETTLESHIP, D.N. - 1976
Seabird resources of eastern Canada: status, problems and prospects; presented at Canadian Nature Federation's Sym; "Canada's Endangered Species", Studies on northern seabirds, No. 45, Can. Wildl. Serv. unpublished report, 46 p.

Some seabirds are showing marked changes in status which are believed to be caused by widespread industrial expansion and resource development in both Atlantic Canada and the eastern Canadian Arctic. This paper reviews the distributions, status, problems and prospects of the major colonial species breeding in eastern Canada. It identifies the general nature and source of some of the main threats to seabirds both as a group and to individual species. These threats include human activities such as oil pollution, fisheries development, incidental kill of birds in fishnets, toxic chemical pollution, mineral developments, and disturbance at breeding sites by animals and man. It is concluded that pollution of the seas by oil poses the largest single threat to seabirds at the present time. Oil pollution is widespread and likely to increase at an alarming rate in both temperate and arctic regions of Canada from the developments of offshore oil, where the potential for disastrous accidents is high because information, skills, technology and conditions for safe underwater drilling are limited. Populations of certain species in eastern Canada are more immediately threatened by these activities and should be given first consideration for protection and conservation. Such species include Northern Fulmar, Gannet, Razorbill, Common Murre, Thick-billed Murre, and Atlantic Puffin. The immediate needs are for the planning of a conservation policy and for the identification of processes by which this endangered seabird resource can be protected and maintained. Secondly, stringent government legislation is required to regulate and control the exploration and exploitation of offshore oil developments and tanker transport of petroleum, both in territorial waters and on the high seas. Recommendations and priorities for further planning and study are made.

0967 NETTLESHIP, D.N. - 1976
Studies of seabirds at Prince Leopold Island and vicinity, Northwest Territories; preliminary report of biological investigations; Env. Can., Can. Wildl. Serv. Studies on northern seabirds, unpublished report No. 40, 24 p.

This interim report gives provisional findings and views of the biological team based on field work at Prince Leopold Island, N.W.T., May to September 1975, They are necessarily provisional because many of the records have yet to be analyzed.

The status (breeding population size), use of habitat (distribution), phenology of breeding, breeding performance and food preferences were studied for five species of seabirds (Northern Fulmar *Fulmarus glacialis*, Glaucous Gull *Larus hyperboreus*, Black-legged Kittiwake *Rissa tridactyla*, Thick-billed Murre *Uria lomvia* and Black Guillemot *Cepphus grylle*) on the cliffs and adjacent waters of Prince Leopold Island during the 1975 breeding season. The purpose of the study, current state of knowledge of seabird populations in the region, description of the study area and methods and approach are outlined briefly.

Provisional findings are summarized and discussed in order to show the types of population parameters measured at Prince Leopold Island and permit input regarding possible approaches of investigation in the future. It is believed that, after completion of the analysis of the 1975 summer's records, the data will show population performance of four of five seabird species breeding at Prince Leopold Island (studies of Black Guillemots were limited to breeding distribution and population size) and determine the importance of Barrow Strait and associated waters for successful breeding. Preliminary results indicate that Barrow Strait has a relatively high density of fish food which is critical to the nutritional requirements of a large proportion of the total seabird population, especially Thick-billed Murres during the chick-rearing period when the demand for food is greatest. Implications of these findings are discussed.

It is concluded that at least two additional seasons of similar observations are necessary to determine the average performance and variation between years of accurately measurable population parameters such as population sizes, timing of breeding, hatching and fledging success, food types and feeding frequencies, fledging periods and growth rates of chicks, which can then be used to assess the impact of disturbances in the marine environment from industrial developments. It is also emphasized that much more work needs to be done on the identification of precise feeding areas and general water habitat usage by birds in Barrow Strait (most of which breed at Prince Leopold Island) both geographically and chronologically. These types of data (pelagic distribution of seabirds) can only be investigated by systematic coverage by helicopter of permanent marine transects over the open water areas of Barrow Strait at intervals through the breeding season which will require a considerable increase in funding.

Finally, it is clear from the analysis of 1975 data that a thorough understanding of population performance at the major breeding site (by a monitoring system sensitive enough to measure changes in levels of important population parameters) and of the distribution of birds in associated open water areas (pelagic

distribution of seabirds in space and time) is required if we are to determine the ecological requirements of seabirds in the region and be able to assess the impact of industrial expansion.

0968 NETTLESHIP, D.N., and GASTON, A.J. - 1977

Identity, abundance and patterns of distribution of populations of seabirds in Western Lancaster Sound and Barrow Strait, Northwest Territories; Final Report to the Arctic Islands Pipeline Pro., Studies on northern seabirds, No. 50, Can. Wildl. Serv. unpublished report, 76 p.

Features of the distribution, use of water habitats and foraging range were studied for the four major species of seabirds (Northern Fulmar *Fulmarus glacialis*, Black-legged Kittiwake *Rissa tridactyla* , Thick-billed Murre *Uria lomvia*, and Black Guillemot *Cepphus grylle*) breeding in a 24000 km^2 area of Barrow Strait and western Lancaster Sound during the 1976 summer season. A large proportion of the more than one million seabirds that reproduce in the survey area each summer nest at one location, Prince Leopold Island: 100% of murres, 95% of kittiwakes, at least 40% of guillemots, and 40% of fulmars. Five sets of aerial surveys were conducted over all marine waters between latitude 73°30' and 75°05'N and longitudes 87°00' and 95°10'W (i.e., survey area) in August and September to determine the distribution of seabirds and to identify areas which were important to them for feeding during the crucial period when chicks were being reared.

A total of 18616 birds of 13 species were recorded in 6455 km of transects. Ninety-eight percent of all birds observed belonged to the four major species breeding in the Barrow Strait area. The distributions of all species were highly non-random with a significant tendency for all species to occur at higher density in coastal than in off-shore waters. In coastal waters, species distributions were further clumped with major concentrations most often occurring in bays or waters where there was land-fast ice and where streams or rivers flowed into the sea. The concentration of Polar Cod *Boreogadus saida* in these estuarine water habitats for spawning is believed to be responsible for the high numbers of feeding birds associated with such sites, as this fish species forms a major portion of the summer diet of most seabirds in the region.

The Northern Fulmar was the most numerous species in the survey area, comprising 55% of all birds seen, and foraged over much greater distances than other species. Black-legged Kittiwakes were more frequent on coastal than offshore transects on all surveys usually foraging within 48 km of Prince Leopold Island, though large numbers were seen as far as 96 km from the colony. Thick-billed Murres showed a relatively dispersed feeding pattern on the open sea with a foraging range up to 112 km from the breeding colony. They showed an abrupt shift in preferred feeding area between 2 and 6 August probably due to heavy accumulations of pack-ice along the north coast of Somerset Island where they had previously concentrated for feeding. Some Black Guillemots were restricted to coastal waters where they were breeding, but birds from the large population at Prince Leopold Island foraged away from the colony at a considerable distance, at least as far as the northeast coast of Somerset Island to Garnier Bay, 55 km away.

On the basis of survey observations, and observations made on Prince Leopold Island in 1975 and 1976, the most important aspect of the conservation and management of the seabird fauna and its habitats is the protection of critical feeding areas and breeding sites. The concentrating of birds near the mouths of only a small number of bays and estuaries, where Polar Cod are likely to be most abundant, suggests that food availability is very limited and is a major determinant in the way that seabird populations selectively use habitat types. Such feeding areas are extremely vulnerable to industrial activities and should be carefully protected. Any environmental changes in these bays and inlets, man-made or natural, could cause severe reductions in the abundance and accessibility of Polar Cod which would undoubtedly lower seabird productivity in the Barrow Strait area.

The site most immediately threatened by the proposed route for a gas pipeline is Cunningham Inlet, Somerset Island. Construction, operation and associated pollution and disturbance will adversely affect seabird populations and their food resources, as will any man-made alteration in patterns of water flow and run-off from adjacent lowlands.

Further studies are required to determine patterns of habitat usage and nutritional requirements of seabirds throughout the breeding season. Detailed information on changes and shifts of preferred feeding areas both within a single season and from year to year is necessary if effective management of this seabird resource is to be achieved.

0969 NORCOR ENGINEERING AND RESEARCH LIMITED - 1975

The interaction of crude oil with arctic sea ice; Beaufort Sea Technical Report No. 27, December 1975, 202 p.

The principal objectives of the study were to assess the impact of an offshore oil well blowout on the thermal regime of the Beaufort Sea, and to evaluate potential countermeasure techniques.

The main program, which consisted of nine controlled discharges involving 54 m^3 (11,900 gallons) of crude oil, was undertaken in a small bay 20 km to the south west of Cape Parry (70°02'N, 124°53'W). Two types of crude were injected under the ice at various stages of growth, between October 1974 and May 1975. The initial spreading and entrainment was documented by means of divers and a remote video system. An array of eleven point thermistor chains was logged hourly to assess the rate of migration and the effect of the oil on the thermal regime of the sheet. Oil, water and ice samples were recovered at regular inter-

vals to determine the degree of weathering and dissolution of the oil. Detailed radiation studies were undertaken in the spring to assess the impact of surface oil on ice depletion. As well, two small discharges were conducted 30 km north of Cape Parry in April 1975, to determine the importance of currents on the transport of oil under solid ice cover. The oil was injected under the ice in the presence of a 10 cm sec^{-1} current, and the movement documented by means of divers.

When oil is released in the water column, it rises towards the surface in a conical shaped plume. The oil tends to be unstable, and breaks into small spherical particles of about 1 cm in diameter or less. On striking the underside of the ice, the oil radiates outward, progressively filling depressions in the sheet. Since most crudes naturally form sessile drops at an ice-water interface, the minimum oil film thickness is about 0.8 cm. Spherical drops of a lesser diameter can exist, but this normally only occurs near the periphery of the contaminated area, where the probability of collision with other drops is small. The maximum film thickness is controlled by the depth of depressions, or variation in ice thickness, which is typically about 20 percent of the average ice thickness. Within a matter of hours of the oil coming in contact with the ice, a lip of ice forms around the lens, preventing horizontal movement. During the depth of winter, a new layer of ice forms beneath the oil within several days. Once entrapped, the oil is stabilized until spring. The properties of the oil remain unchanged and there is little evidence of weathering or degradation.

Throughout the winter, the oil only penetrates between 5 and 10 cm into the loose skeletal layer. As the sheet begins to warm in the spring, activity intensifies in the brine channels and the oil begins to migrate upward. Initially the movement is slow; typically in the range of 15 to 20 cm during the months of February and March. The rate of migration increases with the level of solar radiation and the ambient air temperature. Oil released in late April under 150 cm of ice, was detected on the surface within one hour.

On reaching the surface of the ice, the oil saturates the snow cover, and substantially reduces the albedo. This causes an increase in the level of absorbed solar radiation, which accelerates the process. Oiled melt pools quickly develop. The albedo of an oil film on water is about one quarter that of oiled snow, and consequently the melt is further accelerated. Oil is splashed on the surrounding snow by wind and wave action, and the pools gradually enlarge until interconnected. New oil is continually being released until the melt reaches the initial level of the oil lens. Once melt holes develop and surface drainage patterns are established, the sheet rapidly deteriorates. Depending on the nature and location of the sheet, oiled areas are likely to be free of ice between one and three weeks earlier.

A variety of clean-up techniques were investigated and in situ burning was found to be both the most efficient and effective. A minimum film thickness of about 0.5 cm was required to sustain combustion. Even when heavily weathered, most films could be ignited by sprinkling gasoline on a piece of paper towel. Between June 7 and July 17, 1975, four burns on were conducted in the study area. On the first burn approximately 20 m^3 or 90 per cent of the oil on the surface was removed. The effectiveness of successive burns decreased, due to the reduction in film thickness. Of the 54 m^3 of oil discharged, approximately 15 m^3 evaporated naturally, and 33 m^3 was removed by burning. About 5 m^3 of residue was manually recovered from the ice. This proved to be a very costly and labour intensive operation. Less than three per cent of the oil reached the shore, of which one third was recovered.

In an effort to determine the impact of the tests, detailed physical and biological studies were conducted prior to the first discharge, and after the clean-up. With the exception of a very light oiling of the shingles in the tidal zone over about 900 m of shoreline, there was no evidence of oil in the water column, or deleterious effects on the marine ecosystem.

0970 PARKER, G.R., THOMAS, D.C., BROUGHTON, E., and GRAY, D.R. - 1975
Crashes of muskox and Peary caribou populations in 1973-74 on the Parry Islands, Arctic Canada; *Env. Can.*, Can. Wildl. Serv. Progress Notes No. 56, December 1975, 10 p.

Muskox (*Ovibos moschatus*) and Peary caribou (*Rangifer tarandus pearyi*) populations on eastern Melville, Bathurst, and Byam Martin islands declined sharply in the winter 1973-74. A study of caribou from those islands in March and April 1974 revealed that they (1) were in poor physical condition, (2) had an extremely low pregnancy rate, 7.1%, (3) had no indications of debilitating diseases, and (4) were utilizing habitats where the snow was relatively shallow. Fat in marrow from one-half of the femurs from muskox carcasses found on Bathurst Island in the following summer was below 1%. Of 48 recently-dead muskoxen found on Bathurst and eastern Melville Islands and whose ages were determined, 27 (56%) were over 10 years of age, one was 9 years old and the rest were less than 3 years old. Males comprised 69% of the 42 muskoxen of identified sex.

Severe snow storms which produced hard dense drifts occurred in September and November of 1973. Meteorological records show a record snow depth for Resolute Bay in early spring 1974, and we believe that extreme winter conditions were the main cause of the crash.

0971 PERCY, J.A. - 1975
Ecological physiology of arctic marine invertebrates. Temperature and salinity relationships of the amphipod *Onisimus affinis* H.J. Hansen; *J. exp. mar. Biol. Ecol.*, vol. 20, pp. 99-117.

Effects of temperature and salinity upon the survival, locomotion and metabolism of the Arctic marine amphipod *Onisimus affinis* H.J. Hansen have been investigated. The LD_{50} for

temperature is $\approx 18.7^{o}C$. The metabolic rate-temperature curve shows a distinct plateau of relative temperature insensitivity the position of which varies seasonally to include a lower temperature range in winter than in summer. Similar shifts in the plateau can be induced in the laboratory by acclimating the animals at summer- and winter-like temperatures.

Optimal locomotory activity was between 5^{o} and $8^{o}C$ and included a combination of swimming and crawling. Above $12^{o}C$ the swimming component was increasingly inhibited.

Onisimus is euryhaline and appears to be most successful in brackish water habitats. It tolerates elevated salinities better at low temperatures. The metabolic rate varies inversely with salinity during short-term exposures, but, if the animals are pre-adapted to the experimental salinities for 10 days, the metabolic rate is essentially independent of salinity between $10^{o}/_{oo}$ and $25^{o}/_{oo}$.

The significance of these physiological responses in relation to the general ecology of the species is discussed.

0972 PERCY, J.A., and MULLIN, T.C. - 1975
Effects of crude oils on arctic marine invertebrates; Beaufort Sea Technical Report No. 11, December 1975, 167 p.

Recent developments in the Canadian Arctic have made it increasingly clear that our present understanding of both short and long-term consequences of oil pollution upon Arctic marine ecosystems is far from adequate. It is generally conceded that recovery from a severe ecological disturbance would be a lengthy process in the Arctic. This study addresses itself primarily to the question of just how susceptible certain invertebrate components of the marine inshore ecosystem are to significant disruption by oil pollution.

Physical and biological variables that are likely to play an important role in modifying the ecological impact of a spill are discussed briefly. Marine organisms may encounter varying concentrations and forms of crude oil depending upon habitat and circumstance. Oil-animal interactions in three distinct habitats are considered, namely, the sub-ice, the neritic and the benthic habitats. Biological effects of three general types are examined; short term lethal effects, sublethal physiological effects and sublethal behavioral effects. Considerable variability in the responses of different species occurred in all three categories.

Lethal toxicity studies indicate a relatively high tolerance level for crude oil among most of the species examined. However, a closer examination of the more subtle sublethal effects suggests that the oil is not as benign as it first appears. Activity and metabolism may both be severely impaired by exposure to relatively low oil concentrations. Potential ecological consequences of such sublethal physiological effects are discussed.

Behavioral studies were carried out to investigate the responses of several species to the presence of crude oil masses, crude oil tainted food and crude oil contaminated sediment. None of the species examined were attracted by the oil. Some species such as *Onisimus* avoided oil masses, rejected oil-tainted food and preferentially selected uncontaminated over contaminated sediment. In contrast, other species such as *Mesidotea* were strictly neutral; there was no attraction to or repulsion from oil masses, tainted food was consumed almost as readily as untainted and the animals did not differentiate between contaminated and uncontaminated sediment. Possible long-term ecological consequences of these behavioral responses are discussed in detail.

0973 PERCY, J.A. - 1976
Responses of arctic marine crustaceans to crude oil and oil-tainted foods; *Environ. Pollut.*, vol. 10, pp. 155-162.

The responses of several arctic marine crustaceans to oil masses and oil-tainted food have been investigated. None of the species were attracted to crude oil. Amphipods tended to avoid oil masses; however, the response was significantly diminished if the oil was weathered or if the animals were pre-exposed to light crude oil emulsions. Untainted food was preferentially selected over oil-tainted food. In contrast, an isopod was generally neutral to the presence of oil masses and consumed oil-tainted food as readily as untainted material.

0974 PERCY, R. - 1975
Fishes of the outer Mackenzie Delta; Beaufort Sea Technical Report No. 8, December 1975, 114 p.

Baseline information was gathered in 1974 and 1975 on 23 species of freshwater, anadromous and marine fishes in the outer Mackenzie Delta and nearshore Beaufort Sea. The biological data presented include numerical abundance, summer and winter distributions, nursery areas, food habits, migration and age-length relationships.

The possible impact of offshore exploratory drilling to the fish resources is discussed. Although the major impact would arise from an oil well blowout, the cumulative effects of other disturbance factors, such as seismic activity, disposal of drilling fluids and "housekeeping waters" will also be significant over the long term.

An effective program of monitoring studies for the renewable resources is essential to facilitate the identification and resolution of potentially dangerous environmental problems at the earliest possible stage.

0975 RICHARDSON, W.J., MORRELL, M.R., and JOHNSON, S.R. - 1975
Bird migration along the Beaufort Sea Coast: radar and visual observations in 1975; Beaufort Sea Technical Report No. 3c, December 1975, 131 p.

Bird distribution within and the patterns and timing of movements over the south-central Beaufort Sea and northern Yukon were studied from 9 May to 9 July 1975. Three techniques were used: 1) near-continuous monitoring by the Komakuk, Y.T., DEW radar of the distribution, flight paths, and relative numbers of

birds aloft within 74 km of Komakuk; 2) systematic daily observations of migrating and local birds at two sites on the Yukon coast--Komakuk and Clarence Lagoon (see Johnson *et al.* In Press); and 3) aerial surveys of lengths 326-694 km of the south-central Beaufort Sea on seven dates.

Three main classes of movement were recorded by radar: eastward, westward, and northeastward.

0976 RIEWE, R.R. - 1975
The High Arctic Wolf in the Jones Sound Region of the Canadian High Arctic; *Arctic*, vol. 28, no. 3, pp. 209-212.

0977 RUSSELL, R.H., and EDMONDS, E.J. - 1977
Report on Caribou (*Rangifer tarandus*) and Muskoxen (*Ovibos moschatus*) habitat studies on Prince of Wales and Somerset Islands and Boothia Peninsula, 1975 and 1976; Env. Can., Can. Wildl. Serv. Completion Report for Project TEP-4-1, Arctic Islands Pipeline Program, March 1977, 69 p.

Studies of habitats of caribou (*Rangifer tarandus pearyi* and *R.t. groenlandicus*) and muskoxen (*Ovibos moschatus*) along the proposed pipeline route between Resolute Bay and Spence Bay, Northwest Territories, were carried out in 1975 and 1976 by the Canadian Wildlife Service. Emphasis in 1975 centered on Somerset Island, portions of which are considered vital caribou range by Resolute Bay Inuit. The studies were expanded in 1976 to include Prince of Wales Island and northern Boothia Peninsula.

With the decline of Peary caribou on Bathurst Island (Parker *et al.* 1975, Miller and Russell 1976), the Inuit of Resolute Bay have shifted their caribou hunting from Bathurst to Somerset and Prince of Wales islands. Boothia Peninsula has long been a traditional hunting ground of Spence Bay Inuit. Although not currently harvested the muskoxen population of Prince of Wales Island is potentially valuable as a source of protein and wool.

Prior to AIPP, very little was known regarding what constituted important seasonal caribou and muskoxen habitats. The locations of critical habitats were also largely unknown.

0978 SAMUEL, W.M., and GRAY, D.R. - 1974
Parasitic infection in muskoxen; *J. Wildl. Manage.*, vol. 38, no. 4, October 1974, pp. 775-782.

A study of the parasites of muskoxen (*Ovibos moschatus*) was conducted from June 1969 to August 1972. Fecal samples were examined from 101 captive and 216 wild muskoxen from 11 regions in the United States (Alaska), Canada (Alberta, Northwest Territories, and Quebec), and Norway; eggs and oocysts of eight genera of parasites were found. Two additional genera were recovered during necropsy of six muskoxen. *Capillaria* sp. and *Trichuris* sp. were found only in captive muskoxen suggesting acquisition of infection from domestic or other captive ruminants. *Moniezia* sp. was found commonly only in wild muskoxen suggesting successful control of this parasite through use of anthelmintics. *Moniezia* sp. and *Eimeria* spp. were most prevalent in calves. Prevalence of most parasites was low in March and October, high in June and July. Parasites may pose a problem for captive muskoxen used in domestication and transplanting projects due to acquisition of new parasites and/or the increase in numbers of existing parasites.

0979 SCHWEINSBURG, R.E., and STIRLING, I. - 1976
More research needed to minimize conflicts between men and polar bears; *Oilweek*, vol. 27, no. 5, pp. 54-55.

0980 SEARING, G.F., KUYT, E., RICHARDSON, W.J., and BARRY, T.W. - 1975
Seabirds of the southeastern Beaufort Sea; aircraft and group observations in 1972 and 1974; Beaufort Sea Technical Report No. 3b, December 1975, 257 p.

Data on the distribution and movements of seabirds and other birds in the southeastern Beaufort Sea area were gathered during 1972 and 1974. Data collected during offshore aerial surveys conducted over the Beaufort Sea during 1974 were analysed in relation to ice-cover conditions; the results of such analyses indicated the distributions and movements of birds offshore during a year of above-average ice cover. It was found that the distributions of most species are related to the amount of ice cover present and that birds generally prefer areas of at least partly open water. Maps of species distributions and abundances in relation to ice-cover conditions were prepared for offshore areas.

Densities were calculated for all species and species groups observed during aerial transect surveys. Densities of ducks were found to decrease radically after June; it was speculated that this decrease was related to the timing of the initiation of nesting activities, at which time many ducks move ashore. An overabundance of males in the male/female ratio of eiders remaining offshore after June supported this speculation.

Shipboard observations were also planned for 1974, but due to the extensive ice cover, movement by boat was possible only in the Mackenzie Delta area. Shipboard observations in the study area were made during only two days.

Aerial surveys conducted over the coastal Beaufort Sea area during 1974 provided information on the distribution of some avian species along the coast and in different habitat types. Multiple regression analysis techniques were applied to the results of these surveys in order to develop prediction equations for the number of individuals and number of species occurring on various waterbodies along the coast of the Beaufort Sea; these equations were based on the following variables: date, waterbody type, distance from the coast, and waterbody size.

The results of migration watches conducted during 1972 along the coast, primarily during fall, provided a general overview of the migrational patterns along the coast of many of the species present in the Beaufort Sea area. These

data are presented in relation to the wind conditions that prevailed. Birds that were migrating into headwinds were observed more frequently and in greater numbers than were birds that were migrating with tailwinds. Reasons for this apparent relationship between migrating birds and winds are considered. The limitations of migration watches of this type are discussed. The data were summarized and analysed on a species-by-species basis and are presented in an annotated list of species.

0981 SERGEANT, D.E., and BRODIE, P.F. - 1975
Identity, Abundance, and Present Status of Populations of White Whales, *Delphinapterus leucas*, in North America; *J. Fish. Res. Board Can.*, vol. 32, no. 7, pp. 1047-1054.

White whales, *Delphinapterus leucas*, in the North American arctic number at least 30,000 animals. Largest herds identified are about 10,000 animals in western Hudson Bay, at least as many in Lancaster Sound, and at least 5000 summering in the Beaufort Sea. Hunting in the Canadian arctic has decreased in the last decade from 1000 or more to about 500 annually and is clearly well below sustainable yields except in one locality, Cumberland Sound, where the local population of white whales has never recovered from historic depletion. The species is most vulnerable when concentrated in river estuaries in summer, probably for reproduction. The species' range has shrunk in the St. Lawrence estuary, a change that can be associated with hydroelectric developments in the last decade. The effects of oil exploration, drilling, and island building in shallow water in the Mackenzie Delta are under study, and developments in oil and gas could have an influence on other populations in the Canadian arctic. Tourism related to this species is increasing, without undue disturbance to date.

0982 SMITH, P., and STIRLING, I. - 1976
Résumé of the trade in polar bear hides in Canada, 1974-75; *Env. Can.*, Can. Wildl. Serv. Progress Notes No. 66, August 1976, 7 p.

In 1974-75, the six auction houses dealing in Canadian polar bear hides handled similar numbers of hides as in the past two years. There was a 46% decrease in the number of new hides shipped to the auction sales in 1974-75 because of the large number of unsold hides remaining from the previous season. The Japanese were still the principal buyers. The average price received by the auction houses showed a 60% decrease from 1973 - 74 levels.

The average prices received by the native hunters did not decrease to the same extent which may be a reflection of the increase in local sales. Only two settlements offered a sport-hunt and only two of a possible four bears were taken. A summary of the polar bear kills and quotas by jurisdiction is presented.

0983 SMITH, T.G. - 1975
Parameters and dynamics of ringed seal populations in the Canadian Eastern Arctic; *in* Rapp. P.-v. Réun. Cons. int. Explor. Mer, vol. 269, pp. 281-295.

Field work for this study was begun in 1966 and was terminated in 1970. Two contiguous hunting areas of the east Baffin Island coast were studied, Home Bay and Cumberland Sound. Each area contains an Eskimo village which depends mainly on the ringed seal as a cash crop and as the most constant source of protein for human consumption. In Cumberland Sound the Eskimos are also able to kill approximately 2000 harp seals each summer which adds a considerable sum to their cash income.

The basic biology and life history of the ringed seal has been well described by McLaren (1958a). Although additional data have been gathered on age determination, growth, and reproductive biology, this paper deals specifically with population statistics and dynamics. A discrete deterministic model was constructed which allowed a comparison of the dynamics of the exploited populations with the intrinsic rates derived from a hypothetical unhunted stock. This resulted in the calculation of minimum sustainable yields, which can be used if management of these stocks becomes necessary.

0984 SMITH, T.G. - 1975
Rough-legged Hawks, *Buteo lagopus* (Pontoppidan) as Carrion Feeders in the Arctic; *Can. Field-Naturalist*, vol. 89, p. 190.

0985 SMITH, T.G., and ARMSTRONG, F.A.J. - 1975
Mercury in Seals, Terrestrial Carnivores, and Principal Food Items of the Inuit, from Holman, N.W.T.; *J. Fish. Res. Board Can.*, vol. 32, no. 6, pp. 795-801.

Total mercury analyses were made on liver and muscle of ringed and bearded seals, of caribou, and on muscle of Arctic char (the principal items in the diet of local people), of Arctic fox and sledge dogs (which feed mostly on ringed seal) and on wolves (predacious on caribou). About half of the 123 samples were also analyzed for methyl mercury, and some for selenium.

Ringed seals showed mean total mercury levels of 27 ppm in liver and 0.73 in muscle. Bearded seals showed 143 in liver and 0.53 in muscle. In the livers, methyl mercury was a small fraction of the total, being 5.6% in ringed and 0.38% in bearded seals. There were positive and significant correlations of mercury content with age and body weight. In Arctic char, mean total mercury was 0.049 ppm. and in caribou 0.20 in liver and 0.017 in muscle. In Arctic fox, values for liver and muscle were 0.77 and 0.32, and in sledge dogs 11.5 and 0.79 ppm.

Seals form only part of the diet of the local people. Blood mercury levels have been reported for this community as being above average though not dangerously so. A change in diet, such as increased consumption of seals, might change this.

0986 SMITH, T.G., and GERACI, J.R. - 1975
The effect of contact and ingestion of crude oil on ringed seals of the Beaufort Sea; Beaufort Sea Technical Report No. 5, December 1975, 66 p.

The ringed seal, *Phoca hispida*, is the most abundant and widely distributed of the marine mammal species present in the Beaufort Sea. Because it is available to the Inuit (Eskimo) throughout the year, it has always been the basis of the coastal economy. In modern times it provides cash income from the sale of seal pelts, and is an important and constant source of food. In Canada the natives of Sachs Harbour, Paulatuk, Tuktoyaktuk and to a lesser degree Aklavik, hunt in the Beaufort Sea area. There is also positive evidence that seals in the Amundsen Gulf and Beaufort Sea are part of the same populations. The large seal catches from Holman, on western Victoria Island, must therefore be considered dependent, at least in part, on seal production in the Beaufort Sea.

This paper attempts to evaluate the effects of crude oil on ringed seals primarily, and on harp seal whitecoat pups. Studies were conducted on both the effect of immersion in oil and ingestion of oil on wild and captive seals; there exist few experimental data on the effects of oil on mammals, and none on seals.

0987 SMITH, T.G., and STIRLING, I. - 1975
The breeding habitat of the ringed seal (*Phoca hispida*). The birth lair and associated structures; *Can. J. Zool.*, vol. 53, no. 9, pp. 1297-1305.

The subnivean lairs of the ringed seal (*Phoca hispida*) were studied in the Amundsen Gulf and Prince Albert Sound areas from 1971 through 1974. The structure of several different types of lairs are described. The existence of a birth-lair complex consisting of several closely adjacent lairs appears likely. The spacial distribution of lairs and lair types found on refrozen leads and in pressure ridges is described. Lairs were more abundant in inshore ice than in offshore ice. The function of subnivean lairs appears to be to provide thermal shelter, especially for neonate seals, and protection from predation by arctic foxes (*Alopex lagopus*) and polar bears (*Ursus maritimus*).

0988 SMITH, T.G. - 1976
Predation of ringed seal pups (*Phoca hispida*) by the arctic fox (*Alopex lagopus*); *Can. J. Zool.*, vol. 54, no. 10, pp. 1610-1616.

The arctic fox (*Alopex lagopus*), commonly assigned the role of scavenger of marine mammal remains left by polar bears (*Ursus maritimus*), is for the first time quantitatively described as an important predator of the pups of the ringed seal (*Phoca hispida*). Foxes enter and kill the seal pups in their subnivean birth lairs. In no case were any seals other than pups killed by foxes. While predation was seen to vary over the 3 years of study, an average pup predation of 26.1% in nearshore sea ice is estimated. Estimates of the contribution of seal pups to the fox energy budget are calculated. Newborn seal pups contribute a maximum of 45.2 and a minimum of 30.2 days of maintenance energy. Almost weaned pups provide a maximum of 341.5 and a minimum of 227 days of maintenance energy.

0989 STIRLING, I. - 1974
An overwintering walrus in the Beaufort Sea; *Murrelet*, September-December 1974, 2 p.

0990 STIRLING, I. - 1974
Midsummer observations on the behavior of wild polar bears (*Ursus maritimus*); *Can. J. Zool.*, vol. 52, no. 9, pp. 1191-1198.

Wild polar bears (*Ursus maritimus*) were observed from Caswall Tower, Devon Island (74° 43'N; 91°10'W), from 24 July to 8 August 1973. A total of 602.7 bear hours of observations was recorded. Two types of hunting were observed, stalking and still-hunting. Of 288 hunts observed, 65 (22.6%) were stalks and 233 (77.4%) were still-hunts. All cubs observed hunted, but they exhibited great variety in patience and apparent skill. Scavenging and intraspecific competition for possession of kills were observed. When threatened, adult females with cubs were not subordinate to bears of any other age or sex classes. A diurnal rhythm was recorded in which bears slept most during the latter third of the 24-h cycle and least in the first third. The average of 17 sleeps longer than 60 min was 465±301.3 min.

Basking ringed seals (*Phoca hispida*) alternated between lying flat and raising their heads to look about for predators. The mean duration of the lying and looking phases was 26.3 and 7.0s respectively (n= 591 and 580). The variation between individual seals was greater than within individuals. If a group of seals hauled out together, all individuals maintained watchful behavior; no single animal acted as a "sentry" for the others.

0991 STIRLING, I., ANDRIASHEK, D., LATOUR, P., and CALVERT, W. - 1975
The distribution and abundance of polar bears in the eastern Beaufort Sea; Beaufort Sea Technical Report No. 2, December 1975, 59 p.

This report presents baseline information on the biology, distribution, and abundance of polar bears in the Beaufort Sea; identifies critical feeding and denning areas; and makes recommendations relative to projected industrial activity and future research requirements.

From October 1970 through July 1975, 425 polar bears were tagged in the western Arctic. Subsequent to tagging, 25 polar bears were shot, 51 were recaptured, and 117 sightings were made of tagged bears (with numbers painted on them, up to two months after tagging). Seven polar bears, originally tagged in Alaska were recaptured in Canada and six bears tagged in Canada were recaptured in Alaska, demonstrating that a limited amount of exchange takes place between the two areas. In general however, polar bears tagged within the study area showed a high degree of fidelity to it.

Seasonal movements in the population were largely determined by ice conditions. From freeze-up in the fall through to break-up in the spring, most of the polar bears moved throughout the southeastern Beaufort Sea and Amundsen Gulf. As break-up proceeded, the bears moved north so as to be able to remain with the ice and continue to hunt seals.

Five sea-ice habitat types for polar bears were described. Eighty-seven percent of the sightings of bears were made in two similar types of habitat which occurred in a relatively narrow band parallel to the mainland coast to Cape Parry and off the west coast of Banks Island. This zone of critical feeding habitat overlies much of the offshore acreage currently under lease for future petroleum exploration activities.

The distribution of polar bears varied between years with changes in the abundance and accessibility of the seals they preyed upon. Heavy ice conditions in 1974 stimulated marked changes in seal productivity, distribution and availability which were reflected in lower survival of polar bear cubs and changes in polar bear distribution.

Most maternity denning of polar bears in the western Arctic occurred along the west and south coasts of Banks Island and, to a lesser degree on the western peninsulas of Victoria Island. Little maternity denning occurred along the mainland coast.

Although a small proportion of three and four-year-old female polar bears conceived (≈10%), the onset of sexual maturity appeared to be at five. Theoretically, adult females breed every three years for an annual conception rate of 33.3%. The fact that an annual conception rate of 39.1% was calculated indicated that some females were losing their cubs or suffering intrauterine mortality and consequently were breeding more often than every three years. The mean litter size of the three and four-year-old females (1.16 and 1.33) was also lower than that of the older females (1.66).

The average age of male polar bears killed by Inuit hunters was lower than the average age of male polar bears captured by us. There was no significant difference between the average ages of female polar bears killed by Inuit hunters and those captured by us. The reason that adult females and cubs one year of age and older were so highly represented in the age structure of polar bears killed by Inuit hunters was that the family groups of bears constituted a high proportion of bears present in the most accessible hunting areas and the Inuit harvested the bears non-selectively.

The mortality rates of male and female polar bears three years of age and older, calculated from the age structure of bears captured by us, were 22.5% and 21.5% respectively. The mortality of cubs less than one year of age appeared to be higher in 1974 and 1975 than in previous years. Recorded emigration from the study area was higher in 1975 than in previous years. These latter two results were probably stimulated by a marked reduction in the abundance and accessibility of the seal species preyed upon by the polar bears.

The population of polar bears in the study area in 1974 was estimated as 1,521. Crude estimates of the population size in 1975 indicated that the total could be as low as 1,000 individuals.

Recommendations for the protection of the critical feeding and maternity denning areas were made as were recommendations for future monitoring and research needs.

0992 STIRLING, I., ARCHIBALD, R., and DeMASTER, D. - 1975
The distribution and abundance of seals in the eastern Beaufort Sea; Beaufort Sea Technical Report No. 1, December 1975, 58 p.

The two main seal species which occur in the Beaufort Sea are the ringed seal (*Phoca hispida*) and the bearded seal (*Erignathus barbatus*). Harvest of these seals provides an important part of the Inuit economy. In addition, the seals support the polar bear (*Ursus maritimus*) population of the western Arctic and, to a substantial degree, the arctic fox (*Alopex lagopus*), both of which are also important to the Inuit economy and culture.

In a randomly stratified aerial survey, conducted in 1974, we counted 41,982 ringed seals and 2,759 bearded seals. In an identical survey, conducted in 1975, we counted 21,661 ringed seals and 1,197 bearded seals, which indicated a substantial decline in the total population size. Tests for observer bias in the surveys were negative. Substantial reductions in pup productivity, pup survival, ovulation rate, and pregnancy rate were also recorded in 1974 and 1975, compared with available data from the same population in earlier years and from other studies. It appeared that these changes were caused by abnormally heavy sea ice conditions in 1974. However, the mechanisms by which these changes in environmental conditions stimulated the changes in seal numbers, distribution, and productivity were not clear.

Neither ringed nor bearded seals were distributed randomly over depth but their distributions were different. Bearded seals were more strongly associated with shallow water areas.

Ringed seal pupping habitat is widely distributed in the inshore fast ice areas of the western Arctic. Bearded seal pupping habitat is mainly restricted to the offshore moving lead areas north of the mainland coast and west of Banks Island. Both ringed and bearded seals concentrate in the moving lead areas during the winter.

0993 STIRLING, I., and McEWAN, E.H. - 1975
The caloric value of whole ringed seals (*Phoca hispida*) in relation to polar bear (*Ursus maritimus*) ecology and hunting behavior; *Can. J. Zool.*, vol. 53, no. 8, pp. 1021-1027.

Throughout its circumpolar range, the polar bear (*Ursus maritimus*) feeds predominantly on the ringed seal (*Phoca hispida*). Despite seasonal variation in availability and distribution of seals, polar bears prefer to eat mainly the fat, often leaving substantial portions of seal meat and blubber. In the present study, 12 seals were minced and analyzed for water, fat, protein, and ash contents. The percentage composition varied from 23 to 58% protein, 34 to 76% fat, 2 to 5.5% ash, and 47.4 to 69.5% total body water. The caloric values varied from 2.3 to 5.3 kcal/g wet weight. Relationships between total body water and fat (%), body water (litres) and protein (kg) are presented. These results are discussed in relation to the ecology and hunting behavior of the polar bear.

0994 STIRLING, I., and SMITH, T.G. - 1975
Interrelationships of Arctic Ocean mammals in the sea ice habitat; *in* Proc. Circumpolar Conference on Northern Ecology, September 15-18, 1975, Ottawa, Sponsored by NRC of Can., in assoc. with Can. Nat. Com./Scientific Com. on Problems of the Environment, CNC/SCOPE, pp. 11-129 - 11-136.

Integration of our long-term studies of polar bears (*Ursus maritimus*) and ringed seals (*Phoca hispida*), and our less intensive studies of bearded seals (*Erignathus barbatus*) and arctic foxes (*Alopex lagopus*), has resulted in considerably more insight into their basic ecology and interspecific relationships than the usual single species approach. This paper reports on: the extent and significance of predation and scavenging to the individual species; variation between years in productivity and distribution that may be caused by changes in the environment; new approaches to the collection of population data; and, critical areas for future investigation.

0995 STIRLING, I., PEARSON, A.M., and BUNNELL, F.L. - 1976
Population ecology studies of polar and grizzly bears in Northern Canada; *in* Transactions of the 41st North American Wildlife and Natural Resources Conference, Wildlife Management Institute, Washington editors; pp. 421-430.

Polar bears (*Ursus maritimus*) and grizzly bears (*Ursus arctos*) are two of the most spectacular large mammals in North America. Both bears have a high value to the public, are prized as game animals by sport hunters, and have significant resource value to native people. Although neither species is imminently in danger of total extinction in Canada, subpopulations of both are vulnerable to local, and possibly more widespread, extinction as a result of overhunting or major changes in their environment. For this reason, the Canadian Wildlife Service, in conjunction with the Provinces and Territories, has been involved in active research on the population ecology of both polar and grizzly bears to facilitate better management and ultimately, the survival of the species (see reviews in Pearson 1972; Stirling and Jonkel 1972).

Our research has three broad objectives: (1) estimation of the size, reproductive rates, age structures and mortality rates of various subpopulations, or ecotypes, to enable us to make the best possible management recommendations; (2) evaluation of the effect of changes in the pattern of harvest, habitat, or environmental conditions, on reproduction, survival, and distribution; and eventually (3) modeling of all necessary data to evaluate the usefulness of various parameters to predict population size, reproduction, or survival in a sufficiently dynamic fashion to provide a useful tool for management.

0996 STIRLING, I., SCHWEINSBURG, R.E., and KILIAAN, H.P.L. - 1976
Polar bear research along the proposed Arctic Islands gas pipeline route; Progress Report to Environmental Management Service, Dept. Env., Edmonton, Alta., 32 p.

The objective of this study is to provide baseline information on polar bears, as part of an overall environmental study which the Federal Government may use to assess the proponent's application to build a gas pipeline from the high arctic islands to southern Canada. Limited funds precluded extensive field work in 1975. Some data had already been collected coincidentally in part of the area of concern by independently funded studies in earlier years. This report gives a preliminary summary of the data available on the distribution, movements of tagged bears, locations of maternity denning and summer sanctuaries, and age structures of polar bears captured or killed in the study area. We note that staging areas, the shoreline at each end of the channel crossings, and some parts of the coastlines of islands represent areas of potential conflict because of their importance as maternity denning or summer sanctuary areas. Between the winters of 1967-68 and 1974-75, polar bears probably accounted for about half a million dollars in cash income to the Inuit hunters that hunt polar bears from subpopulations that might be affected by the proposed pipeline.

0997 STIRLING, I., and ARCHIBALD, W.R. - 1977
Aspects of Predation of Seals by Polar Bears; *J. Fish. Res. Board Can.*, vol. 34, no. 8, pp. 1126-1129.

Data were collected from 227 ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) killed by polar bears (*Ursus maritimus*) in the western arctic and the eastern high arctic. During periods of high ringed seal productivity, pups constituted at least half of the seals killed in both areas during the spring. Bearded seals were taken less often than ringed seals in both areas but were more important as prey to polar bears in the western arctic. Carcass utilization was significantly higher in the eastern high arctic than in the western arctic although the reason was not apparent. Scavenging of unutilized seal remains is probably of great importance to the survival of large numbers of arctic foxes (*Alopex lagopus*) through the winter.

0998 STIRLING, I., ARCHIBALD, W.R., and DeMASTER, D. - 1977
Distribution and abundance of seals in the Eastern Beaufort Sea; *J. Fish. Res. Board Can.*, vol. 34, no. 7, pp. 976-988.

The objectives of this study were: (1) to design a statistically reliable method for surveying ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) that could be repeated and (2) to obtain baseline information on the distribution, abundance, and general biology of ringed and bearded seals in relation to other mammals in the pack-ice ecosystem of the Eastern Beaufort Sea.

Because of the limitations encountered in aerial surveying during the period of optimum haul out, and the heterogeneous environment, we employed a stratified design incorporating a weighted linear regression model. Identical surveys, conducted from June 15 to 29, 1974 and from June 12 to 20, 1975, showed a significant decline in numbers of both seal species in 1975. This conclusion was supported by other independent observations. Observer bias

in sighting and identifying the species of seals was tested for and rejected. Neither species was distributed randomly over the heterogeneous habitat but the degree of clumping was different. In general, bearded seals preferred shallower areas and ringed seals deeper ones.

When the seal population declined, the reproductive rates of both species dropped markedly and young of the year virtually disappeared from the population. The reduction in numbers of seals stimulated a major change in reproductive rates of the polar bears (*Ursus maritimus*) and arctic foxes (*Alopex lagopus*) that depend upon them for food, and the bear and fox populations decreased in size.

Some possible causes of the decline are discussed. This unprecedented variability in the stability of the marine ecosystem has serious management implications.

0999 TANNO, K. - 1975
Permafrost and Invertebrates; *in* Joint Studies on Physical and Biological Environments in the Permafrost; Alaska and North Canada, June to July, 1974, Inst. Low Temp. Sci., Hokkaido Univ., Japan, pp. 127-143.

A study was made as to the distribution of soil-inhabiting invertebrates in permafrost in the North American Arctic. Field work was in Ibyuk Pingo at Tuktoyaktuk, Canada, from June to July, 1974.

BARROW A polygon is a topographic feature of tundra where its soil has been elevated into a mound by frost action. Abundant individuals of nematodes were found in troughs, covered with grasses (*Dupontia spec.*), located between two polygons. Collembola were abundant (7.9/cm^2) in high central parts of the polygons covered with lichen, and were less (0.2/cm^2) under grasses. The mean thickness of melted layers was 14 cm in the lichen area, and 6 cm in the grass area, in the late June. Within a depth of 2 cm 92.5 per cent of soil-inhabiting invertebrates occupied a microcosm.

TUKTOYAKTUK The pingo observed had the dried top, where no vegetation was seen. The population density of soil-inhabiting invertebrates was 0.2/cm^2 in the top, and was 39.1/cm^2 in the foot of the pingo covered with much vegetation prodominated by shrub birch, *Betula glandulosa*. Abundant individuals of soil-inhabiting invertebrates were also found in wet troughs located along the slope of the pingo. There was no difference in the distribution of soil-inhabiting invertebrates and vegetation between the north and the south slope of the pingo.

1000 THOMAS, D.C., RUSSELL, R.H., BROUGHTON, E., and MADORE, P.L. - 1976
Investigations of Peary caribou populations on Canadian Arctic Islands, March-April 1975; *Env. Can.*, Can. Wildl. Serv., Progress Notes No. 64, June 1976, 13 p.

We collected 46 Peary caribou (*Rangifer tarandus pearyi*) from two populations on six Canadian Arctic islands in March-April 1975, the second year of a 3-year ecological study.

All 21 caribou collected on the Parry Islands were over 4 years of age but only 8 of 23 (two were not aged) obtained on the Peel Islands (Prince of Wales and Somerset) were that old. Subcutaneous, mesenteric and femur marrow fat reserves were depleted or low in samples from the Parry Islands but all three reserves were excellent, except in two individuals, in our sample of caribou from the Peel Islands. Mean percentage fat in the femur marrows was 32.4 and 88.4 in the populations. Only 1 of 15 adult females was pregnant in our sample from the Parry Islands; 11 of 12 adults and 4 of 5 yearlings were pregnant in our other sample.

Our data suggest that fertility in Peary caribou is closely linked to physical condition, which in turn is largely dependent on availability of forage in winter. Our data also suggest that Peary caribou are slow to recover from malnourished states.

Measurements of long bones in the hind leg indicate that both populations are Peary caribou although we found some significant between-island differences in physical attributes.

Rumen analyses indicate that mosses, *Luzula* spp. and other monocotyledons, *Saxifraga oppositifolia*, *Salix* spp. and several lichen species were most frequently eaten. We believe that mosses are accidently ingested with preferred species.

1001 WACASEY, J.W. - 1974
Biological oceanographic observations in the Eskimo Lakes, Arctic Canada I. Zoobenthos Data, 1971-1973; *Fish. Mar. Serv.* Tech. Report No. 475, 69 p.

Data on benthic invertebrates were obtained from grab samples taken at 20 selected stations in the Eskimo Lakes, Arctic Canada, during 1971-1973. The results, which apply to individual stations, consist of collecting data, lists of species with their density and biomass, and related data determined from mechanical and chemical analyses of sediments.

1002 WACASEY, J.W. - 1974
Zoobenthos of the Southern Beaufort Sea; *in* The Coast and Shelf of the Beaufort Sea, eds. John C. Reed and John E. Sater, Arctic Inst. N. Amer., pp. 697-704.

In July 1973, 17 samples were collected by grab from inshore areas of the Beaufort Sea from Cape Dalhousie to Herschel Island in water depths from 3 to 94 m in order to obtain baseline information on zoobenthos. Each sample consisted of five grabs with a total surface area of 0.25 m^2. The number of species, their density, and their biomass were determined from invertebrates that were retained after washing the substrate through a 0.5-mm screen.

The fresh water from the Mackenzie River mixes with the salt water of the Beaufort Sea, and the effects of this dilution are evident in the southern Beaufort Sea. The physical and biological data demonstrate estuarine conditions in water depths to 15 m, which depth may occur up to 24 km offshore as far as Shingle Point to the west and almost to Cape Dalhousie to the east. Near the bottom, the water salinity gradually increases and the temperature

decreases with distance and depth offshore from the channel outlets of the river. The freshwater influence, however, is greater to the east along the Tuktoyaktuk Peninsula. In shallow depths zoobenthic diversity is low, with one to 33 species; biomass is also low, averaging 2.6 g dry meat weight per m^2 on bottoms with water salinities below 25 $^0/_{00}$ and temperatures above 1°C. In depths over 30 m, zoobenthos diversity is higher, with 36 to 51 species; biomass is also higher, averaging 58.9 g north of Cape Dalhousie and 9.5 g near Herschel Island. In these arctic marine habitats the salinity of the water near the bottom ranges from 30 $^0/_{00}$ to 33 $^0/_{00}$, and the temperature is below 0°C.

1003 WACASEY, J.W. - 1975
Biological productivity of the southern Beaufort Sea: zoobenthic studies; Beaufort Sea Technical Report No. 12b, December 1975, 39 p.

Baseline data obtained from a sampling program carried out from 1971 through 1975, primarily during the open water season, demonstrate the existence of zonation of zoobenthos across the shelf of the southern Beaufort Sea. These zones, which can be characterized physically and biologically, are designated: (1) Estuarine Zone, (2) Transitional Zone, (3) Marine Zone, and (4) Continental Slope Zone.

The Estuarine Zone, which exhibits salinities under 20 $^0/_{00}$, is located in waters of depths up to 15 m along the shore from Herschel Island to Cape Dalhousie at the tip of Tuktoyaktuk Peninsula. Positive temperatures may occur seasonally. Diversity is less than 20 species per station and biomass averages 2g m^{-2}. Biomass is highest (average of 5g m^{-2}) in Mason Bay. Most species in this zone are restricted to waters of low salinity. Echinoderms are conspicuously absent from this zone.

The Transitional Zone is located between the Estuarine Zone and the Marine Zone at water depths of 15-30 m, where salinities fluctuate between 20 and 30 $^0/_{00}$. Positive temperatures may occur seasonally. Diversity is over 20 species per station and biomass averages 5g m^{-2}. Species in this zone are largely a mixture of estuarine and marine species. Echinoderms are present in this zone, as in the succeeding zones.

The Marine Zone is located in water depths from 30 to 200 m, where salinities range from 30 to 33 $^0/_{00}$, and water temperatures are negative. Diversity is over 20 species with a maximum of 81 species at stations in the eastern part. Biomass averages 34g m^{-2} with maximum values of 71g m^{-2} at stations in the eastern part. Very few of the many species in this zone are found in the Estuarine Zone.

The Continental Slope Zone is located at depths of 200 to 900 m. Salinities range from 34 to 35 $^0/_{00}$ and water temperatures are slightly higher than in the Marine Zone, reflecting characteristics of Atlantic Ocean water which covers the bottom of the continental slope in the arctic. Diversity is over 20 species per station and biomass averages 4g m^{-2}. Although Marine Zone species are represented, the characteristic species of this zone are those that are absent or rare in the Marine Zone.

Approximately 337 species have been identified from the study area. Average biomass is estimated to be 6g m^{-2}.

The factors that regulate distribution and abundance of zoobenthos are not definitely known. On the shelf of the southern Beaufort Sea some probable factors of significance, without specifying zonal applicability, are salinity, stability of environment, and nutrients.

Exploratory drilling on the continental shelf of the southern Beaufort Sea is regarded as having little impact on the zoobenthos. Damage can be assessed in terms of biomass per area and size of area jeopardized. Although the greatest biomass of zoobenthos would be damaged in the eastern sector of the Marine Zone, the most vulnerable areas are protected embayments because zoobenthos and substrate in these areas would be more disposed to contact with large quantities of oil in the event of a spill.

BOTANY

1004 BABB, T.A. - 1972
The effects of Surface Disturbance on Vegetation in the Northern Canadian Arctic Archipelago; unpub. M.Sc. Thesis, Univ. Alberta.

A combination of surface manipulation experiments on Devon Island, N.W.T. and extensive investigations of disturbance on other High Arctic islands was undertaken. These provided information in a variety of habitats on the physical and biological effects of removal of vegetation by blading or vehicle movement, spillage of diesel fuel, animal grazing, and fertilization.

Surface energy relations on artificially bladed and control plots on Devon were determined, and thaw depth and soil temperature profiles at disturbed sites on other islands were measured. Results indicate that although albedo decreases, soil heat flux and subsequent thaw are affected relatively little by removal of vegetation. This is partly due to lower air and permafrost temperatures than in the Low Arctic, and therefore to higher latent and sensible heat losses, especially to the atmosphere, but downward as well.

Soil stability is low during summer months because of steep moisture gradients associated with permafrost, especially on fine-grained soils.

Diesel fuel spilled at low intensities on meadow and beach ridge habitats on Devon Island killed exposed photosynthetic parts of vascular plants and mosses, but did not measurably affect lichens. Plants recovered partially the year following treatment because of the protection of many perennating buds shielded by exposed plant parts. The effects of treatment on soil microbiota are not known.

Bi-weekly clipping of graminoids in a meadow community decreased above-ground yield by 20-30%. It is thought that greater decreases in

yield will occur in subsequent years.

Treatment of beach ridge and meadow habitats on Devon with nitrogen, phosphorus, and potassium fertilizers showed that nitrogen and phosphorus increases production in many native species. There is an apparent mutual enhancement of effect by the two elements in combination. Potassium is thought to have no effect. It is not known whether the plant community changes which result from fertilization would be desirable on a long-term basis.

1005 BARNETT, D.M., DREDGE, L.A., and EDLUND, S.A. - 1976
Terrain characteristics - Cornwallis and adjacent islands, Northwest Territories; *Geol. Surv. Can.*, Open File No. 457.

This is a preliminary draft of a photomosaic map (semi-controlled) with a brief descriptive legend. A 3-level hierarchial system of characterization is used that integrates botanical information with the geological data. An expanded legend that further evaluates the data is in preparation for release at a later date. The map deals with parts of NTS map-areas 58 F (Resolute), 58 G (Baillie-Hamilton Island), 68 E (Lowther Island), and 68 H (McDougall Sound) at a scale of 1:125 000.

1006 BARNETT, D.M., DREDGE, L.A., and EDLUND, S.A. - 1976
Terrain inventory: Bathurst, Cornwallis, and adjacent islands, Northwest Territories; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 201-204.

1007 BARRETT, P.E., and THOMSON, J.W. - 1975
Lichens from a High Arctic Coastal Lowland, Devon Island, N.W.T.; *THE BRYOLOGIST*, vol. 78, no. 2, pp. 160-167.

One hundred eighty-two lichen taxa are reported from a coastal lowland area on Devon Island, N.W.T. One hundred thirty-two of these are reported from the island for the first time. The comparatively rich lichen flora in this limited area is attributed to the wide diversity of habitats available within the lowland system.

1008 BLISS, L.C., and KERIK, J. - 1973
Primary production of plant communities of the Truelove Lowland, Devon Island, Canada - rock outcrops; *in* Primary Production and Production Processes, Tundra Biome, Bliss, L.C. and F.E. Wielgolaski (eds.); Tundra Biome Steering Committee, Edmonton, Alta., pp. 27-36.

Within the Canadian Arctic, much of the landscape consists of low rolling terrain, well covered with vegetation in much of the Low Arctic but with a much sparser plant cover in the High Arctic. Rocky terrain with a predominance of dwarf shrub heath communities is relatively common on the Pre-Cambrian Shield of the eastern Low Arctic. In the High Arctic, heath communities are a minor feature and are often restricted to rock outcrop masses and the lower slopes of raised beach ridges where snow melts 1 to 3 weeks later than in the surrounding land. This is especially true in the eastern islands (Baffin, Devon, Axel Heiberg, and Ellesmere Islands) where *Cassiope tetragona* dominates many of the sites.

Within the Truelove Lowland, rock outcrops comprise 12.4% of the 43 km^2 area. Their importance is enhanced because they provide habitat for collared lemming, snow buntings, short-tailed weasel, and muskox.

The objectives of the study were: (1)to determine the kinds of plant communities present; (2) to determine their standing crop and net annual production; and (3) to gather some data on floristic diversity and plant phenology. Field work was conducted in 1972 and 1973.

1009 BLISS, L.C. - 1975
Devon Island, Canada; Structure and Function of Tundra Ecosystems; T. Rosswall, and O.W. Heal (eds.); *Ecological Bull.*, No. 20, Swedish, pp. 17-60.

In the Lowland seven major topographic-plant community units are recognized with several subdivisions. Many of the biological data are presented in relation to the land area of these units. Of these, hummocky sedge-moss meadows, raised beaches including the transition zone to meadows, and the rock outcrops were studied most intensively.

1010 BLISS, L.C. - 1975
Tundra grasslands, herblands, and shrublands and the role of herbivores; *Geoscience and Man*, vol. X, April 20, 1975, pp. 51-79.

Arctic, subantarctic, and alpine tundras, polar deserts, and nival zones are seldom considered as grasslands or cold steppes, but in many of them sedges, grasses, or rushes predominate. In addition, grazing animals, both mammals and birds, predominate, although their biomass, production efficiency, and species diversity are small. Various arctic and alpine tundras are used extensively by domestic reindeer, sheep, and cattle. The objectives of this paper are (1) to describe grass- or sedge-dominated arctic and alpine tundras, (2) to discuss the ecological role of herbivores in some of these tundra systems, and (3) to present information on a High-Arctic ecosystem concerning the functional role of small and large herbivores in this ecosystem.

1011 GRACE, B., and GILLESPIE, T. - 1977
A study of lichen distributions and microclimates in the Mackenzie Valley, N.W.T.; Atmospheric Env. Serv., internal report, 162 p.

More than a decade ago the northern Mackenzie Valley was referred to as the centrum of population, economic activity and transportation facilities in extreme northwestern Canada. Accelerated activities associated with oil and gas exploration since that time have confirmed this statement. The rapid exploration and development of the Canadian north has directed much attention to the subject of environmental safeguards in this region. One aspect of this concern is the control of air quality, especially in relation to the petroleum industry.

In an attempt to set air quality criteria for sulphur dioxide emissions in the Mackenzie

Valley, lichens have been used as indicators of vegetation sensitivity. Many studies have shown extreme sensitivity of lichens to atmospheric pollutants and have been reviewed by Puckett (1974). Ferry *et al.* (1973) and more recently Tuerk *et al.* (1974) and Nieboer *et al.* (1975) have examined the sensitivity of lichens to atmospheric pollution and noted the dependence of sensitivity on environmental parameters such as temperature and atmospheric humidity.

The objectives of the present study were to investigate the ecological importance of tericolous macrolichens in the Mackenzie Valley, to examine a rationale for a preliminary model describing time periods when lichens would be moist and hence susceptible to sulphur dioxide fumigations, and to collect the necessary microclimatic data for the purposes of building such a model.

0949 HSIAO, S.I.C. - 1976
Biological productivity of the southern Beaufort Sea: phytoplankton and seaweed studies; Beaufort Sea Technical Report No. 12c, March 1976, 99 p.

1012 JORDAN, C., MERRICK, R., COURTIN, G.M., NOSKO, P., and PEARSON, D. - 1975
Devon Island Research Station 1975; *Arctic*, vol. 28, no. 3, p. 226.

0953 KINOSITA, S. - 1975
General outline of joint studies on physical and biological environments in the permafrost, Alaska and North Canada, June to July, 1974; *in* Joint Studies on Physical and Biological Environments in the Permafrost, Alaska and North Canada, June to July, 1974, Inst. Low Temp. Sci., Hokkaido Univ., Japan, pp. 1-32.

1013 MAYO, J.M., DESPAIN, D.G., and VAN ZINDEREN BAKKER, Jr., E.M. - 1973
CO_2 assimilation by *Dryas integrifolia* on Devon Island, Northwest Territories; *Can. J. Botany*, vol. 51, no. 3, pp. 581-588.

In situ measurements of CO_2 assimilation by *Dryas integrifolia* at different stages of development and under different environmental conditions were made on Devon Island, Northwest Territories. *Dryas* can fix CO_2 in excess of respiration over a 24-h period under conditions of clear nights and cloudy days. The maximum net assimilation rate measured was 4.2 mg g^{-1} dry weight h^{-1}. The maximum amount of CO_2 fixed in 24 h was 61.54 mg g^{-1} dry weight. Maximum net assimilation occurred at 8 to 10°C leaf temperatures. Positive net assimilation occurred at 1°C leaf temperature. Light compensation was shown to be less than 0.04 langley min^{-1}. Leaf temperatures were always greater than ambient. The maximum leaf temperature measured was 39°C. Net assimilation rates appear to decrease as the season progresses.

1014 MUC, M. - 1973
Primary production of plant communities of the Truelove Lowland, Devon Island, Canada-sedge meadows; *in* Primary Production and Production Processes, Tundra Biome, Bliss, L.C. and F.E. Wielgolaski, eds., Tundra Biome Steering Committee, Edmonton, Alta., pp. 3-14.

Sedge meadows are the predominant plant communities in the Truelove Lowland, occupying approximately 41% of the lowland ecosystem. In order to accurately describe the role of these meadows in the total bioenergetics of the Lowland, it was most practical to divide them into three main sedge meadow community types, even though a more thorough phytosociological treatment was already available. Community refers to a unit of vegetation having a distinct pattern in the lowland ecosystem. Community type refers to two or more meadows possessing similar floristic and physiognomic features.

1015 MUC, M. - 1975
Ecology and primary production of high arctic sedge-moss meadows, Devon Island, N.W.T., Canada; unpub. Ph.D. Thesis, Univ. Alberta.

Sedge-moss meadows were the dominant (41%, 1767 ha) Truelove Lowland plant community. They developed along a distinctive increasing moisture gradient ('dry' - wet) and constituted three basic community types: frost-boil, hummocky, and wet sedge-moss meadows. Monocots (primarily sedges) were the predominant community plants and provided the major portion of the plant biomass and cover. *Carex stans* Drej. was the dominant meadow species and was intensively studied from a number of autecological aspects. The studies reported in this thesis represent 1 - 4 seasons of data.

Frost-boil meadows were only partially (58%) vegetated and possessed prominent but poorly vegetated mineral frost-boils. Hummocky meadows were totally vegetated and had a distinctive hummock/hollow physiography. The more uniform topography and plant cover of the wet meadows developed as a result of the seasonal flooding found in these habitats. Community vascular plant composition, microclimate, soil, and physiographic data were collected in representative meadow stands of each community type and provided the data for inter-community comparisons.

Vascular plant cover ranged from 58 - 86% and community stem densities ranged from 1100 - 2200 stems/m^2. The potential meadow growing season averaged 50 days (45 - 55) and although plant growth began immediately after snowmelt (late June - early July), it did not reach its peak development until early to mid-August. Meadow plants showed a net positive tiller total leaf increment for only a 20 - 40 day interval over the potential growing season. Growth ceased 2 - 3 weeks before the onset of extended periods of inclement weather. Meadow flowering rates were low (<10%) and reflected the previous season's growth conditions.

Sedge-moss meadow standing crops and primary production peaked by early to mid-August. Monocots, primarily *Carex stans*, contributed the major (85 - 95%) portion of the community biomass and primary production. Peak season average total biomass ranged from 821 g/m^2 (frost-boil meadow) to 2316 g/m^2 (hummocky meadow). Of the total biomass, 80 - 90% was

of belowground structures. The majority (85%) of the root biomass was concentrated in the upper 20 cm of the soil profile. Of the total root biomass 52% consisted of live root material. Total seasonal productivity averaged 87 g/m^2 (frost-boil meadow) to 174 g/m^2 (wet meadow) and reflected an increasing habitat moisture ('dry' - flooded) gradient. Belowground net primary production was 150% higher than the aboveground production.

Seasonal community chlorophyll and photosynthetic leaf area indices paralled the development of the aboveground biomass. Peak community chlorophyll levels ranged from 162 mg/m^2 (frost-boil meadow) to 283 mg/m^2 (wet meadow) and the corresponding green tissue leaf area indices were 0.31 and 0.38. The hummocky meadow, as a result of its higher (70 - 100%) stem densities had a green leaf area index of 0.63.

Sedge carbohydrate levels ranged from 17 - 24% of the total tiller weight. Tiller carbohydrates exhibited a characteristic early season depletion of belowground reserves in maintaining aboveground growth and a corresponding late season belowground translocation to compensate for these deficits. Reproductive sedge tillers possessed larger aboveground and corresponding lower belowground carbohydrate levels than did non-reproductive tillers.

Woody plants had the highest (>5000 cal/g) and monocots the lowest (<4750 cal/g) energy content of any of the meadow plants. Seasonal energy content of the plants varied by less than 2%. Variation in tissue chemical levels were on the order of 15 - 20%. Forb materials had chemical levels 85% higher than those in comparable monocot and woody plant tissues. Live aboveground tissues on the average maintained chemical levels 120% higher than those in dead and in belowground structures.

The lowland sedge-moss meadows were the most extensively vegetated and most productive plant communities in the Truelove Lowland. These high arctic meadows are merely latitundinal extensions of their low arctic counterparts and when compared to similar low arctic meadow communities their plant biomass and physiological parameters were lower (*ca.* 50%).

Meadow soil moisture was the most important environmental factor and had a positive affect on both community biomass and production. Meadow plants appeared highly efficient in their utilization and conservation of limited nutrient and energy resources. An ability to 'internally control' the extent of seasonal growth so as to maintain a consistent growth level from year to year, was another successful adaptive strategy used by the meadow plants. The ability of the meadow plants to accommodate the severity of the high arctic environment was a major contribution to their ecological success and importance in the high arctic ecosystem.

1016 PAKARINEN, P., and VITT, D.H. - 1973
The major organic components and caloric contents of high arctic bryophytes; *Can. J. Botany*, vol. 52, no. 6, pp. 1151-1161.

Thirty-five bryophyte species representing the major habitats of a high arctic tundra lowland (Devon Island, Canada, 75^{o}N) have been analyzed for contents of nitrogen, carbon, ash, and ether- and alcohol-soluble fractions. Mean contents (%) for the green portion of these species are total nitrogen, 1.00(1.08 ash-free); total carbon, 45.9(48.7 ash-free); ether-soluble fraction, 2.8(3.0 ash-free); alcohol-soluble fraction, 11.8(12.5 ash-free); and ash, 5.7. In the hydric species group, the total nitrogen content and the alcohol-soluble fraction are significantly greater than in mesic or Xeric groups. When the green and brown segments are compared, the nitrogen content and the alcohol-soluble fraction are greater in the green portion, while the ash content is higher in the brown portion. The ash-free caloric values of hydric species range from 4.57 to 4.97 kcal/g, while the mesic and xeric species have a range from 4.50 to 4.69 kcal/g. The relations between habitats and between the green and brown portions are discussed in relation to general metabolic activity and productivity.

1017 PAKARINEN, P., and VITT, D.H. - 1973
Primary production of plant communities of the Truelove Lowland, Devon Island, Canada - moss communities; *in* Primary Production and Production Processes, Tundra Biome, Bliss, L.C. and F.E. Wielgolaski (eds.); Tundra Biome Steering Committee, Edmonton, Alta., pp. 37-46.

The objectives of the bryophyte studies on Devon Island in 1971-1972 were twofold: first, to study moss production using the harvesting method in a few intensive sites (mainly meadows) and secondly to study the variation in bryophyte vegetation and nutrient contents in the whole lowland to allow extensions of the data gathered in intensive sites. This paper describes the bryophyte vegetation of all the major habitats in the Truelove Lowland, gives the estimates of moss production and growth in wet sites for the 1971 season, and presents the results of nutrient analyses of bryophytes in different habitats.

1018 PRICE, L.W., BLISS, L.C., and SVOBODA, J. - 1974
Origin and Significance of Wet Spots on Scraped Surfaces in the High Arctic; *Arctic*, vol. 27, pp. 304-306.

1019 RICHARDSON, D.H.S., and FINEGAN, E.J. - 1973
Primary production of plant communities of the Truelove Lowland, Devon Island, Canada - lichen communities; *in* Primary Production and Production Processes, Tundra Biome, Bliss, L.C. and F.E. Wielgolaski (eds.); Tundra Biome Steering Committee, Edmonton, Alta., pp. 47-56.

Lichens are found colonising soil and pebbles on the beach ridges and also on rocks in the rock outcrops. Areas of heath vegetation between the rocks are termed inter-outcrop areas and lichens form an important part of this vegetation. Lichens were studied at the intensive beach ridge site (age *ca.*7,500 years, King 1969) which is predominantly of granitic gravel and in the intensive rock outcrop site which is also granitic. Some comparative work

was done on an extensive beach ridge (3,300 years) nearer to the sea where the substrate is mainly limestone.

1020 SAKAI, A., YOSHIDA, S., and SAITO, M. - 1975
Ecological characteristics of forests on permafrost; *in* Joint Studies on Physical and Biological Environments in the Permafrost, Alaska and North Canada, June to July, 1974, Inst. Low Temp. Sci., Hokkaido Univ., Japan, pp. 95-126.

The northern region of the boreal forest zone of Alaska comprises woodlands of primarily open, slow-growing black spruce with occasional dense, well-developed forest stands and treeless bogs. This type of regional vegetation is referred to "taiga", as is differentiated from the closed, fast-growing forests of the more southerly region of the zone. The distribution of the various features such as forests, bogs, and shrubs is closely related to the altitude, slope, drainage, presence or absence of permafrost, and to the past history of forest fires, which apparently have been prevalent throughout the history of development of the taiga.

Permafrost and vegetation exist in a delicate equilibrium. The distribution of vegetation is largely related to the permafrost, or lack of it, while to some extent the distribution of permafrost is related to the presence of vegetation. Also, the aspect and slope are of special importance in the distribution of vegetation and soils.

There are two general types of tree succession in both Alaska and Canada. They relate in a large degree to the presence or absence of permafrost or at least of poorly drained soils. On warm, well-drained sites such as south-facing slopes and river sides, the usual forest vegetation is made up of white spruce, paper birch, aspen, balsam poplar, or some combination of these species. Hardwood stands are replaced by white or black spruce, but the process is a slow one. As the fall of balsam or aspen leaves becomes lesser and as the litter of spruce accumulates, a continuous and thick moss mat develops under the stand. The insulating effects by a thick layer of moss under the stand account for delayed thawing and cooler soil temperatures. As thawing becomes progressively slower in the soil, a permafrost layer develops in a flat land not far from a river. This prevents drainage and creates a wetter soil on which Sphagnum mosses may develop. Moss growth is rapid, and tree growth becomes slower either as a result of cooler soil temperatures or the water-logged nature of the soil. Since these conditions favor the growth of black spruce over white spruce, the former becomes established in the stands. As succession continues, the permafrost layer rises closer to the surface. When the organic layer has developed sufficiently, the mineral layer may be entirely frozen and all tree roots become located in the organic layer. Then the black spruce and Sphagnum mosses attain the climax stand, finding optimum conditions for their growth. Thus, on the warmest, well-drained sites where no permafrost occurs or the active layer is thick, the forests consist of closed spruce-hardwood stands, namely, white spruce, paper birch and aspen. On poorly drained sites, including north-facing slopes, flats and plateaus which are underlain by permafrost, the black spruce-Sphagnum moss association is predominant. Black spruce is one of the tree species well adaptable to permafrost.

The best sites for tree growth were found to be on south-facing slopes and in river sides. However, the height of trees growing on permafrost seems to be restricted below about 15 m.

In Inuvik, paper birch (*B. papyrifera*) is the only predominant broad-leafed deciduous species. The annual production of paper birch was investigated in the birch stands growing on earth hummocks on a south-facing slope with an inclination of about 10 degrees in Inuvik. The total biomass was estimated at 74.5 ton/ha, with 1.7 in leaves. Net primary productivity of above-the-ground parts was estimated at 2.16 ton/ha/year with only 0.42 (20%) in the trunk, 0.06 (2%) in the branch, compared with 1.68 (78%) in the leaves. The annual net production was very low and 22% of the products was apportioned to the organs of photosynthesis of the trees. The results probably represent nearly the minimal value for deciduous woodland and show a characteristic of annual production of deciduous tree species growing near tree lines.

1021 SCHULTEN, R.B. - 1975
Some Flowering Plants of the Devon Island Lowlands; *Arctic*, vol. 28, no. 2, pp. 92-98.

When the massive ice sheet of the last Pleistocene glacier melted 10,000 years ago, land which had been forced below sea level under its weight began to rise, and the receding water left behind rows of beach ridges and shallow depressions. On the northern shore of Devon Island in the Canadian Arctic, there is an area of such lowland about 40 square kilometres in extent. It is bounded in the north and west by Jones Sound and in the south by the Truelove Inlet and River, while to its east lies an escarpment 1000 ft (300 m) high separating it from the upland plateau of the interior of the Island and the remains of its ice cap.

From the base of the escarpment to the sea, this lowland area is a treeless terrain of lakes and ponds separated by grassy meadows and rocky beach ridges, dissected by meandering melt streams. During the summer, many of the meadows are wet and muddy, retaining a good deal of standing water during the short growing season. The raised beach ridges are dry and pebbly along their tops, becoming progressively moister as they slope down towards the meadows and ponds. The flowers described and illustrated in this article are all to be found growing in this lowland area.

1022 STUTZ, R.C. - 1973
Nitrogen Fixation in a High Arctic Ecosystem; unpub. Ph.D. Thesis, Univ. Alberta.

Biological nitrogen-fixation was studied on Truelove Lowland, Devon Island, N.W.T., in three different habitats. Raised beach ridges,

resulting from post-glacial uplift, form well-defined xeric habitats which are dominated by dwarf shrubs and cushion plants. Hummocky meadows dominated by sedges, mosses and forbs compose the second intensively studied habitat. Water-logged meadows of moss and sedge were studied less intensively.

Nitrogen-fixation was estimated using acetylene-reduction assay. Incubation temperatures were moderated by immersing the incubation jars in water or burying them in a soil pit (10 cm) on site.

Soil algae populations were estimated by correlating field microscopic observations with dilution culture.

Available nitrogen was determined by microkjeldahl analysis of KCl soil-extracts.

Symbiotic nitrogen-fixation by vascular plants is nil on Truelove Lowland, One lichen species, *Peltigera aphthosa*, reduced acetylene (5.1 uumoles.$mg^{-1}.hr^{-1}$). *Nostoc commune*, a prominent blue-green algae on meadow soils, reduced acetylene at a rate 10 times that of *P. aphthosa*.

Soil algae populations were measured as high as 9.3×10^4 cells. g $soil^{-1}$ on beach ridges and 5.0×10^5 cells.g $soil^{-1}$ on meadows. *Nostoc* sp. usually accounted for 50 to 90% of the algal flora. Based on population data, acetylene-reduction data and hourly soil surface temperature data, soil algae were estimated to fix 14 ug $N.m^{-2}.yr^{-1}$ in meadows.

Nitrogen-fixation was greatest at the anaerobic-aerobic interface in soils, and was a function of anærobic bacteria. Nitrate nitrogen applied to the soil at a rate of 1 ppm decreased fixation 56%. Normally nitrate is absent from these soils. The rate of fixation responded exponentially to temperature with an apparent Q_{10} of 5.6. An estimated 30 and 7 mg $N.m^{-2}.yr^{-1}$ was fixed on the beach ridges in 1971 and 1972 respectively, and 190 and 65 mg $N.m^{-2}.yr^{-1}$ was fixed on the meadows in the same years.

1023 STUTZ, R.C., and BLISS, L.C. - 1974
Nitrogen fixation in soils of Truelove Lowland, Devon Island, Northwest Territories; *Can. J. Botany*, vol. 53, no. 14, pp. 1387-1399.

Biological nitrogen fixation was studied on Truelove Lowland, Devon Island, N.W.T., in three different habitats. Raised beach ridges, resulting from postglacial uplift, form well-defined xeric habitats, which are dominated by dwarf shrubs and cushion plants. Hummocky sedge meadows with associated mosses and forbs comprise the second intensively studied habitat. Waterlogged wet sedge meadows with moss were studied less intensively.

Nitrogen fixation was estimated using acetylene-reduction assay. Incubation temperatures were moderated by burying the jars in soil pits (10 cm) on site.

Available nitrogen was determined by microkjeldahl analysis of KCl soil extracts.

Symbiotic nitrogen fixation by vascular plants is nil on Truelove Lowland. One lichen species, *Peltigera aphthosa*, reduced acetylene (5.1 uu mol·mg^{-1}·h^{-1}). *Nostoc commune*, a prominent blue-green alga on meadow soils, reduced acetylene at a rate 10 times that of *P. aphthosa*. An estimated 30 and 7 mg $N·m^{-2}.year^{-1}$ was fixed by bacteria and soil algae in beach ridge soil in 1971 and 1972 respectively, and 380 and 120 mg $N·m^{-2}.year^{-1}$ was fixed in meadow soils in the same years.

1024 SVOBODA, J. - 1973
Primary production of plant communities of the Truelove Lowland, Devon Island, Canada - beach ridges; *in* Primary Production and Production Processes, Tundra Biome, Bliss, L.C., and F.E. Wielgolaski (eds.), Tundra Biome Steering Committee, Edmonton, Alta., pp. 15-26.

Raised beach ridges occur in a stepwise sequence across the Truelove Lowland, the result of isostatic recovery after deglaciation. They are several hundred meters long, vary from 30 to 150 m in width, are frequently curved, and account for 13.2% of the total lowland area. They are formed of sand, sedimentary sandstone, dolomite, and granitic gravel.

Ridges are one of the prominent topographic features on the lowland, with much ecological significance. They are free of snow usually by mid-June, while the adjacent meadows become snow-free 1 to 2 weeks later. Being relatively well-drained and exposed to the wind, they are considered the driest and climatically most severe habitat on the lowland, and form a transition to the true Polar Desert on the upland plateau of the island. These habitats are ecologically related to the cushion plant dominated Polar Semi-Deserts of the western islands. Maximum active layer depth is 100 cm on the crest but only 40 to 60 cm in the ridge-meadow transition.

1025 SVOBODA, J. - 1974
Primary production processes within polar semi-desert vegetation, Truelove Lowland, Devon Island, N.W.T., Canada; unpub. Ph.D. thesis, Univ. Alberta.

Plant communities, their production and some production processes were studied on raised beaches in the High Arctic, Devon Island for three years. Historical prospectives of the site and area are outlined. On crests and slopes of these beaches a cushion plant-lichen community is present while the "foot" of the beach which forms a transition to the adjacent meadow is occupied by a cushion plant-moss community. Soil, microclimate, vascular plant phenology, growth and distribution of vascular plants across the raised beach were also studied. Vascular plant cover is low, *ca.* 20% on crests and 60% in transitions, and so are aboveground and belowground standing crop (350 - 400 $g.m^{-2}$) and seasonal production (*ca.* 22 $g.m^{-2}$). Chemical analyses of soil and plants showed a low content of some minerals (N, P, K) but a high content of Ca.Carbohydrate levels were very low (*ca.* 1 to 3%) in cushion plants but relatively high in soft herbs (*ca.* 30%). Also, chlorophyll, lipids and other compounds were analysed. *Dryas integrifolia* was chosen for more detailed autecological study and served as representative species of the community in respect to form and function. Raised beach

ridges were recognized as a Polar Semi-desert habitat, autonomous and genuine in microclimate as well as vegetation.

1026 TARNOCAI, C., BOYDELL, A.N., NETTERVILLE, J.A., and DRABINSKY, K.A. - 1977
Biophysical land classification, Boothia Peninsula and Northeast Keewatin; *Geol. Surv. Can.*, Open File No. 390.

Preliminary drafts of 17 biophysical land classification maps (scale 1:125 000) of Boothia Peninsula and adjacent northeast Keewatin (NTS 57 A-G, 58 D,E, G) showing the distribution of landforms, soils and vegetation. Legend information includes data on soil type and texture, drainage, ground ice conditions and vegetative cover. An explanatory text (31 pages) describes the project objectives and methodology and the area's ecoregions, ecodistricts, landforms, soils, vegetation and terrain sensitivity.

1027 TEERI, J.A., and BARRETT, P.E. - 1975
Detritus transport by wind in a high Arctic terrestrial ecosystem; *Arctic and Alpine Res.*, vol. 7, no. 4, pp. 387-391.

In a High Arctic lowland ecosystem wind transported organic matter is frequently deposited in late snowbank habitats on the slopes of raised beachridges. Analysis of this detritus indicates its principal source is the adjacent snow-free beachcrest. In some snowbank locations this wind transported detritus may account for 10 to 20% of the yearly accumulation of organic matter and may provide an additional supply of nutrients.

1028 WEIN, R.W., and RENCZ, A.N. - 1976
Plant cover and standing crop sampling procedures for the Canadian High Arctic; *Arctic and Alpine Res.*, vol. 8, no. 2, pp. 139-150.

Vegetation types on Melville and Bathurst islands in the Canadian Arctic Archipelago were sampled for plant cover and standing crop to determine the most efficient sampling methods and to recommend procedures for surveying large areas of the High Arctic. Vegetation types ranged from polar deserts to meadows. The estimation of plant cover from color positive film and the point method proved to be the most efficient methods. The polar desert communities were up to 10 times more variable than the wet meadows. Standing crop estimations ranged from a low of 5 g m^{-2} for a polar desert stand to a high of 4078 g m^{-2} for a wet moss-sedge meadow. The most efficient sample plot sizes were small (25 x 50 cm or 20 x 100 cm) rather than large (20 x 100 cm or 50 x 100 cm). Four times as many samples were required to sample polar deserts as wet meadows.

1029 WOO, M., and MARSH, P., - 1977
Effect of vegetation on limestone solution in a small High Arctic basin; *Can. J. Earth Sci.*, vol. 14, no. 4,(Part 1); pp. 571-581.

To evaluate the effect of tundra vegetation on limestone solution processes, the present study was carried out in a small basin in southwestern Ellesmere Island, N.W.T. A test reach was selected along the stream, and water samples were collected at regular intervals from a seepage point entering the reach, a soil water pit at the bottom of a vegetated slope along the test reach, and from the stream at the outlet of the reach. Hydrochemical characteristics of the samples were described by several measured and calculated variables including water temperature, pH, calcium and total hardness, bicarbonate concentration, equilibrium partial pressure of carbon dioxide, and indices of saturation with respect to calcite and dolomite. Throughout the growing season of 1975, all samples indicated higher concentrations in water hardness and in bicarbonate than those reported in nonvegetated areas of the Arctic. A rising trend was apparent in these data, with the concentrations reaching a seasonal maximum in late summer. These phenomena are attributed to the production of biogenic carbon dioxide, which increased the aggressiveness of the water. The partial pressure of carbon dioxide in soil water was directly increased by this process, while the addition of soil water to the stream caused noticeable downstream increase in partial pressure of carbon dioxide and a corresponding reduction in saturation with respect to calcite and to dolomite. The influence of vegetation was therefore very marked in both surface and in subsurface flows.

1030 ZOLTAI, S.C., and TARNOCAI, C. - 1975
Perennially frozen peatlands in the western Arctic and subarctic of Canada; *Can. J. Earth Sci.*, vol. 12, no. 1, pp. 28-43.

Perenially frozen peatlands were divided into five morphological types; peat plateaus, polygonal peat plateaus, palsas, fen ridges and lowland polygons. One hundred and eight different peatlands were cored, measured and sampled. The internal structure of all but the lowland polygons suggests that the peat was deposited in wet fens unaffected by permafrost, and that permafrost developed only after a thin layer of Sphagnum covered them. The lowland polygons evolved in a permafrost environment. The study area was divided into four regions on the basis of predominance of different peatlands forms.

1031 ZOLTAI, S.C., and WOO, V. - 1976
Soils and vegetation of Somerset and Prince of Wales Islands, District of Franklin; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1B, pp. 143-145.

CLIMATOLOGY

1032 ALT, B.T. - 1975
The energy balance climate of Meighen Ice Cap, N.W.T.; *Polar Cont. Shelf Proj.*, vols. 1 & 2, 168 p.

Data obtained during the summers of 1968 to 1970 on Meighen Island, N.W.T. were combined with three years of existing observations to

investigate the climate and synoptic regime of the area, and to obtain values of the energy balance components for Meighen Ice Cap. Creation of a Synoptic Energy Balance Diagram permitted analysis of the interaction of meso and synoptic scale influences with the energy balance and hence mass balance of the Ice Cap.

The existence of Meighen Ice Cap, although precarious, stems from the Island's small size and its position on the edge of the Polar Ocean surrounded by expanses of ice covered sea. The Ice Cap is maintained by suppression of melt resulting from advection of cool thin cloud and fog from the Polar Ocean, and by the spring and summer accumulation associated with Cyclonic System Conditions. There is evidence that it originated following the Climate Optimum during a period dominated by such Cyclonic System Conditions.

1033 BERRY, M.O., DUTCHAK, P.M., LALONDE, M.E., McCULLOCH, J.A.W., and SAVDIE, I. - 1975

A study of weather, waves and icing in the Beaufort Sea; Beaufort Sea Technical Report No. 21, December 1975, 143 p.

The objective of this study is to provide a description, based on analyses of historic data, of weather and wave conditions which could be significant to offshore operations in the Beaufort Sea. Except where noted, the area of study lies between the Yukon-Alaska border and Amundsen Gulf, extending from the coast of the most northerly extent of open water.

Part I: In this part of Technical Report No. 21 the problem of estimating extreme winds in areas of sparse data is discussed, with particular reference to the Beaufort Sea. Alternative approaches to the problem are described briefly. Based on an analysis of data from three coastal locations, extreme wind values are presented for offshore areas. Values are given for various return periods and durations. The analysis suggests that the distribution of extreme winds is relatively uniform over southern and eastern portions of the area of interest. In the northwest, where the wind regime is virtually unknown, extreme values may differ from those presented.

Part II: The work described here was carried out by Dames and Moore, Consulting Engineers, along lines specified by the Atmospheric Environment Service (AES). The evaluation by AES of an earlier study suggested that the latter underestimated the probability of extreme events, particularly during the meteorologically unstable autumn period. While portions of the final report by Dames and Moore have been given limited distribution, it would be possible to consult the complete report by arrangement with the AES.

The approach used by the consultant is described in some detail in the following sections, which are quoted essentially verbatim from their report, except for minor editing mainly to delete reference to figures which are not included in this presentation.

Part III: This portion of Technical Report No. 21 contains a description of visibilities, wind temperatures and ceilings which can be expected to occur in the June to October period in the Beaufort Sea. The description is based on weather observations from ships and coastal stations.

Part IV: The effects of icing on ships and the hydrometeorological variables conducive to its formation are presented.

Empirical relationships developed by Dr. H.O. Mertins to relate ice accretion rates to wind, speed, air and sea temperatures are applied to Cape Parry and Sachs Harbour data to estimate superstructure icing and its severity in the Beaufort Sea.

The total number of selected ice accretion rates, and their maximum and average durations are displayed in tabular form. An extreme Gumbel distribution analysis is performed, and ice accumulations for selected return periods are derived.

The study shows that conditions conducive to the accretion of substantial amounts of superstructure icing occur in the Beaufort Sea, and that these conditions may pose hazards to offshore operations.

Part V: The intent of this study was to look in detail at various storms affecting the Beaufort Sea area and to draw for this series of case studies, conclusions about the formation, motion, and dissipation of the several types of storms.

With this in mind, seven storms were investigated. Detailed descriptions of these are included in an appendix. Seven is an inadequate number for division into classes and any generalizations are dangerous, but some conclusions can tentatively be given. More case studies would, of course, enhance the value of this report, but time did not permit them to be made. The nature of the report, however, is such that further studies can be made at any time by anyone interested and the results combined with those presented here.

1034 BROWN, R.J.E. - 1973

Influence of climatic and terrain factors on ground temperatures at three locations in the permafrost region of Canada; *in* North American Contribution Permafrost, Sec. Inter. Conf., July 13-28, Yakutsk, U.S.S.R., ed. Nat. Acad. Sci., Washington, D.C., pp. 27-34.

Regular periodic measurements (at least monthly) of ground temperatures are being taken by the Division of Building Research, National Research Council of Canada, at three locations in northern Canada to assess the influence of climatic and terrain factors on permafrost. These are Thompson, Manitoba (55°48'N, 97°52'W), situated in the southern part of the discontinuous permafrost zone, Yellowknife, Northwest Territories (62°28'N, 114°27'W), in the northern part of the discontinuous permafrost zone, and Devon Island (76°N), located in the Canadian Arctic Archipelago (Queen Elizabeth Islands) in the northern part of the continuous zone. Ground temperature measurements with thermocouple cables down to the 15-m depth

in various types of terrain are being taken at these locations and analyzed to determine the range of mean annual ground temperatures that may exist at any one site in the permafrost region.

1035 COGLEY, J.G., and McCANN, S.B. - 1976
An exceptional storm and its effects in the Canadian High Arctic; *Arctic and Alpine Res.*, vol. 8, no. 1, pp. 105-110.

Heavy precipitation fell over the eastern Queen Elizabeth Islands on July 21-23, 1973; 54.6 mm fell at Vendom Fiord, south central Ellesmere Island. The rainfall at Vendom Fiord was associated with a depression which had moved over the rest of the archipelago without producing unusual precipitation. None of the official weather stations in the region reported exceptional amounts, yet there is evidence that the record from Vendom Fiord was representative of a much larger area. The storm was responsible for inundation of flood plains, reworking of coarse alluvium, and rapid mass movements on slopes in the locality of Vendom Fiord, and it is possible that it was the catalyst for a glacier outburst flood (jökulhlaup) which issued from an ice-dammed lake 10 days later. Depressions which impinge upon the mountains of the eastern High Arctic merit further climatological attention.

1036 CONWAY, F.J. - 1976
A summer climate study for Barrow Strait, N.W.T.; unpub. M.Sc. Thesis, McGill Univ., 128 p.

Variations in the time of the breakup of the ice cover of Barrow Strait are investigated by simulations of the ice sheet, considering radiative and atmospheric turbulent energy exchanges. It is demonstrated that the variations can be largely attributed to differences in the rate of energy accumulation. By means of a synoptic typing technique, it is shown that these rate differences can be directly connected to synoptic conditions, at least as regards period means.

In this investigation, only meteorological observations from Resolute are used, though it has been suggested that this station is not representative of the region around it. A preliminary study, using observations from ships and scientific camps in the area, shows that this is a reasonable approach, though some reservations must be retained.

1037 FISHER, D.A. - 1976
A study of two $\delta(O^{18})$ records from Devon ice cap, Canada, and comparison of them to Camp Century δ record, Greenland; unpub. Ph.D. Thesis, Geophysical Isotope Laboratory, Copenhagen, Denmark, 287 p.

Basic information is given about the Devon ice cap, the bore holes, the data available from them and the organization of this data. O^{18} concentration in precipitation is related to climate and other factors. These factors are discussed in reference to ice cores and a schema laid down to represent their various contributions.

1038 FISHER, D. - 1977
Final report on the melt feature stratigraphy from the Devon Island Ice Cap drill site; *Polar Cont. Shelf Proj.*, internal report, 33 p.

In high altitude regions such as the Devon bore hole site, 1835 masl., where melted snow percolates down and refreezes on site, the amount of melt m_H, cm of ice yr^{-1}, is related in a complicated way to the average summer air temperature, T_S (June, July, August). At any given depth or time interval the percent, by weight, of melt features can be determined from the ice cores by measuring a vertical crossection for the area covered by these features relative to the total area of the core interval.

1011 GRACE, B., and GILLESPIE, T. - 1977
A study of lichen distributions and microclimates in the Mackenzie Valley, N.W.T.; Atmospheric Env. Serv., internal report, 162 p.

1039 KOERNER, R.M., and TANIGUCHI, H. - 1976
Artificial radioactivity layers in the Devon Island ice cap, Northwest Territories; *Can. J. Earth Sci.*, vol. 13, no. 9, pp. 1251-1255.

Bomb-produced radioactive fall-out layers are evident in the firn at the top of the Devon Island ice cap and also lower down in a zone where accumulation is in the form of re-frozen melt-water. This allows 1963-1974 snow accumulation (positive balance) gradients for the same period to be determined on sub-polar ice caps in Canada.

1040 KOERNER, R.M. - 1977
Devon Island Ice Cap: Core Stratigraphy and Paleoclimate; *Science*, vol. 196, no. 4285, pp. 15-18.

Valuable paleoclimatic information can be gained by studying the distribution of melt layers in deep ice cores. A profile representing the percentage of ice in melt layers in a core drilled from the Devon Island ice cap plotted against both time and depth shows that the ice cap has experienced a period of very warm summers since 1925, following a period of colder summers between about 1600 and 1925. The earlier period was coldest between 1680 and and 1730. There is a high correlation between the melt-layer ice percentage and the mass balance of the ice cap. The relation between them suggests that the ice cap mass balance was zero (accumulation equaled ablation) during the colder period but is negative in the present warmer one. There is no firm evidence of a present cooling trend in the summer conditions on the ice cap. A comparison with the melt-layer ice percentage in cores from the other major Canadian Arctic ice caps shows that the variation of summer conditions found for the Devon Island ice cap is representative for all the large ice caps for about 90 percent of the time. There is also a good correlation between melt-layer percentage and summer sea-ice conditions in the archipelago. This suggests that the search for the northwest passage was influenced by changing climate, with the 19th-century peak of the often tragic exploration coinciding with a period of very cold summers.

1041 MACKAY, J.R. - 1976
Ice-wedges as indicators of recent climatic change, Western Arctic Coast; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 233-234.

1042 MacKINNON, P.K. - 1976
The oxygen isotope technique and its application to ice and sea cores; unpub. manuscript, Carleton Univ., 117 p.

This paper centres on an examination of the oxygen isotope technique and its application to deep ice and deep-sea cores. The ratio of O^{18}/O^{16} is temperature dependent. Thus, examination of stratigraphic samples of ice and deep-sea sediment by this method yields a pattern of temperature variation over time. An interplay between changing ice volumes and ocean levels is reflected in O^{18}/O^{16} curves. Deep-sea sediments show a systematic sequence of up to eight oscillations similar to that preserved in present day ice sheets. The methods of dating both ice and deep-sea sediment will be examined. For this it will be shown that the age and shape of the O^{18}/O^{16} curve for the last 'Ice Age', as preserved in glacial ice, is similar in duration and character to each of the cycles in deep-sea sediments. Thus, evidence will be provided to show that glaciation in the Pleistocene has been a long lasting phenomenon, exceeding the classical terrigenous glacial record.

1043 MARKHAM, W.E. - 1975
Ice climatology in the Beaufort Sea; Beaufort Sea Technical Report No. 26, December 1975, 87 p.

This report consists of four separate studies concerned mainly with ice climatology in the southern Beaufort Sea. The first, based on a study of twenty years' of historical ice charts, describes the variation of ice concentration with the time of year for six regions with different ice regimes. The second describes the motion of individual ice floes relative to the wind. The third describes a reasonably accurate method for predicting the gross features of the northward retreat of the polar pack ice in the Beaufort Sea and the fourth is an examination of the size of ice floes within various ice concentration ranges near the edge of the polar pack.

1044 MÜLLER, F. - 1970
Automatic climatological recording stations in remote areas; *in* Can. Hydrology Sym. No. 7, Instrumentation and Observation Techniques, Victoria, B.C., October 8-9 1969, pp. 205-217.

Some experience with two types of automatic climatological stations, established in a glacierized basin of the Canadian High Arctic, is presented as an example of one of their many applications in remote areas. Some other designs are also reviewed, and the need for further development of protection against the severity of the environment is stressed.

1045 MÜLLER, F., BLATTER, H., BRAITHWAITE, R., ITO, H., KAPPENBERGER, G., OHMURA, A., SCHROFF, K., and ZUST, A. - 1975
Glaciological and Climatological Investigation of the North Water Polynya in Northern Baffin Bay; A progress report on North Water Activities, October 1, 1974 to September 30, 1975, internal report, 149 p.

During more than three years activity (July 1972 to September 1975) the North Water project has generated enormous quantities of data and samples for analysis. Analyses will go far in fulfilling the scientific objectives of the project and in defining areas for future investigation. Furthermore the project has provided and will continue to provide raw data (mainly meteorological and sea ice) to the meteorological services of Canada and Denmark.

1046 MÜLLER, F. - 1976
North Water; *Ice*, No. 50, pp. 13-14.

1047 MÜLLER, F. - 1976
Problems of an Arctic Polynya - the North Water; *in* Proc. Sym. on Geography of Polar Countries, 23rd Intern. Geographical Conference, Leningrad, U.S.S.R., 22-26 July, 1976, pp. 52-55.

North Water, one of the major polynyas of the North American Arctic is located in Smith Sound in northern Baffin Bay. The existence of the polynya has been known since the early 17th century and has attracted several scientific expeditions in the last 100 years. The precise location, size and surface characteristics, which are all continually changing, remained, however, only vaguely known. In particular, the mechanisms of its formation and effect upon the surrounding climate and glaciers were little understood.

1048 MÜLLER, F., BACHMANN, W., BERGER, P., BLATTER, H., BRAITHWAITE, R., CRAWFORD, J., DUTTER, C., ITO, H., ITO, S., KAPPENBERGER, G., MÜLLER, H., OHMURA, A., SCHRIBER, G., SCHROFF, K., SIEGENTHALER, H.U., ZUST, A., and WEISS, J. - 1976
Glaciological and Climatological Investigations of the North Water Polynya in Northern Baffin Bay; A Report on North Water Project Activities, October 1, 1975 to September 30, 1976, internal report, 128 p.

During the period 3 April to 12 September 1976 field work has been carried out as part of a continuing field study. However, the highest priority of the project is now the analysis of data and samples collected during the intensive field work of 1972-74 and, on a reduced scale, in 1975. The 1976 field programme involved continuation of routine climatological, glaciological and sea ice programmes on a reduced scale together with repetitions of the isotope sampling and sea ice dynamics programmes. The performance of the OTT automatic weather stations during the 1975-76 winter was encouraging.

1049 MÜLLER, F., OHMURA, A., and BRAITHWAITE, R - 1976
On the climatic influence of North Water; *in* Proc. Sym. on Geography of Polar Countries, 23rd Intern. Geographical Conference, Leningrad U.S.S.R., 22-26 July, 1976, pp. 55-58.

The climatic effect of a polynya such as North Water has long been speculated upon. The accurate understanding and quantitative assessment was, however, delayed due to the lack of climatological data of such a region in winter. The present article summarizes the analyses of the surface weather records and the aerological data collected during the three years 1972 to 1975 by the North Water Project of McGill University. Three manned stations located at Cape Herschel (78°54'N, 74°43'W, near northern end of polynya), Coburg Island (75°54'N, 79° 02'W, western edge) and Carey Islands (76°44'N, 73°11'W, within the polynya) were supplemented by six automatic weather stations situated within travelling distance of the manned stations.

1050 MÜLLER, F., and SCHROFF, K. - 1976
Experience with three types of automatic climatological recording stations in remote areas; paper presented at Reading, England, September 1976.

After defining the term "remote areas", the scientific goals are described of the three research projects for which automatic weather stations were needed. The three basically different types of automatic weather stations tested and used in the field in the Canadian and Greenland arctic (approx. 80° N) and on a mountain top in the Swiss Alps are: a) analogue strip chart and digital recorder (Rauchfuss, Australia), b) digital magnetic-tape recorder (Plessey, U.K.), and c) digital punch-tape recorder (Ott, Germany).

Basic design requirements for the stations (battery-power supply, unattended operation for long periods, light-weight for man-hauling, and low cost) are discussed. The development and evaluation phase started in 1965 on Axel Heiberg Island; the operational phase began in 1972 when nine Ott and one Rauchfuss stations were installed for year-round data collecting in the North Water area.

The three types of stations with their gradual improvement to the present models are described including field experiences, particularly with the Ott and Rauchfuss stations, and discussion of the problems of power supply, insulation, field installation and calibration as well as the very serious implications of sensor riming is presented. Finally, data recovery rates and procedures for data evaluation are considered. A notable amount of handcollected data is available for comparison.

1051 OHMURA, A. - 1975
Heat balance and meso-climate; *Ice*, No. 47, p. 6.

1052 OHMURA, A., and MÜLLER, F. - 1976
A numerical experiment on the effect of the North Water Polynya on the meso-scale temperature and humidity fields and atmospheric circulation; *in* Proc. Sym. on Geography of Polar Countries, 23rd Intern. Geographical Conference, Leningrad, U.S.S.R., 22-26 July, 1976, pp. 58-61

The basic problems relating to the North Water polynya in northern Baffin Bay, namely (1) the magnitudes of the sensible and latent heat fluxes and the shear stress at the surface, (2) the extent of the airmass modification, (3) the contribution of the polynya to cyclogenesis and precipitation, are discussed in detail by F. Müller et al. (1973) and F. Müller (in this volume). An effective method of attempting solution of these problems is by numeric experiment with a thermodynamic atmospheric model. The present paper describes the main features of the two-dimensional, six-layer moist model which generates cloud layers and precipitation fields. First results of this experiment using realistic Arctic winter boundary conditions as obtained through field observations are presented.

1053 PATERSON, W.S.B. - 1976
Climatic interpretations from glacier ice cores; *Abstract in* American Quaternary Assoc., Abstracts of the fourth biennial meeting, October 9 and 10 1976, Tempe, Arizona, pp. 16-19.

The oxygen isotope ratio (δ) in precipitation depends on the temperature at which the precipitation formed. Thus a core drilled through a polar ice cap contains a record of past temperature variations. For time periods of the order of 100,000 years, this technique provides a record of climatic fluctuations more detailed than any other available at present. Interpretation of isotope variations in terms of temperature is not always straightforward however, and, in addition, derivation of a time scale for the core presents problems. Some of these difficulties will be discussed and illustrated by comparison of data from two cores from the Devon Island ice cap (Arctic Canada) and the core from Camp Century (Greenland).

1054 PATERSON, W.S.B. - 1976
Vertical strain-rate measurements in an arctic ice cap and deductions from them; *J. Glaciology*, vol. 17, no. 75, pp. 3-12.

Closely spaced measurements of diameter of thermally drilled bore holes reveal a pattern of small variations. These patterns serve to identify points on the bore-hole wall; thus the change in length of sections of bore hole can be determined as a function of time. This method has been used to measure vertical strain-rate as a function of depth in two bore holes near the crest of the Devon Island ice cap. The measured strain-rate, corrected for firn compaction, varies significantly with depth. The vertical component of velocity at the surface was determined from the contraction rate of a bore hole that penetrated to the base of the ice. Comparison of this velocity with the present accumulation rate suggests that the ice cap, in the vicinity of the bore hole, is thickening slightly at present. The age of the ice at various depths, as calculated from the measured vertical velocities, is in broad agreement with radio-carbon dates covering the past 6000 years. This suggests that the flow of the ice cap has not varied significantly over this period, and thus that the present accumulation rate, which is causing thickening, is slightly above the average for the period.

1055 PATERSON, W.S.B., KOERNER, R.M., FISHER, D., JOHNSEN, S.J., CLAUSEN, H.B., DANSGAARD, W., BUCHER, P., and OESCHGER, H. - 1977
An oxygen-isotope climatic record from the Devon Island ice cap, arctic canada; *Nature*, vol. 266, no. 5602, pp. 508-511.

Isotope measurements on two adjacent cores through the Devon Island ice cap provide a well-dated climatic record for the past 5000 yr. Fluctuations in annual values include much 'noise', and ice flow over a rough bed produces distortions in the lowest 5% of core which covers roughly 120,000 yr. Comparison with the Camp Century, Greenland, record helps to separate climatic changes from changes in ice thickness or flow pattern.

1056 SCHRIBER, G., STAUFFER, B., and MÜLLER, F. - 1975
$^{18}O/^{16}O$- and ^{3}H-measurements on precipitation and air moisture samples from the North Water Area; paper presented at the Symposium on Isotopes and Impurities in Ice, 16th General Assembly of the I.U.G.G., Grenoble, September 1975.

From 1972 until 1974 a mesoclimatic study was conducted in the North Water area with the aim to find an explanation for the existence of this polynya between North Greenland and Ellesmere Island and to analyse the influence of this open water on its surroundings.

To support the meteorological program an isotope study was carried out: At Coburg Island, Carey Island and Cape Herschel precipitation and air moisture were systematically collected. The analysis of all samples collected from November 1972 to May 1973 on Coburg is complete. In the precipitation samples the $^{18}O/^{16}O$ and D/H ratios as well as the tritium content were measured, on the air moisture samples the $^{18}O/^{16}O$ ratios were determined.

The data obtained from the precipitation and air moisture samples show remarkable correlations with the temperature, however the air moisture samples may be affected by isotopic fractionation during collection.

The isotopic data suggest that approximately 25% of the precipitation is of local origin.

1057 SCHROFF, K. - 1975
Automatic weather stations; *Ice*, No. 47, p. 6.

1058 SMITH, M.W. - 1975
Numerical simulation of microclimatic and active layer regimes in a High Arctic environment; *Indian and Northern Affairs*, North of 60, ALUR 74-75-72, INA Publication No. QS-8039-000-EE-A1, 29 p.

Field data are being gathered to evaluate a computer simulator which predicts microclimatic and ground thermal regimes from routine weather information and site-specific radiative, aerodynamic, thermal and hydrologic characteristics. From these data the model synthesizes the local surface energy budget and the surface temperature which is used as the boundary condition in the soil thermal diffusion equation. The predictive capability can be used as a basis for land use decisions.

Field measurements of energy budget components and ground temperatures are being used to test the accuracy of predictions. Two natural sites, one wet and one dry, near Eureka, N.W.T., have been fully instrumented. At another two disturbed sites ground temperatures are being measured.

The spring snowmelt event is very well duplicated by the model with predictions closely matching the observations for the start and finish of melt. Active layer thicknesses reach a maximum in mid-August, with mean values of 30 cm at the wet site and 52 cm at the dry site. The model predictions are 29 cm and 53 cm respectively, also by mid-August. The pattern of freezeback is also well duplicated. The zero-curtain period lasts for about four weeks at the wet site but less than two weeks at the dry site. The predicted sequences match this fairly well, except that they lag by about five days throughout. Removal in July, 1973 of a 10-cm surface layer at the wet site led to a 10-cm thickening of the active layer in mid-August. Simulation of this disturbance yielded an almost identical result. The effects of winter snow compaction were also investigated through simulation, the results showing that there is negligible carry-over effect on summer ground temperatures.

Model predictions of mean daily net radiation under naturally cloudy skies are within 5% of observed values.

1059 WALKER, E.R. - 1975
Oil, ice and climate in the Beaufort Sea; Beaufort Sea Technical Report No. 35, December 1975, 40 p.

The amount of crude oil which may be released to the environment during drilling in the Beaufort Sea is estimated. The effects of oil in terms of the Beaufort Sea surface heat budget are briefly discussed. Considering the amount of oil likely to be released in exploratory drilling, its movement, and its effect on the surface heat budget, it is estimated that no important climatic effects are likely.

1060 WHITING, J., and MÜLLER, F. - 1969
Evaluation of the OTT automatic weather station; McGill Univ., internal report, 39 p.

The Ott automatic digital punch tape climatological recording station became available in August 1967. The punch tape produced by the station is compatible with the computer through a tape compiler and, in this way, the tedious chart reading is replaced by direct data output as well as statistical computation.

This station was tested for 25 days in 1967 and recorded two parameters, temperature and relative humidity, in a combined sensor. In the summer of 1968, the recorder was slightly modified to operate down to a temperature of -25°C on dry cell batteries. The station was put through extensive tests during this summer. The following summer, 1969, the station was used as a standard recording instrument.

EQUIPMENT

1061 ANONYMOUS - 1959
General specifications for a position-fixing system for hydrographic and geophysical surveys in Arctic regions on scales 1/50,000 or less; *Polar Cont. Shelf Proj.*, internal report, 5 p.

1062 ANONYMOUS - 1977
Bathymetry sounding system devised; *Oilweek*, February 28 1977, pp. 44-45.

This system uses a modified Canadair Flextrac C-23 as the sounding vehicle, using spike coupled transducers attached to hydraulically operated rams placed at each corner of the vehicle.

1063 BANISTER TECHNICAL SERVICES - 1976
Final report, development and testing of production through ice survey techniques; D.S.S. Contract 1SZ5-0401, 181 p.

In December, 1975, Banister Technical Services was granted a contract by the Canadian Government to design, construct and test a tracked vehicle for the rapid determination of depth profiles in ice covered waters. This contract was the result of an unsolicited proposal for scientific work.

This report contains within it Conclusions specific observations, recommendations and suggestions for future work.

1064 CAULFIELD, D.D., and LIRON, A. - 1975
Preliminary report on Bancqes sub-bottom Tuktoyaktuk tests; *Geol. Surv. Can.*, internal report, 72 p.

In April 1975, a joint program was undertaken by Banister Technical Services and the Geological Survey of Canada, Department of Energy, Mines and Resources, to field test the BANCQES through-ice sub-bottom system in the shallow waters of the Mackenzie Delta. Test data was acquired at four sites where cores were previously taken and analyzed by the Geological Survey of Canada. Multiple samples were acquired in three different regions.

1065 CAULFIELD, D.D., LIRON, A., LEWIS, C.F.M., and HUNTER, J.A. - 1976
Preliminary test results of the "Bancqes" through-ice sub-bottom acoustic profiling system at Tuktoyaktuk, Northwest Territories; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 503-510.

1066 CRUTCHLOW, M.R. - 1976
Tracked Vehicle Sounding Over Ice; *Light House*, J. of the Can. Hydrographers' Assoc., No. 14, pp. 16-18.

Sounding in ice covered waters from a tracked vehicle using a transducer mechanically coupled to a spike is a new field for the Canadian Hydrographic Service. Although tracked vehicles and through-ice sounding have both been around for a number of years, the combination of both is a recent development.

1067 GRAY, D.H. - 1975
Propagation Velocity of Decca Frequency Transmissions Over Sea Ice; *The Can. Surveyor*, vol. 29, no. 3, pp. 277-288.

In April and August 1973, a phase lag comparison test was performed using a double monitor system with the hyperbolic Decca chain established for various scientific surveys in the Amundsen Gulf. The test compared the secondary phase lag effect of sea ice and sea water. The observed values of the August test over sea water are consistent with the theoretical formulas of J.R. Johler. The observed values of the April test over sea ice cannot be compared with the formulas because the formulas are based on the assumption of a vertically homogeneous medium and this assumption is not valid in a sea-ice situation. The observed average velocity over sea ice is 299510 km/sec and over sea water is 299610 km/sec.

1068 GRAY, D.H. - 1977
The propagation velocity of decca-frequency transmissions over sea ice; *Intern. Hydrographic Review*, Monaco, vol. LIV, no. 1, pp. 59-71.

1069 IIZUKA, K., OGURA, H., YEN, J.L., NGUYEN, V., and WEEDMARK, J.R. - 1976
A Hologram Matrix Radar; *in* Proc. of the IEEE, vol. 64, no. 10, pp. 1493-1504.

The concept of *hologram matrix* is proposed. This concept was incorporated into the design of a novel radar which, unlike conventional radars, determines the distance by the spatial distribution of the scattered wave rather than by the lapse of time. The radar based upon this principle was developed and built for the purpose of mapping ice thickness in the range of 0.5~5m, but it has potential applications in other fields.

Such a radar has real-time processing capability, resulting from an amalgamation of the antenna and computer subsystems. The programability of the radiation pattern by software of the processing simplifies the construction of the radar. Capability of dual focussing of the transmitter and receiver eliminates the necessity of either pulsing, or frequency modulation of the tramsmitting signal. Superior performance in the short range, with high resolution, is particularly advantageous for measuring lossy ice.

These features were substantiated by experimental results obtained from the field operation of the system.

1070 KERR, A. - 1977
Developments in through-the-ice hydrographic surveying; presented at Int. Cong. Surveyors, Stockholm, June 1977, 13 p.

Much of the work of the hydrographer of today is directly associated with the search for resources at sea. In Canada, the search for hydrocarbons offshore has primarily been concentrated on the Atlantic Coast and in the Arctic. In the Arctic there are two main areas of interest, the Mackenzie-Beaufort Basin and the Sverdrup Basin. The latter extends over most of the Queen Elizabeth Islands, which

are situated to the north of Parry Channel. Both these geological provinces have been the scene of intense exploration during the last decade and oil and gas have been found in significant quantities.

It was fortuitous for the exploration companies that the Canadian government, in order to emphasize its sovereignty, decided in 1959, to establish a major project to carry out research studies in the high Arctic. This operation, known as the Polar Continental Shelf Project (P.C.S.P.), included work in many scientific disciplines. Bathymetry is fundamental to the understanding of numerous marine phenomena and as a result hydrography occupied a major part of the work. During the eighteen years that hydrographers have worked with the project they have systematically mapped most of the area surrounding and between the Queen Elizabeth Islands, including the continental shelf bordering the Arctic Ocean. The hydrographic work has been mainly of a reconnaissance nature with spot depths measured on a square grid of between two and ten kilometres. This information which was originally intended as a basis for scientific studies, has turned out to be of use to exploration companies planning their operations. With the actual discovery of oil and gas, thoughts have turned to the extraction of these resources. Consequently a need has quickly arisen for more detailed hydrographic information about these ice covered waters.

1071 MARINAV CORPORATION - 1977
The Hearne Point Decca Lambda System; *Marinav Corp.*, Report No. 1211/TM, January 1977, 18 p.

This publication is prepared by Marinav Corporation to introduce new users to the Decca Lambda System used by the Polar Continental Shelf Project for navigation and positioning requirements.

The system has been used since 1960 during which time it has been installed in different locations as survey activities have moved south-westward from Meighen Island to the Beaufort Sea. Each system configuration has been named by the location of the Master station, in the case of the 1977 location where Master is installed at Hearne Point it is known as the Hearne Point Decca Chain.

1072 PEISTER, K. - 1977
Flying by global navigation; *Canadian Flight*, March-April 1977, pp. 8-10.

1073 ROYAL MILITARY COLLEGE OF CANADA - 1975
Conceptual and preliminary design of a manned submersible: KES-1; *Royal Military College of Canada*, Dept. Chemistry and Chemical Eng., Final Report of the Chemical Eng. 415B Design Project, May 1975, 180 p.

During the 1975 winter term, consisting of about fourteen teaching weeks, a design project was included in the fourth year chemical engineering program. The general course objectives were: 1) to integrate the course of study by applying general engineering, chemistry, physics, mathematics and chemical engineering to the solution of a design problem; 2) to teach design techniques; and 3) to develop the conceptual and preliminary design of a system with military and civilian relevance in the Canadian scene.

1074 STELTNER, H.A.R. - 1977
Transportation of personnel, instruments and equipment on first-year sea ice for oceanographic survey and research purposes; paper presented at P.O.A.C. 77, St. John's, Nfld., September 26-30.

This report represents the experience of more than 21,000 vehicle kilometers driven on first-year sea ice during arctic winter conditions without accident, injury, mishap or loss. This experience was accumulated during the years 1972 (March) to 1977 (July) on the Eclipse Sound and adjacent waterways.

1075 VEILLETTE, J.J., and NIXON, F.M. - 1975
A modified ATV-drill for shallow permafrost coring; *in* Report of Activities, Part C, Geol. Surv. Can., Paper 75-1C, pp. 323-324.

1076 VEILLETTE, J., and NIXON, F.M. - 1976
Permafrost coring equipment; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, p. 269.

GENERAL

1077 ANONYMOUS - 1977
Can. Hydrographer's Assoc., personal notes, Hans Pulkkinen and Gerry Wade; *Lighthouse*, no. 15, April 1977, pp. 38-39.

1078 ANONYMOUS - 1977
Hans Pulkkinen: Arctic explorer and polar pilgrim; *Fisheries & Marine News*, vol. 11, no. 2, February 1977, p. 4.

0932 BECK, B., and SMITH, T.G. - 1976
"Seal Finger"-- An unsolved medical problem in Canada; *Fish. Mar. Serv.*, Res. Dev. Tech.Rep. 625, 7 p.

0933 BECK, B., and SMITH, T.G. - 1976
Seal finger: an unsolved medical problem in Canada; *CMA Journal*, vol. 115, July 17, p. 105.

1033 BERRY, M.O., DUTCHAK, P.M., LALONDE, M.E., McCULLOCH, J.A.W., and SAVDIE, I. - 1975
A study of weather, waves and icing in the Beaufort Sea; Beaufort Sea Technical Report No. 21, December 1975, 143 p.

1079 BIEFER, G.J. - 1975
Exploratory corrosion tests in the Canadian Arctic; *Can. Centre for Min. & Energy Tech.*, internal report ERP/PMRL-75-7 (R), 25 p.

A few exploratory sea-water and atmospheric corrosion tests on structural steels were performed in the Arctic and on the east coast of Canada. The results obtained in the tests are reported and discussed.

1080 BIEFER, G.J. - 1976
Examination of steel specimens after immersion in sea water for one year at Devon Island, N.W.T.; *Can. Centre for Min. & Energy Tech.*, internal report MRP/PMRL-76-58 (TR), 11 p.

Specimens of G40.8 Grade B structural steel and crevice-containing Type 304 and Type 316 austenitic stainless steel were immersed in Arctic sea water near Devon Island, N.W.T., for one year.

Corrosion attack on the specimens of structural steel was relatively uniform. On the basis of weight loss, corrosion rates were 81-93 μm/yr (3.2 to 3.65 mils/year), while typical penetrations, measured using a depth gauge, ranged from 25-175 μm (1-7 mils). Both stainless steels showed light crevice attack where they had been in contact with rubber bands. The deepest penetration measured with a depth gauge were 230 μm (9 mils) for Type 316 and 115 μm (4.5 mils) for Type 304 stainless steel.

1081 BIEFER, G.J., and BLOUIN, A. - 1976
Field trip to Tuktoyaktuk and Inuvik, N.W.T., to emplace atmospheric corrosion monitoring devices, July 1976; *Can. Centre for Min. & Energy Tech.*, internal report MRP/PMRL-76-19 (FT), 12 p.

In the summer of 1972, a long-term atmospheric corrosion test of three structural steels was initiated at Tuktoyaktuk. Specimens from this test were withdrawn in 1973 after one year on test and a rack of titanium specimens was installed by request.

In other research at PMRL during the summer of 1975, the capabilities of wire-on-bolt devices, as a simple means of obtaining an index of atmospheric corrosivity, were investigated.

In 1976, it was decided to monitor the atmospheric corrosion tests at Tuktoyaktuk, and also to install wire-on-bolt and other conventional rectangular sheet specimens at Tuktoyaktuk and other sites in the vicinity. One of the authors, A. Blouin, undertook this assignment.

1082 BIEFER, G.J. - 1976
Short-term tests of an atmospheric-corrosion monitoring device; *Can. Centre for Min. & Energy Tech.*, internal report ERP/PMRL-76-4 (TR), 12 p.

Assemblies, each consisting of a length of iron wire wound on a stainless steel bolt, were given short-term atmospheric corrosion tests in comparison with conventional rectangular specimens cut from mild steel sheet. It was found that the wire-on-bolt specimen tested was capable of measuring very small amounts of atmospheric corrosion, but that the maximum amount measurable was too low to consider its general usage for year-long exposures in the Arctic. However, it might be useful for tests in regions where corrosion rates are known to be extremely low (e.g. average penetration by corrosion of mild steel not greater than about 4 μm/year).

1083 BJORNERT, R. - 1975
Field operations report for the AIDJEX main experiment; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 29, pp. 173-181.

0934 BRAKEL, W.D. - 1977
The socio-economic importance of wildlife resource utilization in the Southern Beaufort Sea; Beaufort Sea Technical Report No. 32, March 1977, 91 p.

1084 HOBSON, G.D. - 1975
Polar Continental Shelf Project (PCSP); *in* Government Activities in the North, 1974-75, Dept. Ind. and N. Aff., Advisory Comm. N. Devel., pp. 55-62.

1085 HOBSON, G.D., and VOYCE, J. - 1975
Titles and Abstracts of Scientific Papers Supported by PCSP; *Polar Cont. Shelf Proj.*, Dept. Energy, Mines & Resources, vol. 2, Cat. No. M78-3/1975, 68 p.

1086 HOBSON, G.D. - 1976
Measuring Arctic ice - a joint experiment; *GEOS*, Fall 1976, pp. 15-17.

AIDJEX was designed to answer the four following questions: 1) How is large-scale ice deformation related to the external stress fields? 2) How can these external stresses be derived from a few fundamental and easily measured parameters? 3) What are the mechanisms of ice deformation? and 4) How do ice deformation and ice morphology affect the heat balance?

1087 HOBSON, G.D. - 1976
Polar Continental Shelf Project; *in* Activities of the Science and Technology Sector 1975-76, Energy, Mines & Resources Can., pp. 155-159.

0954 KNOWLES, R. - 1975
Nitrogen fixation in Arctic Marine Sediments; Beaufort Sea Technical Report No. 9, December 1975, 44 p.

0955 LEGAULT, J. - 1976
Wilderness, Ordeal in the jaws of the white bear; *Outdoor Life*, April 1976, pp. 69, 150, 152, 154, 156.

1088 PEISTER, K. - 1973
Land of the midnight sun; *Canadian Flight*, Jan.-Feb. 1973, pp. 7-9.

Flight in the Canadian Arctic requires a special brand of skill -- even if you're only ice observing...

1089 PELLETIER, B.R. - 1976
Outline for a marine science atlas of the Beaufort Sea; *in* Report of Activities, Part C, Geol. Surv. Can., Paper 76-1C, pp. 325-331.

1090 PULKKINEN, H.W. - 1976
Aerial photography of the artificial islands, Mackenzie Delta, N.W.T.; *Polar Cont. Shelf Proj.*, internal report, July 1976, 7 p.

1091 PULKKINEN, H.W. - 1976
Aerial photography of the artificial islands, Mackenzie Delta, N.W.T.; *Polar Cont. Shelf Proj.*, internal report, September 1976, 4 p.

1092 QUINTNER, D. - 1975
Canada will ship Christmas dinner to students drifting on Arctic ice floe; *The Toronto Star*, Saturday, December 13, 1975.

0982 SMITH, P., and STIRLING, I. - 1976
Resume of the trade in polar bear hides in Canada, 1974-75; *Env. Can.*, Can. Wildl. Serv. Progress Notes No. 66, August 1976, 7 p.

0985 SMITH, T.G., and ARMSTRONG, F.A.J. - 1975
Mercury in Seals, Terrestrial Carnivores, and Principal Food Items of the Inuit, from Holman, N.W.T.; *J. Fish. Res. Board Can.*, vol. 32, no. 6, pp. 795-801.

1093 STANLEY ASSOCIATES ENGINEERING LTD. - 1973
Polar Base Camp Sewage Disposal Study; *Polar Cont. Shelf Proj.*, internal report, 59 p.

The purpose of this study is to provide recommendations and cost estimates for the establishment of a modern and practical sanitary plumbing and sewage disposal system for the Polar Continental Shelf Project Base Camp at Tuktoyaktuk, N.W.T.

1094 WADHAMS, P. - 1976
Oil and ice in the Beaufort Sea; *Polar Record*, vol. 18, no. 114, pp. 237-250.

As the world's oil resources dwindle, the search for new supplies is touching regions of the globe previously considered too hostile for any kind of sustained operation. The ice-infested coastal waters of eastern and northern Canada are one such region. Already rigs have been at work off Newfoundland and Labrador where there is a long ice-free season and where drifting icebergs are the chief danger. Wells have been drilled on land in the Arctic islands and in one case from fast ice artificially thickened by flooding. However, a proposal to drill in the environmentally sensitive Beaufort Sea aroused widespread concern because of the enormous damage that could be caused by an accidental oil spill or by the blowout of an offshore well. People realized that the polar pack ice presents great dangers, that almost no information existed on the interactions between oil and sea ice, and that the oceanography and biology of the Beaufort Sea were understood only sketchily. To remedy these deficiencies a major environmental impact study, the Beaufort Sea Project, was undertaken in 1974-75 by the federal government of Canada and the oil industry acting in co-operation. The study also served the purpose of defining the conditions and restrictions under which the government would allow offshore drilling to proceed.

1095 WONG, C.S., MACDONALD, D., and CRETNEY, W.J. - 1976
Distribution of tar and other particulate pollutants along the Beaufort Sea Coast; Beaufort Sea Technical Report No. 13, March 1976, 96 p.

This report summarizes the objectives of the project, the study area, methods, sources of data and field and laboratory results of the investigation during the summers of 1974 and 1975 along the Beaufort Sea Coast. The objectives of the study are: (1) to establish the baseline distribution of particulate pollutants, especially for tar and plastics, in the present-day Beaufort Sea marine environment, (2) to establish areas with natural seepage of crude oil and (3) to establish the chemical characteristics of hydrocarbons in the present-day beach sediment, nearshore sediment and marine organisms, including fish. The study area in 1974 covered the SW coast of Mackenzie Bay and portions of the western coast of Tuktoyaktuk Peninsula. In 1975 the area was expanded to include not only the Yukon Coast, but also some of the offshore islands of the Mackenzie River Delta and a larger portion of Tuktoyaktuk Peninsula. No extensive tar pollution was found and no natural seepage was evident, although some isolated occurrences of asphalt near Drift Point and grease near Shingle Point and around Tuft Point and Warren Point were encountered. However, plastic wastes, in particular explosive cannister fragments originating from marine seismic activities, were prevalent and were found to have re-inundated beaches that had been cleaned up during the 1974 survey. Beach sediment, nearshore sediment and fish samples were collected to establish their hydrocarbon characteristics.

GEOLOGY

1096 APOLLONIO, S. - 1961
The Devon Island Expedition; *Arctic*, vol. 14, no. 4, pp. 252-265.

In 1959 the Arctic Institute of North America undertook an integrated program of long term research on Devon Island in the Queen Elizabeth Islands of arctic Canada. The co-ordinated studies were designed to help understand the interrelationships between the glacier-ice of Devon Island, the ocean in Jones Sound, and the encompassing atmosphere. They are being carried out over a 3-year period under the leadership of Spencer Apollonio. The main effort is concentrated on attempts to evaluate such factors as physical, chemical, and biological variations in the arctic waters of Jones Sound caused by discharging glaciers; evaporation and transfer of moisture between the ocean waters and the ice-cap and glaciers; and the overall influences of solar radiation energy on the mass balance of the ice-cap, the biological production in the sea, and the growth and decay of sea-ice. Some supplementary studies in archaeology and geology are included in the expedition's work because of the marked deficiency of knowledge in those subjects for Devon Island.

1097 BALKWILL, H.R., HOPKINS, Jr. W.S., and WALL, J.H. - 1977
Lougheed Island and neighbouring small islands, District of Franklin; *in* Report of Activities, Part B; Geol. Surv. Can., Paper 77-1B, pp. 181-183.

1098 BARNETT, D.M. - 1976
Ground ice on Bathurst, Cornwallis and adjacent islands; *Ice*, no. 50, p. 16.

1005 BARNETT, D.M., DREDGE, L.A., and EDLUND, S.A. - 1976
Terrain characteristics - Cornwallis and adjacent islands, Northwest Territories; *Geol. Surv. Can.*, Open File No. 457.

1006 BARNETT, D.M., DREDGE, L.A., and EDLUND, S.A. - 1976
Terrain inventory: Bathurst, Cornwallis, and adjacent islands, Northwest Territories; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 201-204.

1099 BARR, W., and KOERNER, R.M. - 1966
Devon Island Programs, 1965; *Arctic*, vol. 19, no. 2, pp. 201-204.

The Arctic Institute of North America has made available for future research the facilities left by the Devon Island Expedition of 1960-63. In 1965, taking advantage of these facilities, two scientific programs were followed. The first, in geomorphology, was essentially a base-camp-oriented project run by two men. The second, in glaciology, was a field-oriented program run by two men and one woman working on the ice cap and three outlet valley glaciers.

1100 BLAKE, Jr., W. - 1975
Radiocarbon age determinations and postglacial emergence at Cape Storm, southern Ellesmere Island, Arctic Canada; *Geografiska Annaler*, vol. 57, Ser. A, pp. 1-71.

Age determinations on marine mollusks indicate that the northwestern part of Jones Sound became open to the sea more than 9000 conventional radiocarbon years ago. The presence of postglacial marine features at elevations of up to 130 m near Cape Storm, Ellesmere Island, shows that a significant thickness of glacier ice was present in this area, and the differential uplift of pumice and other materials associated with raised beaches provides convincing evidence that the former ice cover was thicker to the west and to the north.

Numerous cross-checks have shown that in such an Arctic environment the organic (collagen) fraction of whale bones gives reliable results, as opposed to the bone apatite fraction, "which commonly yields ages that are too young". Marine mollusks also are reliable for ^{14}C age determinations, and the evidence available from areas of carbonate rocks in the Queen Elizabeth Islands suggests that the ages of marine mollusks are no more than 350 years older than the ages of contemporaneous terrestrial plants.

Near Cape Storm over fifty ^{14}C age determinations on driftwood, whale bone, and marine mollusks have permitted the construction of a curve showing the pattern of emergence over the past 9000 to 9500 years. Emergence between 9000 and 8000 years ago proceeded at a rate of 7 m/century, and over one-half of the total emergence (70 m out of 130 m) since the initial incursion of the sea took place during this interval. By 6500 to 4500 years ago emergence had slowed to 0.8 m/century, and for the last 2400 years it has averaged <0.3 m/century. The age determinations are sufficiently numerous and closely-spaced, especially between 6500 and 4400 years B.P., to indicate that fluctuations of sea level have not exceeded amplitudes of 2 m or periods >500 years. The concentration of the pumice and the nature of the features associated with it suggest that its deposition may be related to: 1) a eustatic rise close to 5000 years ago; 2) a period of more open water, when wave action and storm surges would have been more effective; 3) a combination of these two factors. The formation of the strandline where the pumice occurs is not believed to be related to a slowing-down or cessation of uplift due to the thickening of ice caps and glaciers.

1101 BLAKE, Jr. W., - 1976
Quaternary geochronology, Arctic Islands; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 259-264.

1102 BLAKE, Jr. W., - 1977
Radiocarbon age determinations from the Carey Islands, Northwest Greenland; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 77-1A, pp. 445-454.

1103 BORNHOLD, B.D., LEWIS, C.F.M., and FENERTY, N.E. - 1975
Arctic marine surficial geology; AIDJEX 1975; *in* Report of Activities, Part C, Geol. Surv. Can., Paper 75-1C, Part C, pp. 79-84.

1104 BORNHOLD, B.D. - 1975
Suspended matter in the southern Beaufort Sea; Beaufort Sea Technical Report No. 25b, December 1975, 31 p.

Concentrations of suspended matter measured in the southern Beaufort Sea in August and September, 1975 ranged from less than 0.1 mg/l to more than 17 mg/l. The highest concentrations were recorded at nearshore stations off Kugmallit Bay. Mid-water and near-bottom zones of turbid water are common, though their exact causes are not clear.

The distributional pattern of suspended matter reflects closely the physical oceanography of the area. As seen from satellite photographs, the sediment plume from the Mackenzie River is carried eastwards along the inner shelf while the plume emanating from Kugmallit Bay remains as a distinct band of turbid water along the southwestern Tuktoyaktuk Peninsula. The small basin southeast of Herschel Island receives considerable suspended sediment from longshore drift produced by a small clockwise eddy and the easterly flow past Herschel Island. The anticlockwise gyre which flows south and south-

eastward into Mackenzie Bay, brings little suspended matter into the shelf waters west of Herschel Island.

The major components of the suspended matter include fine inorganic particles, organic aggregates of plankton and inorganic particles, and phytoplankton. Throughout the area the clay minerals display distinct differences. The Mackenzie Bay and outer shelf samples contain montmorillonite, kaolinite and little chlorite and inshore samples off Kugmallit Bay contain no kaolinite or montmorillonite and abundant chlorite.

0924 BORNHOLD, B.D., FINLAYSON, N.M., and MONAHAN, D. - 1976
Submerged drainage patterns in Barrow Strait, Canadian Arctic; *Can. J. Earth Sci.*, vol. 13, no. 2, pp. 305-311.

1034 BROWN, R.J.E. - 1973
Influence of climatic and terrain factors on ground temperatures at three locations in the permafrost region of Canada; *in* North American Contribution Permafrost, Sec. Inter. Conf., July 13-28, Yakutsk, U.S.S.R., ed. Nat. Acad. Sc., Washington, D.C., pp. 27-34.

1105 BURKE, K.B.S., and HOBSON, G.D. - 1975
A seismic study of surficial deposits in the Winkler Area, Manitoba; *Geol. Surv. Can.*, Paper 75-44, 13 p.

The surficial deposits of the Winkler area, southern Manitoba, were investigated by a series of seismic experiments. Clay, gravel, sand, silt and till units overlie a bedrock of limestone, sandstone and shale. Within the survey area is northwest trending, glaciofluvial, sand and gravel deposit that was located by electric resistivity measurements and which is a major source of groundwater.

The seismic model established by uphole wavefront investigations showed that a thin, high velocity, till unit was the only consistent source of first arrival headwaves in the overburden. A till unit beneath the sand and gravel deposit gave rise to secondary arrivals. Two other refractors were identified in refraction profiles and were associated with a shale unit and a limestone unit. The dips on these refractors suggest a bedrock depression underlying the sand and gravel deposit.

A study of three-component particle motion at the site of the uphole wavefront investigations showed the absence of a direct compressional wave at shot detector distances of less than 150 feet. The directly travelling energy is instead carried in the form of a coupled surface wave with a down-away, up-toward particle motion.

1064 CAULFIELD, D.D., and LIRON, A. - 1975
Preliminary report on Bancqes sub-bottom Tuktoyaktuk tests; *Geol. Surv. Can.*, internal report, 72 p.

1065 CAULFIELD, D.D., LIRON, A., LEWIS, C.F.M., and HUNTER, J.A. - 1976
Preliminary test results of the "Bancqes" through-ice sub-bottom acoustic profiling system at Tuktoyaktuk, Northwest Territories; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 503-510.

1106 CHI, B.I., and HILLS, L.V. - 1976
Biostratigraphy and taxonomy of devonian megaspores, Arctic Canada; *Bull. Can. Pet. Geol.*, vol. 24, no. 4, pp. 640-818.

Late Middle and Upper Devonian megaspores and miospores have been obtained from approximately 15,240 m (50,000 ft.) of strata from 7 sections in the Canadian Arctic. These sections include: the Okse Bay Group on Ellesmere Island; the Blackley (oldest), Cape De Bray, Weatherall, Hecla Bay, Beverley Inlet and Parry Islands Formations on Melville, Prince Patrick and Banks Islands; and the Imperial Formation of the District of Mackenzie.

The palynomorphs recovered are assignable to 19 genera and 47 species. Of these, 38 are megaspores and 9 are miospores. Two genera, 21 megaspore species, 3 miospore species and 14 varieties assignable to 4 species of megaspores are described as new.

Seven assemblage zones, Givetian to Famennian in age, are established on the basis of the relative abundance and the first or last occurrence of characteristic species. From oldest to youngest these are: 1) the *Macromanifestus* zone; 2) the *Delicatus* zone; 3) the *Grandis* zone; 4) the *Medius* zone; 5) the *Maclarenii* zone; 6) the *Devonica* zone and 7) the *Magnifica* zone. The contact between the *Grandis-Medius* zones approximates the Givetian-Frasnian boundary whereas that of the *Devonica-Magnifica* zones approximates the Frasnian-Famennian boundary.

By utilizing megaspore counts and some sedimentological data, the depositional environments have been classified into continental, stable nearshore marine, unstable nearshore marine, and offshore marine.

1107 CHI, B.I., and HILLS, L.V. - 1976
Morphologic variation and stratigraphic significance of *Triangulatisporites rootsii* Chaloner; *Can. J. Earth Sci.*, vol. 13, no. 6, pp. 847-861.

The morphologic variations in *Triangulatisporites rootsii* is described and illustrated, and five new varieties (*rootsii, irregularis, reticulatus, regulatus,* and var. A) are erected. Stratigraphic evidence presented indicates that this species is indicative of Frasnian Age in the Canadian Arctic.

1108 COWIE, J.W. - 1961
Geology (The Devon Island Expedition); *Arctic*, vol. 14, no. 4, p. 255.

During the summer of 1961 an attempt was made to trace the geological succession on eastern Devon Island upwards from the metamorphic basement rocks through any Precambrian sediments into the Cambrian and Ordovician. All fossil collections made were accurately located in

measured stratigraphical order and came from rocks *in situ*. In addition a detailed map of the central part of Devon Island was begun and will be completed from aerial photographs at a scale of 1:250,000.

1109 DAWSON, M.R., WEST, R.M., RAMAEKERS, P., and HUTCHISON, J.H. - 1975
New Evidence on the Palaeobiology of the Eureka Sound Formation, Arctic Canada; *Arctic*, vol. 28, no. 2, pp. 110-116.

The Eureka Sound Formation, a thick sedimentary unit in the Canadian Arctic having a late Cretaceous and/or early Tertiary age, is known to contain plant fossils indicative of a continental origin of deposition and a relatively temperate climate. The Formation was selected for a palaeontological survey in order to determine whether it could, as suggested by distribution of fossil vertebrates in other areas and from evidence of plate tectonics, provide evidence on terrestrial migrations between North America and Europe in the Palaeogene. Fossils of plants, invertebrates and fish were found. They indicated that large parts of the Formation are marine in origin, although other parts are continental and thus could still be interpreted as representing part of a land connection between the northern land masses.

1110 DAWSON, M.R., WEST, R.M., LANGSTON, Jr., W., and HUTCHISON, J.H. - 1976
Paleogene Terrestrial Vertebrates: Northernmost Occurrence, Ellesmere Island, Canada; *Science*, vol. 9192, no. 4241, pp. 781-782.

Recently discovered Paleogene land vertebrates from the Eureka Sound Formation at about latitude 78° north in Arctic Canada include fish, turtles, an alligatorid, and several taxa of mammals. The assemblage, which is probably early or middle Eocene in age, adds to previously known paleobotanical evidence in suggesting temperate to warm-temperate climatic conditions.

1111 DAY, T.J., and ANDERSON, J.C. - 1976
Observations on river ice, Thomsen River, Banks Island, District of Franklin; *in* Report of Activities, Part B, Geol. Surv. Can., Paper 76-1B, pp. 187-196.

1112 DAY, T.J., and GALE, R.J. - 1976
Geomorphology of some Arctic gullies, Banks Island, District of Franklin; *in* Report of Activities, Part B, Geol. Surv. Can., Paper 76-1B, pp. 173-185.

1113 DAY, T.J., and LEWIS, C.P. - 1977
Reconnaissance studies of Big River, Banks Island, District of Franklin; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 77-1A, pp. 75-86.

1114 DINELEY, D.L. - 1976
New Species of *Ctenaspis* (Ostracodermi) from the Devonian of Arctic Canada; *in* ATHLON: Essays on Palaeontology in Honour of Loris Shano Russell, edit. C.S. Churcher, Royal Ontario Museum, Toronto, pp. 26-44.

Three new species of *Ctenaspis* from the Peel Sound Formation of Prince of Wales Island, N.W.T., are basically similar to known species but differ in their large size, minor details of proportions and ornamentation. The body form, tail and squamation are described for the first time and a mode of life involving partial burial in sediment is suggested.

1115 DIXON, J. - 1976
Corallite increase and a new corallite type in Upper Ordovician Cateniform Corals; *J. Paleontology*, vol. 50, no. 5, pp. 916-921.

Variations of lateral and interstitial corallite increase are newly recognized in cateniform corals. These variations commonly occur in *Tollina* Sokolov, 1949 (= *Manipora* Sinclair, 1955) and less commonly in *Catenipora* Lamarck, 1816. A new, large corallite type (megacorallite) occurs in specimens of two Upper Ordovician species of *Catenipora*. These megacorallites may have housed large polyps specialized for gamete production.

1116 DIXON, J. - 1976
Patterned carbonate - a diagenetic feature; *Bull. Can. Pet. Geol.*, vol. 24, no. 3, pp. 450-456.

Patterned carbonates consist of light- and dark-coloured areas of rock, varying in shape, complexity, and intensity of development. The colour difference is caused by a concentration of small pyrite cyrstals in the darker areas. This diagenetic feature forms in rocks of intertidal and supratidal origin, but most commonly in the latter. Preliminary observations indicate that the pyrite is a product of early diagenesis due to chemical reactions in a sulphate-rich, reducing environment.

1117 DYKE, A.S. - 1976
Tors and associated weathering phenomena, Somerset Island, District of Franklin; *in* Report of Activities, Part B, Geol. Surv. Can., Paper 76-1B, pp. 209-216.

1118 ENGLAND, J. - 1976
Postglacial isobases and uplift curves from the Canadian and Greenland High Arctic; *Arctic and Alpine Res.*, vol. 8, no. 1, pp. 61-78.

Local postglacial isobases are constructed over northeastern Ellesmere Island and Polaris Promontory, northwestern Greenland, for 7500 and 6000 BP. Both sets of isobases demonstrate a strong upward displacement extending from northeastern Ellesmere Island toward the Greenland Ice Sheet. This reflects two conditions: (1) the glacioisostatic dominance, but not coverage, of the Greenland Ice Sheet over northeastern Ellesmere Island and (2) an accompanying, restricted advance of the northern Ellesmere Island ice sheet during the last glaciation. Regional isobases are also constructed over the Queen Elizabeth Islands and the adjacent Greenland coast. These isobases provisionally indicate that the Queen Elizabeth Islands contribute to the westward extension of the Greenland isobases. This ridge of uplift was produced by the combined glacioisostatic depressions from the ice sheets over the Queen Elizabeth

Islands and Greenland. These ice sheets, however, are not considered to have been convergent during the last glaciation. Three postglacial uplift curves from northeastern Ellesmere Island more closely parallel the general decay curves characteristic of the central and southern Canadian Arctic than do previously constructed uplift curves from northern Ellesmere Island.

1119 FALCONER, R.K.H. - 1977
Marine geophysical and geological research in Baffin Bay and the Labrador Sea, CSS Hudson 1976; *in* Report of Activities, Part B; Geol. Surv. Can., Paper 77-1B, pp. 255-260.

1120 FORBES, D.L. - 1976
Sedimentary processes and sediments, Babbage River Delta, Yukon Coast: a progress report; *in* Report of Activities, Part C, Geol. Surv. Can., Paper 76-1C, pp. 165-168.

1121 FREBOLD, H., and POULTON, T.P. - 1976
Hettangian (Lower Jurassic) rocks and faunas, northern Yukon Territory; *Can. J. Earth Sci.*, vol. 14, no. 1, pp. 89-101.

The Lower Jurassic Hettangian Stage is documented with certainty for the first time in the Canadian Arctic. It is represented by a basal Jurassic sandstone unit in the Bonnet Lake area of northern Yukon Territory. The two subzones of the Early Hettangian Planorbis Zone, *i.e.*, the Planorbis Subzone and the Johnstoni Subzone, are indicated by poorly preserved *Psiloceras* sp. indet. and *Psilocerus* (*Caloceras*) cf.P (C.) *johnstoni* (J. de C. Sowerby), respectively. The varied but poorly preserved bivalve fauna associated with P. (C.)cf.P. (C.) *johnstoni* includes *Prosogyrotrigonia* (?) sp.cf.P *inouyei* (Yehara), *Cardinia* sp.cf.C *hybrida* (J. Sowerby), C. sp. aff.C. *concinna* (J. Sowerby), *Pleuromya* (?) sp., *Meleagrinella* (?) sp., *Oxytoma* (*Oxytoma*) sp., and *Parallelodon* (?) sp. The bivalves closely resemble approximately coeval forms described from Japan. The above-mentioned faunas are figured as is a specimen of *Psilocerus* cf.P. *erugatum* (Phillips), which was previously described from the Hettangian of southern Yukon. Other occurrences of the Hettangian in Canada and Alaska are reviewed.

1122 FRENCH, H.M. - 1976
Geomorphological process and terrain disturbance studies, Banks Island, District of Franklin; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 289-292.

1123 FRENCH, H.M. - 1976
The Periglacial environment; Longman Group Ltd., London and New York, 308 p.

This university level text describes the nature of geomorphic processes and landforms in high latitude periglacial environments. There is an emphasis upon the permafrost conditions of the Western Canadian Arctic and Central Siberia. The book also provides a guide to the recognition and interpretation of relict periglacial features in the temperate regions of North America and Europe.

1124 FRENCH, H.M. - 1976
Pingo investigations, Banks Island, District of Franklin; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 235-238.

1125 FRENCH, H.M., and DUTKIEWCZ, L. - 1976
Pingos and pingo-like forms, Banks Island, Western Canadian Arctic; *Bull. Peryglacjalny*, no. 26, pp. 211-222.

Dans le travail on a décrit un ensemble de collines atteignant plusieurs mètres en hauteur, très nombreuses sur la terrasse inférieure de la rivière de Bernard dans son cours moyen, ainsi que des collines semblables de l'amont de la vallée de Sachs. Les formes étudiées sont les plus souvent rondes ou ovales; certaines d'eux sont allongées et par leur allure se sesemblent aux ozars. La plupart de collines de la région se caractéerisent par une concavité distincte située dans la partie centrale. Comme on a constaté en se basant sur les coupes géologiques, les collines contiennent un noyau de glace couvert partun manteau de graviers, sables et limons atteignant de 1 à 2 mètres d'épaisseur qui certifie en faveur de l'opinion qu'elles représentent les formes du type de pingo. Pourtant elles se distinguent des pingos classiques "Mackenzie" du type fermé par la situation morphologique, dimensions et la forme irrégulière. D'après les auteurs, les formes décrites des vallées de Bernard et de Sachs ont du se développer en résultat de la congélation des taliks qui sans doute ont existé dans les dépôts perméables situés au-dessous des anciens lits fluviaux. Les parties centrales enfoncées, souvent à petit lac à l'intérieur, montrent que les formes se trouvant actuellement dans l'état de la dégradation.

1126 FREST, T.J., and STRIMPLE, H.L. - 1976
Carpocrinus (Echinodermata: Crinoidea) from the Late Silurian of Somerset Island, Northwest Territories, Canada; *Can. J. Earth Sci.*, vol. 14, no. 1, pp. 132-136.

Carpocrinus arcticus n.sp. is the first Silurian crinoid to be reported from Arctic Canada (Read Bay Formation, Somerset Island). The species is distinguished from other North American *Carpocrinus* by its nonlobate calyx, plates with impressed sutures, and granular plate ornamentation. It is a member of a largely European lineage not previously reported from North America. The typical North American lineage was considered a separate genus (*Stiptocrinus*) by Kirk: it is here considered synonymous with *Carpocrinus*. Review of the stratigraphic distribution of *Carpocrinus* occurrences indicates that the lineage including *C. arcticus* is characteristic of Late Wenlock-Ludlow rocks.

1127 FRISCH, T. - 1976
Igneous and metamorphic rocks, northern Ellesmere Island; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 429-430.

1128 FUKUDA, M. - 1975
Quaternary histories of land form development in permafrost; *in* Joint Studies on Physical and Biological Environments in the Permafrost,

Alaska and North Canada, June to July, 1974, Inst. Low Temp. Sci., Hokkaido Univ., Japan, pp. 62-84.

The author attempts to establish some concept about the process of land form development during the late Quaternary period in this preliminary report about a field survey at Barrow, northern Alaska and the Mackenzie delta area, N.W.T. Canada. The fluctuations of climatic conditions in permafrost regions have been responsible for the land form development, by causing, for example, the process of partial melting and refreezing of the upper layer of permafrost, which has resulted in the development of the topography characterized by pingos and tundra polygons. They are the most striking features of land forms in the continuous permafrost regions; the Quaternary histories of these land forms indicate the past records of physical environments of these regions.

Tundra polygons were found at Barrow, accompanied by ice-wedge formations; they developed on the surface of a beach-ridge, which was formed by a transgression at the early Wisconsin ice-age. The ^{14}C dating of organic samples from the upper layers of tundra polygons stands at 3,700 ± 105 B.P. years, whereby it is indicated that these tundra polygons and ice-wedges were formed nearly 3,000 or more years ago.

Pingos near Tuktoyaktuk are related to the accepted theory as to their origin of formation; namely, when a basin and thawed soil layers below its bottom are refrozen, an ice mass is segregated upward from within the soil and concentrated into a surface layer just below the bottom, which is eventually thrusted upward as a huge ice-core above the basin forming the mound-like topography called pingo, by which-time the basin no longer contains water, liquid or frozen. The sediments covering the ice-core of Ibyukpingo near Tuktoyaktuk derived from the fluvioglacial deposits of a retreating glacier at the Mackenzie delta area. The dating of the sediments, which stands at about 12,000 B.P. years, shows that the pingo was formed after the retreat of the glacier about 10,000 years ago.

1129 HILLS, L.V., and BUSTIN, R.M. - 1976
Picea banksii Hills & Ogilvie from Axel Heiberg Island, District of Franklin; *in* Report of Activities, Part B, Geol. Surv. Can., Paper 76-1B, pp. 61-63.

1130 HODGSON, D.A. - 1973
Terrain performance, Central Ellesmere Island, District of Franklin; *in* Report of Activities, Part A: April to October 1972, Geol. Surv. Can., Paper 73-1, Part A, p. 185.

1131 HODGSON, D.A. - 1975
The terrain mapping and evaluation system adopted for the eastern Queen Elizabeth Islands; *in* Report of Activities, Part C, Geol. Surv. Can., Paper 75-1, pp. 95-100.

1132 HODGSON, D.A. - 1977
A preliminary account of surficial materials, geomorphological processes, terrain sensitivity, and quaternary history of King Christian and southern Ellef Ringnes Islands, District of Franklin; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 77-1A, pp. 485-493.

1133 HORIGUCHI, K. - 1975
Chemical properties, especially pH of the upper layer of permafrost; *in* Joint Studies on Physical and Biological Environments in the Permafrost, Alaska and North Canada, June to July, 1974, Inst. Low Temp. Sci., Hokkaido Univ., Japan, pp. 85-94.

The acidity (pH) of soil is one of its typical physico-chemical properties whereby useful information is provided as to the degree of weathering, the degree of saturation with cations, the activity of micro-organisms in it, and so on. The acidity of soil is also important from a viewpoint of engineering, because it affects the durability of foundation of an artificial construction thereon.

Values of pH were measured with a HORIBA D-5 pH meter of soil samples collected at Barrow, Tuktoyaktuk and Inuvik. The results were shown in Tables 1-12 and Figures 1-8, where values of pH (H_2O) and open circles designate values of true acidity and values of pH (KCl) and solid circles designate values of sub-stitutional acidity.

In order that organic contents in the soil samples were determined, differential thermal analyses and thermal balance analyses of the samples dried at 110°C were carried out between the room temperature and 600°C. Some typical curves obtained by the differential thermal analyses were shown in Fig. 9. They clearly indicated exothermic reaction due to combustion of organic materials, whose weights were estimated by the thermal balance analyses.

The experimental results revealed the following: 1) in the tundra region the pH value of soil solution decreased with the increase of its organic contents; (2) at a given place the pH value of soil increased with the depth, at least on the average; (3) in the polygon region soil was always acid, while at the top of a pingo, some soils were acid and others were alkaline.

1134 JAHN, A. - 1975
Problems of the Periglacial Zone; translated from Polish and published for Nat. Sc. Fndtn., Washington, U.S. Dept. Commerce, Nat. Tech. Info. Service, 221 p.

In this book I wish to give the reader a survey of periglacial problems, which are considered, in every instance, in the comparative aspect: contemporary -- Pleistocene periglacial zone. As far as the Polish student of periglacial problems is concerned, relevant for him are research findings relating to Arctic, specifically those throwing light on the nature of ground forms and structures, that he may find useful in the study of their Pleistocene analogues in exposures in this country.

1135 JEFFERSON, C.W. - 1976
Stromatolites of the Upper Proterozoic Shaler Group, Banks and Victoria Islands, Northwest

Territories; *Abstract in* Geol. Assoc. Can., 1976 Annual Meeting, Edmonton, Alberta

Stromatolites form distinctive marker horizons in carbonate units of the Shaler Group. Columnar stromatolites of specific morphology, lamina shapes and microstructure herewith described, have wide lateral distribution and relatively narrow vertical distribution in the Glenelg and Reynolds Point Formations. The sequence, in ascending stratigraphic order, is interpreted as: cf. *Basisphaera irregularis* Walter, cf. *Inzeria* f. indet., "finger" stromatolites cf. *Gymnosolen* and *Baicalia burra*, cf. *Baicalia burra*, and cf. *Acaciella* f. indet.. This sequence has been used on Victoria Island to correlate detailed stratigraphic sections separated by distances of over 300 km., to predict displacement by faulting, and to identify specific stratigraphic horizons by examination of single specimens. Providing the identifications are correct and these forms are restricted to the ages attributed to them in the U.S.S.R., then this assemblage indicates an age roughly straddling the Helikian/Hadrynian time boundary. Despite increasing doubt concerning the use of stromatolites for interbasinal correlation, it is encouraging that all of the stromatolites of this study resemble Soviet and Australian forms of roughly the same published age ranges.

Specimens from the Rae Group in the Richardson Bay and Berens Islands areas resemble cf. *Inzeria* at the top of the Glenelg Formation on Victoria Island. Further study is required before it can be stated that the same stromatolite succession exists in the Rae and Shaler Groups.

1136 JONES, B., and DIXON, O.A. - 1976
Storm deposits in the Read Bay Formation (Upper Silurian), Somerset Island, Arctic Canada (an application of Markov Chain analysis); *J. Sed. Petrol.*, vol. 46, no. 2, pp. 393-401.

The Read Bay Formation at Cape Admiral M'Clintock, Somerset Island, consists largely of thick units of rubbly argillaceous limestone separated by thin units of shelly limestone, intraclastic shelly limestone or intraformational conglomerate. The latter units are random in occurrence as demonstrated by Markov Chain Analysis, and represent brief periods of deposition in high energy regimes. The rubbly argillaceous limestone units are consistently thicker and represent relatively longer periods of deposition in lower energy regimes. The random deposits appear to have been storm generated, their varied content of shelly and intraclastic debris probably reflecting various combinations of basin physiography, wind strength and wind direction. The rocks were deposited in both intertidal and subtidal environments. The intertidal sequences include numerous vertical facies changes (alternation of thin units of rubbly argillaceous limestone and the random units) whereas the subtidal sequences have fewer facies changes (alternation of thick units of rubbly argillaceous limestone and the random units). The intertidal rocks contain no fauna, a brachiopod fauna of low diversity or a brachiopod-gastropod fauna of low diversity whereas the subtidal rocks commonly contain a rich, diverse in situ fauna of brachiopods and corals.

1137 JONES, B. - 1977
Variation in the Upper Silurian Brachiopod *Atrypella Phoca* (Salter) from Somerset and Prince of Wales Islands, Arctic Canada; *J. Paleontology*, vol. 51, no. 3, pp. 459-479.

Assemblages of *Atrypella phoca* (Salter) from the Upper Silurian Read Bay Formation of Somerset and Prince of Wales islands illustrate that shell size, shell convexity and deflection of the anterior commissure increased in magnitude during ontogeny while shell outline did not. Differences in growth characteristics between individual assemblages appear to be related to the amount of detrital material in the host rock rather than stratigraphic position. Thus, the largest, least convex shells occur in micritic limestone while the smallest, most convex shells occur in argillaceous limestone.

The species *phoca* and *scheii*, as defined in the literature, appear to be end members of a continuous spectrum of morphological variation. Consequently, *scheii* is included as a subjective junior synonym of *phoca*.

1138 JONES, B., and DIXON, O.A. - 1977
Stratigraphy and sedimentology of Upper Silurian rocks, northern Somerset Island, Arctic Canada; *Can. J. Earth Sci.*, vol. 14, no. 6, pp. 1427-1452.

Late Silurian subtidal, intertidal, and supratidal rocks are widely and complexly associated along the north coast of Somerset Island. The Read Bay Formation in the northwest, a subtidal limestone facies with brachiopod-coral faunas, is at least in part the lateral equivalent to the Leopold Formation in the northeast, the latter being an intertidal-supratidal facies of predominantly unfossiliferous dolomitic and sandy carbonate rocks. In intervening areas, the two facies intercalate widely, resulting in sections in which both subtidal and intertidal-supratidal sequences alternate repeatedly. The latter have been referred provisionally to the Read Bay Formation, although subsequent work may justify the designation of new lithostratigraphic units in the area of intercalation.

The intertidal-supratidal rocks contain considerable quantities of texturally and mineralogically immature, sand-sized, detrital quartz, feldspar, and mica, apparently derived from nearby. The subtidal rocks also commonly contain large amounts (up to 50%) of clay-to-silt-sized quartz, dolomite, muscovite, and clay minerals. The detrital sediment and the close association of subtidal and intertidal-supratidal rocks suggest that these Late Silurian rocks are part of a basin-margin succession flanking a low-lying land mass situated to the north and northeast. A general increase in the proportion of detrital sediment and greater persistence of near-shore carbonate facies toward the east suggest either greater proximity to a shoreline or a more persistently elevated land area in that direction.

1012 JORDAN, C., MERRICK, R., COURTIN, G.M., NOSKO, P., and PEARSON, D. - 1975
Devon Island Research Station 1975; *Arctic*, vol. 28, no. 3, p. 226.

1139 KERR, J.W. - 1977
Cornwallis Fold Belt and the mechanism of baseline uplift; *Can. J. Earth Sci.*, vol. 14, no. 6, pp. 1374-1401.

Cornwallis Fold Belt is a north-trending anticlinorium more than 650 km (400 mi) long, that extends from the Precambrian Shield to the Sverdrup Basin. It is the folded and faulted sedimentary suprastructure that overlies Precambrian crystalline basement rocks of the Boothia Horst. The horst and fold belt represent lower and intermediate levels of the Boothia Uplift. Evolution of the Cornwallis Fold Belt includes two phases, formation and modification.

Formation. The basic structure of the Cornwallis Belt, a relatively simple, steep-sided, north-plunging anticlinorium, was formed in the interval from Proterozoic to Late Devonian time during several discrete phases of deformation that involved a similar stress pattern. These phases can be attributed to pulses of differential vertical uplift of the underlying Boothia Horst. The earliest phases involved periods of gentle arching of the crystalline basement and sedimentary cover in late Proterozoic and early Paleozoic times. The fold belt was formed mainly by the Cornwallis Disturbance (new name) which involved further differential vertical uplift, and comprised several pulses: (1) Early Silurian, mild, affecting only part of the belt; (2) Early Devonian, very strong, affecting the entire belt; (3) late Early Devonian, moderately strong, affecting the entire belt; (4) Late Devonian, moderately strong, affecting the entire belt. Each pulse was a cycle that began with uplift and erosion of the fold belt and shedding of detritus into the adjacent basins, and was followed by broader regional subsidence and the resumption of deposition on the belt. Between pulses of uplift there was regional subsidence, during which the fold belt subsided less than the flanking basins and received less sediments.

Differential vertical displacement originated in the crystalline basement, occurring along fault zones that define the Boothia Horst, and are parallel to and controlled by a steep to vertical north-trending foliation. Faults extend into the sedimentary suprastructure comprising the overlying Cornwallis Fold Belt, and change gradually upward from vertical faults to high-angle reverse faults, overturned anticlines, and finally to asymmetric anticlines. Because the fold belt plunges north, this gradational sequence occurs from south to north in the exposed part of the fold belt. Structures formed by early pulses were rejuvenated by later pulses with the same sense of movement.

Modification. The basic structure of the Cornwallis Fold Belt was modified by other types of deformation during the interval from Late Devonian to the present. Many of the preexisting faults were reactivated, but with a different sense of movement. During the Late Devonian to Middle Pennsylvanian Ellesmerian Orogeny, southward overriding of upper levels of the sedimentary succession produced folds in the rocks east and west of the Cornwallis Fold Belt which had not been previously deformed and could easily be displaced southward on an underlying décollement surface. The north-trending Cornwallis Fold Belt, however, was an obstacle to southward overriding in which the effects of overriding were reduced. Zones of interference structures developed near the margins, guided by older basement-controlled structures. Left-lateral faults were developed on the western margin and right-lateral movement is probable on the eastern margin.

The Cornwallis Fold Belt extends an unknown distance northward beneath the younger rocks of the Sverdrup Basin. These younger rocks were deposited during a long period of northward downwarping that began in mid-Mississippian time. This same downwarping caused an abrupt increase in the northward plunge of the fold belt.

During the Cretaceous-Tertiary Eurekan Rifting Episode the Cornwallis Fold Belt was fragmented by block faulting. The horsts form islands, and the grabens form submarine channels, some of which contain thick sections of semiconsolidated Cretaceous-Tertiary sediments. Numerous other normal faults that occur within the fold belt probably formed at this time. Cretaceous-Tertiary faults within the Cornwallis Fold Belt have a rectilinear pattern that was inherited from preexisting structures.

1140 KERR, J.W. - 1977
Cornwallis Lead-Zinc District; Mississippi Valley-fibre deposits controlled by stratigraphy and tectonics; *Can. J. Earth Sci.*, vol. 14, no. 6, pp. 1402-1426.

Cornwallis Lead-Zinc District in the central Canadian Arctic includes occurrences of galena and sphalerite with similar geological settings and controls on mineralization. It includes the Polaris deposit, with 25 million tons of about 19% grade ore, representing 4.7 million tons of metal.

The district occurs in and was controlled by the Cornwallis Fold Belt, a steep-sided anticlinorium of Proterozoic to Devonian formations, that overlies a basement horst.

Four controls on mineralization are: (A) deposits are stratabound within the Ordovician Thumb Mountain Formation; (B) ore occurs in breciated dolomite, in contrast to usual limestone of the host formation; (C) deposits are located close to shale of the Cape Phillips Formation; and (D) the host formation was subject to erosion and karstification in Early Devonian time during Pulse 3 of the Cornwallis Disturbance.

Mineralization is of Mississippi Valley-type, having formed in carbonate rock by epigenetic processes. The sequence of stratigraphic and tectonic events leading to mineral formation was as follows: (1) An Ordovician to Lower Devonian geosynclinal sequence was deposited, containing formations that could be a source of Zn, Pb, Fe, and S, as well as potential

host formation. (2) The sequence was folded by three pulses of the Cornwallis Disturbance. (3) Uplift in Early Devonian time allowed deep erosion that exposed the host Thumb Mountain Formation in anticlinal culminations. (4) Caverns and pores developed in the upper part of that formation, by karst-type solution. (5) During subsidence an unconformable sedimentary cover buried the host formation and its caverns to a considerable depth. (6) Two formation fluids developed, with metal ions in one and sulphur ions in the other. (7) These two brines migrated laterally and upward, and met in cavities in the Thumb Mountain Formation. (8) In these cavities temperatures and other conditions were suitable and the brines precipitated the sulphides, galena, sphalerite, and pyrite.

Deposition probably occurred between temperatures of 52°C and 102°C, suggesting that the caverns were at depths of at least 1280 m (4200 ft.). This probably occurred in Late Devonian time, prior to Pulse 4 of the Cornwallis Disturbance. Major structural events following mineral emplacement raised the occurrences to higher topographic levels where they became exposed.

Metal deposition in this model resembles the accumulation of petroleum in that the components were carried upward and laterally from source formations to structural culminations, and deposited there in open spaces that served as traps.

1141 KERR, J.W., and DeVRIES, C.D.S. - 1977
Structural geology of Somerset Island and Boothia Peninsula, District of Franklin; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 77-1A, pp. 107-111.

1142 KINOSITA, S., SUZUKI, Y., HORIGUCHI, K., and FUKUDA, M. - 1975
Core samplings in the upper layer of permafrost; *in* Joint Studies on Physical and Biological Environments in the Permafrost, Alaska and North Canada, June to July, 1974, Inst. Low Temp. Sci., Hokkaido Univ., Japan, pp. 33-61.

A scientific expedition was carried out in permafrost regions of Alaska and North Canada by seven scientists of the Institute of Low Temperature Science, Hokkaido University, Sapporo, JAPAN, from the middle of June to the end of July, 1974. The group was divided into three sub-groups according to their research subjects: (1) frozen ground; (2) vegetation; (3) soil invertebrates. Reported in this paper is one of the studies done by the frozen ground sub-group, that is, core samplings in the upper layer.

0953 KINOSITA, S. - 1975
General outline of joint studies on physical and biological environments in the permafrost, Alaska and North Canada, June to July, 1974; *in* Joint Studies on Physical and Biological Environments in the Permafrost, Alaska and North Canada, June to July, 1974, Inst. Low Temp. Sci., Hokkaido Univ., Japan, pp. 1-32.

1143 KURFURST, P.J., and HUNTER, J.A. - 1976
Geological and geophysical surveys - Willowlake River, Northwest Territories; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, pp. 161-164.

1144 KURFURST, P.J., and VEILLETTE, J.J. - 1977
Geotechnical characterization of terrain units, Bathurst, Cornwallis, Somerset, Prince of Wales and adjacent islands; *Geol. Surv. Can.*, Open file No. 471.

This file contains an unedited report representing the results of field and laboratory investigations of the behaviour and properties of representative soil types and of the occurrence and spatial variability of ground ice along the proposed Polar Gas Pipeline route in the Arctic Archipelago. The file comprises a brief introduction, Part I - Bathurst, Cornwallis, and adjacent islands by P.J. Kurfurst (75 pages plus appendices) and Part II - Somerset and Prince of Wales islands by J.J. Veillette (118 pages).

1145 LENZ, A.C. - 1974
Silurian Brachipoda, Upper Allen Bay Formation, Griffiths Island, Arctic Archipelago, and Uppermost Whittaker Formation, Mackenzie Mountains, Northwest Territories; *Can. J. Earth Sci.*, vol. 11, no. 8, pp. 1123-1135.

A low diversity fauna of brachiopods is described from the top beds of the Whittaker Formation of the central Mackenzies, and the upper part of the Allen Bay Formation, Griffiths Island. The fauna of the two formations together total 10 species, although only two species are common to the two units. The faunas are dominated by the atrypid *Spirigerina*, and the rhynchonellids *Ancillotoechia* and *Decoropugnax*. The faunas are correlated with the upper Wenlockian or lower Ludlovian, and are considered the equivalents of the shallow water *Salopina* or *Sphaerirhynchia* benthic communities.

1146 LEWIS, C.F.M., BORNHOLD, B.D., and BLASCO, S.M. - 1976
Cruise Report No. 76025, Part 1, C.S.S. Hudson; Bed. Inst. Ocean., Dartmouth, 37 p.

1147 LEWIS, C.F.M., BLASCO, S.M., BORNHOLD, B.D., HUNTER, J.A.M., JUDGE, A.S., KERR, J.W., McLAREN, P., and PELLETIER, B.R. - 1977
Marine geological and geophysical activities in Lancaster Sound and adjacent fiords; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 77-1A, pp. 495-506.

1148 LEWIS, C.P., and FORBES, D.L. - 1975
Coastal sedimentary processes and sediments, Southern Canadian Beaufort Sea; Beaufort Sea Technical Report No. 24, December 1975, 68 p.

This technical report is based primarily on fieldwork conducted during the summer of 1974 into the geometry, composition, origin and stability of coastal landforms bordering the Beaufort Sea from the Alaska-Yukon boundary east to the Mackenzie Delta. The 1974 study

followed general reconnaissance investigations of the northwest coast of the Tuktoyaktuk Peninsula in 1973 and of the Yukon coast in 1972. The results of these earlier studies have been incorporated here to extend coverage as far east as Cape Dalhousie at the eastern end of the Tuktoyaktuk Peninsula. As well, prepared testimony by the senior author, presented to the Mackenzie Valley Pipeline Inquiry on February 13, 1976, is included in this report as an appendix. The reader is referred to this appendix for a more general overview of physical aspects of the Beaufort Sea coast, discussion of the implications of offshore hydrocarbon resource development on the coastal zone, and for additional detailed information on the modern Mackenzie delta plain.

1149 LOEFFLER, E.J., and DINELEY, D.L. - 1976
A new species of *Corvaspis* (Agnatha, Heterostraci) from the upper Silurian to lower or middle Devonian of the Northwest Territories, Canada; *Palaeontology*, vol. 19, part 4, November 1976, pp. 757-766.

A new species of *Corvaspis, C. arctica*, is described from the Peel Sound Formation of Somerset Island, North-west Territories, Canada, where it occurs in association with *Hemicyclaspis murchisoni* (Egerton), an index fossil for the lowest Downtonian of Britain. C. *arctica* sp. nov. is considered to have been a streamlined form, with an undivided dorsal shield; it is probably related to the Cyathaspididae.

1150 LOEFFLER, E.J., and JONES, B. - 1976
An ostracoderm fauna from the Leopold Formation (Silurian to Devonian) of Somerset Island, North-west Territories, Canada; *Palaeontology*, vol. 19, part 1, 1976, pp. 1-15.

An ostracoderm fauna, comprising *Archegonaspis* cf.A.*schmidti* (Geinitz), *Homalaspidella* cf.H.*borealis* Denison, Cyathaspididae indet., and Heterostraci indet., occurs in the Leopold Formation on north-eastern Somerset Island. The associated invertebrate faunas indicate a Pridolian (upper Silurian) or Gedinnian (lower Devonian) age for the ostracoderm horizon; this is the youngest substantiated report of *Archegonaspis*.

1151 MACKAY, J.R. - 1975
The Closing of Ice-wedge Cracks in Permafrost, Garry Island, Northwest Territories; *Can. J. Earth Sci.*, vol. 12, no. 9, pp. 1668-1674.

The closing of thermal contraction (ice-wedge) cracks at Garry Island, N.W.T., 150 km northwest of Inuvik, N.W.T., has been measured by means of gauge probes inserted into the cracks and by precise taping between bench marks across ice-wedge troughs. The results show that a simple elastic model fails to explain the time of cracking, the depth of cracking, the crack spacing, and the time of closing. The mean annual ice vein increment, at Garry Island, is probably less than 20% of the mean winter crack width. Thermal contraction cracks are of potential engineering interest, because they may affect underground cables, reservoirs, and other man-made structures.

1152 MACKAY, J.R. - 1975
Freezing processes at the bottom of permafrost, Tuktoyaktuk Peninsula area, District of Mackenzie; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 75-1, pp. 471-472.

1153 MACKAY, J.R. - 1976
Ice segregation at depth in permafrost; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 287-288.

1041 MACKAY, J.R. - 1976
Ice-wedges as indicators of recent climatic change, Western Arctic Coast; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 233-234.

1154 MACKAY, J.R. - 1976
The age of Ibyuk Pingo, Tuktoyaktuk Peninsula, District of Mackenzie; *in* Report of Activities, Part B, Geol. Surv. Can., Paper 76-1B, pp. 59-60.

1155 MACKAY, J.R. - 1976
The growth of ice-wedges (1966-1975), Garry Island, N.W.T., Canada; *in* Proc. XXIII Inter. Geographical Congress, Section 1, Geomorphology and Paleogeography, Moscow, pp. 180-183.

Ice wedge growth has been studied at Garry Island, N.W.T., Canada through the 1966-1975 period. The ice wedge polygons average from 10 to 20 m in diameter. The surfacial material is a stony till overlying Pleistocene sands, silts, and clays. Garry Island is in the tundra with a mean annual ground temperature of about -8°C. Permafrost is estimated to be about 500 m thick. The field instrumentation has consisted of the following: 1. Steel reference pipes (total of 55) inserted 1 to 1.5 m into permafrost, so that summer-winter separations could be accurately measured across ice wedges. 2. "Breaking cables" of fine copper wire buried in the active layer, across 130 ice-wedge troughs. 3. Closing probe gauges, to measure them in place closing of ice-wedge cracks. 4. Electronic detectors (total of 36) to measure the direction of crack propagation; i.e. upwards from within permafrost or downwards from the ground surface. 5. Timing devices to record the time of ice-wedge cracking. 6. Thermographs to record year round ground temperatures. 7. Snow fences to add extra snow at one site. The results are summarized below.

1156 MACKAY, J.R. - 1976
Pleistocene permafrost, Hooper Island, Northwest Territories; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 17-18.

1157 MACKAY, J.R. - 1977
Permafrost growth and subpermafrost pore water expulsion, Tuktoyaktuk Peninsula, District of Mackenzie; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 77-1A, pp. 323-326.

1158 MACKAY, J.R. - 1977
Probing for the bottom of the active layer; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 77-1A, pp. 327-328.

1159 MACKAY, J.R. - 1977
Pulsating pingos, Tuktoyaktuk Peninsula, N.W.T.; *Can. J. Earth Sci.*, vol. 14, no. 2, pp. 209-222.

Field studies have been carried out on two pingos on Tuktoyaktuk Peninsula, N.W.T. One pingo was studied from 1969-1976; the other was studied from 1974-1976. Precise levelling of bench marks in permafrost shows that the tops of these pingos alternately rise and subside in response to the rate of accumulation and loss of water beneath them. The water lenses may exceed 50 cm in depth. The high pore water pressure that causes pingo uplift is produced by pore water expulsion adjacent to the pingo, where the thickness of permafrost is 2 to 3 times the pingo height. The pore water pressure beneath the permafrost surrounding the pingo may approach 100% of the lithostatic pressure. When uplift from the water lens exceeds the strength of the pingo, peripheral failure occurs, water escapes as a spring, and the pingo subsides. Pulsating pingos seem characterized by long radial tension cracks which extend far onto the drained lake floor.

The pulsation of pingos has also been experimentally achieved by drilling holes through two pingos to release spring flow from subpingo pore water. The field evidence, from precise before-and-after surveys, indicates that the two pingos and their adjacent drained lake floors are virtually 'afloat' on subpermafrost water.

1160 MACKAY, J.R. - 1977
The widths of ice wedges; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 77-1A, pp. 43-44.

1161 MATTHEWS, Jr., J.V. - 1976
Insect fossils from the Beaufort Formation: geological and biological significance; *in* Report of Activities, Part B, Geol. Surv. Can., Paper 76-1B, pp. 217-227.

1162 McCANN, S.B., and TAYLOR, R.B. - 1975
Beach freezeup sequence at Radstock Bay, Devon Island, Arctic Canada; *Arctic and Alpine Res.*, vol. 7, no. 4, pp. 379-386.

Freezeup conditions in the beach and nearshore zone at Radstock Bay in the fall of 1971 are described and provide a basis for a more general discussion of the factors involved. The timing and duration of the freezeup process and the type of ice conditions produced at the shore are considered. The basic control on the process is the rate at which temperature declines in the fall, but wind and wave conditions, the type and amount of pack ice present both offshore and at the beach, and the amount of snowfall in the period are of major significance. In 1971, the final immobilization of the beach did not occur until October 4, though the process began a month earlier; storm-wave action and the grounding of resistant pack ice at the shore were important.

1163 MIALL, A.D. - 1974
Manganese Spherulites at an Intra-Cretaceous Disconformity, Banks Island, Northwest Territories; *Can. J. Earth Sci.*, vol. 11, no. 12, pp. 1704-1716.

Concretions ranging from 10 to 700μ in diameter form a marker zone between the Christopher Formation (Albian) and the Kanguk Formation (Cenomanian to Maastrichtian) in three wells in western Banks Island. The concretions contain in excess of 30% rhodochrosite ($MnCO_3$), plus minor quantities of dolomite, and iron and manganese oxides. Quartz sand and silt, clay, and sparry dolomite comprise the matrix between the concretions. The concretion zone ranges up to 40 ft (12 m) in thickness and is tentatively assigned to the Kanguk Formation.

Manganese was probably derived by decomposition of contemporaneous volcanic rocks, possibly located offshore west of Banks Island. The metal was concentrated by ionic or molecular diffusion processes acting immediately below the sediment-water interface.

Subsequent diagenetic recrystallization allowed for further manganese concentration and the development of a strong radial-fibrous crystal texture as the surrounding sediments were passively replaced. Concentric laminations were caused by further partial expulsion of impurities, probably including organics and iron and manganese oxides.

1164 MIALL, A.D. - 1975
The Evolution of a Jurassic-Tertiary Sedimentary Basin: A Sedimentological Reconstruction; *in* Proc. Congres Inter. de Sedimentologie, Nice, pp. 297-306.

Two major Mesozoic-Cenozoic depocentres are present in the Canadian Arctic, Beaufort-Mackenzie Basin and Sverdrup Basin, in both of which areas post-Paleozoic sediment thicknesses exceed 30,000 feet (9000 m). Banks Island is located between these two basins and is underlain by Mesozoic and Tertiary deposits the thickness of which is probably nowhere greater than 10,000 feet (3000 m).

Regional mapping by Thorsteinsson and Tozer (1962) led to the definition of a structural unit which they named Banks Island Basin, bounded on three sides by cratonic uplifts and open to the west. The area occupied by this basin is the subject of the present paper.

Recently published gravity data and well data, indicate that the structure underlying Banks Island is considerably more complex than that shown in Figure 1. Several subsidiary basins and highs are in fact present as shown in Figure 2. Note that Banks Island Basin, here referred to as Banks Basin, has been re-defined in Figure 2. Owing to the extensive cover of Late Tertiary sediments and glacial and periglacial deposits few of these subsidiary features were apparent from surface structural and stratigraphic mapping. However, the careful use in the field of sedimentological techniques has demonstrated that they have, in fact, controlled sedimentation at least since Early Cretaceous times.

A summary account of the geological history of the area is provided elsewhere. The present paper is concerned mainly with sedimentologi-

cal methods. Laboratory work is continuing and will lead to a more detailed report at a later date.

1165 MIALL, A.D. - 1975
Post-paleozoic geology of Banks, Prince Patrick and Eglinton Islands, Arctic Canada; *in* Can. Soc. Petrol. Geol. Mem. 4, pp. 557-587.

Pennsylvanian to Early Jurassic sediments underlie part of Prince Patrick Island but are absent on Banks Island. From Early Jurassic through Early Tertiary times the Banks-Prince Patrick area underwent fairly continuous sedimentation. A slower subsidence rate than in the Mackenzie Delta and Sverdrup Basin depocentres gave rise to correspondingly smaller sediment thickness.

A late Early Jurassic marine transgression covered most of Prince Patrick Island and Eglinton Graben and probably filled much of Banks Basin. Thick sands and shales resulted (Wilkie Point and Mould Bay Formations). In the Aptian, uplift and block faulting caused a regression and created local troughs in which fluvial sediments accumulated (Isachsen Formation). Sediment was derived from the cration and from local fault-bounded uplifts (?including Storkerson Uplift). Vertical sequences of sedimentary structures demonstrate stream rejuvenation and shifting channel patterns, both thought to have been caused by continued syndepositional fault movement.

Succeeding argillaceous and silty beds (Christopher Formation) reflect an Albian marine transgression. A Late Albian shoreline sand facies developed in Eglinton and northern Banks Island (Hassel Formation) and an Early Cenomanian regression followed. Marine sedimentation may have continued in Big River Basin, while mild erosion ensued elsewhere in the report area. Renewed, eastward transgression commenced in the Turonian but did not reach eastern Banks until Late Campanian time. Prince Patrick Island remained uplifted until the Late Tertiary.

Silty shale accumulated in the Banks Area during the Late Cretaceous (Kanguk Formation). A Campanian shoreface sand facies developed on the flanks of Storkerson and Cape Crozier Uplifts, while extrusive volcanism may have occurred in the vicinity of western Banks Island.

Fault rejuvenation and differential uplift from Maastrichtian through Eocene time caused deltaic wedges to prograde from Storkerson Uplift and the craton into Banks and Big River Basins (Eureka Sound Formation). Fourier analysis of gramma ray logs shows that coarsening upward clastic cycles therein thicken with present basin depth, indicating a Tertiary origin for the present structural configurations.

Uplift and erosion during the Oligocene was followed by subsidence of present offshore areas and commencement of a major deltaic phase which continued to the present. Beaufort Formation is part of this assemblage, which thickens seaward to several thousands of feet.

1166 MIALL, A.D. - 1976
Proterozoic and paleozoic geology of Banks Island, Arctic Canada; *Geol. Surv. Can.*, Bull. 258, 77 p.

Banks Island is the southwesternmost island of the Canadian Arctic Archipelago, and comprises an area of 60 100 km^2 (23,200 sq miles). Proterozoic rocks crop out along the south coast and Upper Devonian strata are exposed in the northeastern portion of the island. The remainder of Banks Island is covered by Mesozoic and Cenozoic sediments.

This report is concerned primarily with the subsurface stratigraphy, based on data obtained from the first seven wells to be drilled in the area. A limited amount of surface data, obtained during field work done by the writer in 1973 and 1974, also is included.

The oldest rocks exposed in the area are upper Proterozoic cherty dolomites and quartzose sandstones of the Glenelg Formation and comprise part of a cratonic sequence of mainly shallow marine origin.

A sequence of Cambrian to Middle Devonian strata, 1200 m (4,000 ft) thick, overlies the Precambrian in Victoria Island. Cambrian to Silurian rocks are not exposed at the surface on Banks Island and have not been penetrated by any wells drilled to date; the succession in Banks Island is assumed to be similar to that of Victoria Island except that a westward transition from cratonic to geosynclinal facies may occur in the western part of Banks Island, similar to that which is now known to characterize the overlying Devonian rocks. The latter range in age from Early to Late Devonian and total an estimated 4600 m (15,000 ft) in thickness.

Lower and Middle Devonian strata display abrupt lateral facies changes. Blue Fiord Formation represents sedimentation on a shelf area which was confined mainly to the southern and eastern parts of the island. The rocks are mainly carbonates. They pass laterally westward and northward into a basin slope facies composed of the calcareous shale of the Orksut Formation (new name), and these in turn pass laterally into siliceous shale comprising a deep basin facies, the Nanuk Formation (new name). The deep basin represents a southward extension of Hazen Trough and is probably linked to a similar basin, the Richardson Trough, in the northern Yukon area.

The facies belts underwent a southward migration during the Early and Middle Devonian. Commencing in late Middle Devonian time, a clastic wedge (Melville Island Group) spread southward into the Banks Island area. The source of the detritus was probably a tectonic landmass to the north and northeast of the report area.

Rocks of late Paleozoic age are not known in Banks Island. However, several lines of evidence suggest that strata of this age may have been deposited, but removed later in pre-Jurassic time. For example, the level of hydrocarbon maturation in the Devonian sediments is everywhere considerably greater than that of the Mesozoic deposits, suggesting deep burial before Mesozoic sedimentation commenced.

There is no evidence of any significant structural deformation of the Proterozoic and Paleozoic rocks other than normal faulting. Dips are generally less than 10°.

Potential for the occurrence of hydrocarbons in the Paleozoic strata is considered to be fair. Stratigraphic traps may be present at the carbonate-shale facies change. In view of the high degree of maturity exhibited by these rocks, any hydrocarbon present is likely to be dry gas. The carbonate-shale facies change also has potential as a locus for sulphide mineral deposition.

1167 MIALL, A.D. - 1976
Sedimentary structures and paleocurrents in a Tertiary deltaic succession, northern Banks Basin, Arctic Canada; *Can. J. Earth Sci.*, vol. 13, no. 10, pp. 1422-1432.

The Eureka Sound Formation of northern Banks Basin is a deltaic unit of Paleocene to Eocene age. A basal member of shale, approximately 100 m thick, passes vertically and, in part, laterally into a succession of sand, silt, shale, and lignitic coal approximately 1000 m thick, which is referred to as the cyclic member because of the abundance of coarsening-upward cycles, averaging 7.4 m in thickness.

Sand beds in the cyclic member can be divided into four lithofacies: (1) A facies dominated by medium- to large-scale planar crossbedding, formed by channel processes, including lateral point bar accretion, in the delta plain environment. (2) A predominance of medium-scale trough and (minor) planar crossbeds, formed by migrating dunes in distributary mouth bar sands. (3) A predominance of small-scale ripple-marks, formed by low energy, unimodal currents in distal distributary mouth sands. (4) A lack of current structures, indicating quiet-water, interdeltaic and prodeltaic deposition. The distribution of these four facies outlines a series of small lobate deltas.

Paleocurrent data suggest a pattern of radiating distributaries within each delta lobe. Directional variance, when analyzed at various levels of the sedimentary structure hierarchy, provides information regarding channel sinuosity and enables comparisons to be made with other deltaic deposits. High variance for the directions of the distributaries is consistent with a fluvially dominated delta.

1168 MIALL, A.D., and KERR, J.W. - 1977
Phanerozoic stratigraphy and sedimentology of Somerset Island and Northeastern Boothia Peninsula; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 77-1A, pp. 99-106.

1169 MILES, M. - 1976
An investigation of riverbank and coastal erosion, Banks Island, District of Franklin; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, pp. 195-200.

1170 MITCHELL, R.H. - 1976
Ultramafic zenoliths from the Elwin Bay kimberlite: the first Canadian paleogeotherm; *Can. J. Earth Sci.*, vol. 14, no. 6, pp. 1202-1210.

Ultramafic xenoliths from the Elwin Bay kimberlite provide samples of the upper mantle beneath arctic Canada. The compositions of coexisting pyroxenes have been used to estimate the temperatures and pressures of equilibration of the three texturally and mineralogically distinct types of zenolith, *i.e.* spinel lherzolite (840-935°C), coarse garnet lherzolite (925-1085°C at 39.5-49.5 kbar (3.95-4.95 x 10^6 kPa)) and porphyroclastic garnet lherzolite (1090-1180°C at 47.0-51.5 kbar (4.7-5.2 x 10^6 kPa)). The garnet lherzolite data define an inflected paleogeotherm whose upper limb lies at shallower depths than found for the Thaba Putsoa - Mothae paleogeotherm but which is identical to the Montana paleogeotherm. No evidence is found for iron enrichment of the upper mantle in this region.

1171 NETTERVILLE, J.A., DYKE, A.S., THOMAS, R.D., and DRABINSKY, K.A. - 1976
Terrain inventory and quaternary geology, Somerset, Prince of Wales, and adjacent islands; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, pp. 145-154.

1172 NORRIS, D.K. - 1976
Structural and stratigraphic studies in the Northern Canadian Cordillera; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, pp. 457-466.

1173 PALMER, H.C., and HAYATSU, A. - 1975
Paleomagnetism and K-Ar Dating of Some Franklin Lavas and Diabases, Victoria Island; *Can. J. Earth Sci.*, vol. 12, no. 8, pp. 1439-1447.

Lavas of the Natkusiak Formation and related diabase sills, Victoria Island, have single polarity remanence directions, which yield a paleomagnetic pole at 163°E, 07°S, which is similar to that obtained from the Coronation Sills of the adjacent mainland. These western Arctic poles are slightly, but significantly different from those obtained from Franklin sills and dikes exposed in the central and eastern Arctic. K-Ar data indicate no resolvable difference in age between the western and eastern Arctic rocks. Although the apparent K-Ar ages from the Victoria Island lavas and sills are discordant, the highest apparent ages are in agreement with a K-Ar isochron age of 625 m.y. obtained from samples of the least altered lavas.

1174 PAWLUK, S., and BREWER, R. - 1975
Micromorphological and analytical characteristics of some soils from Devon and King Christian Island, N.W.T.; *Can. J. Soil Sci.*, vol. 55, pp. 349-361.

Investigation of soils from Devon and King Christian Islands show frost processes as having a dominating influence upon microfabric characteristics. Frost processes are expressed in the various modifications of banded fabric observed in the soils, and fine-grained cappings on framework members. While soils from Devon Island show little evidence of chemical alteration, the soil from King Christian Island has chemical attributes which reflect desalinization and alkalization processes. Mineralo-

gical weathering is minimal, but the soils can be differentiated on the basis of carbonate rock content and clay mineral distribution. Soils from Devon Island are classified as Regosolic Turbic Cryosols, while the soil from King Christian Island cannot be readily classified in the Canadian system of soil classification.

1175 PELLETIER, B.R. - 1975
Sediment dispersal in the Southern Beaufort Sea; Beaufort Sea Technical Report No. 25a, December 1975, 80 p.

This is a study of sediment dispersal based on textural examination of the bottom sediments. It involves the nature, distribution and origin of these sediments as they occur on the sea bottom. With reference to the offshore exploratory drilling, the nature of the sea bottom is important for the following reasons: (1) to determine foundation strength of material. (2) to deduce the fate of sediment particles in connection with deposition and erosion, and (3) to establish a data baseline in the event of an oil spill.

1089 PELLETIER, B.R. - 1976
Outline for a marine science atlas of the Beaufort Sea; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, pp. 325-331.

1176 PERRY, D.G., and CHATTERTON, B.D.E. - 1977
Silurian (Wenlockian) trilobites from Baillie-Hamilton Island, Canadian Arctic Archipelago; *Can. J. Earth Sci.*, vol. 14, no. 2, pp. 285-317.

Wenlockian trilobites representing at least 15 genera are reported from carbonate strata within the Cape Phillips Formation, Baillie-Hamilton Island. The collections are stratigraphically bounded by the graptolite Zones of *Cyrtograptus murchisoni* and *Monograptus testis*. The fauna is generically dominated by lichids, odontopleurids, and cheirurids. Scutelluids, phacopids, dalmanitids, and harpids are notable for their absence. At the familial level the fauna corresponds to one recently discovered from similar age beds of the Mackenzie Mountains, Northwest Territories. The limited quantity and fragmental nature of much of the silicified fauna precludes erection of many new taxa, although four new species described are: *Sphaerexochus dimorphus*, *Dicranogmus skinneri*, *Hemiarges rohri*, and *Hemiarges mikulici*. Dimorphic pygidia are interpreted as probable sexual dimorphs in *Sphaerexochus dimorphus* n. sp.

1177 PISSART, A., and FRENCH, H.M. - 1976
Pingo investigations, north-central Banks Island, Canadian Arctic; *Can. J. Earth Sci.*, vol. 13, no. 7, pp. 937-946.

A number of pingo-like mounds, located in the north-central part of Banks Island, are described. The features are situated on low terraces within the valleys of the Thomsen River and its small tributary, Able Creek. Many are elongate in plan and partially collapsed in form. Sections excavated across four of the mounds reveal cores of massive ice. It is hypothesized that these ice bodies are the result of both segregation and injection processes, induced by the freezing of localized sub-channel taliks.

1178 POULTON, T.P., and CALLOMON, J.H. - 1976
Major features of the lower and middle Jurassic stratigraphy of Northern Richardson Mountains, Northeastern Yukon Territory, and Northwestern District of Mackenzie; *in* Report of Activities, Part B; Geol. Surv. Can., Paper 76-1B, pp. 345-352.

1018 PRICE, L.W., BLISS, L.C., and SVOBODA, J. - 1974
Origin and Significance of Wet Spots on Scraped Surfaces in the High Arctic; *Arctic*, vol. 27, pp. 304-306.

1179 RAHMANI, R.A. - 1977
Fault control on sedimentation of Isachsen Formation in Sverdrup Basin; *in* Report of Activities, Part B; Geol. Surv. Can., Paper 77-1B, pp. 157-161.

1180 RAHMANI , R.A., and HOPKINS, W.S., Jr. - 1977
Geological and palynological interpretation of Eureka Sound Formation on Sabine Peninsula, Northern Melville Island, District of Franklin; *in* Report of Activities, Part B; Geol. Surv. Can., Paper 77-1B, pp. 185-189.

1181 RAMPTON, V.N., and BOUCHARD, M. - 1975
Surficial geology of Tuktoyaktuk, District of Mackenzie; *Geo. Surv. Can.*, Paper 74-53, 17 p.

Tuktoyaktuk is situated on a part of the Arctic Coastal Plain that lies below 100 feet in elevation and that has many lakes. Mean annual ground temperature is -8°C, permafrost reaches a depth of 1200 feet on undisturbed sites, and the active layer is from 3 inches to slightly more than 40 inches in depth.

Near Tuktoyaktuk, a diomicton (till and reworked till) overlies thick outwash, generally sand. Massive ground ice commonly is found along the contact between the two deposits, especially where the till is thick. Outwash is also extensive on the surface. Fine-grained lacustrine sediments are found in areas of till and reworked till: coarse-grained lacustrine sediments are present in areas of outwash. Peat occurs on poorly drained areas, especially lacustrine flats. Intertidal sediments cap low areas that are periodically inundated by the sea; beach and spit deposits are common along exposed coasts. Excess ice is most common in lacustrine, intertidal, and organic deposits, and in the upper 2 to 5 feet of permafrost in other deposits.

Coastal retreat is rapid where massive ground ice or ice-rich sediments are near sea level and vulnerable to exposure by wave erosion. Retreat proceeds either through thermal niching and slumping or through ground-ice slumping. Spits are also moving rapidly landward across drained lake basins.

The Tuktoyaktuk area was last glaciated in

early Wisconsin time. Following 11 500 B.P. the climate warmed, initiating extensive thermokarst activity that continued until about 3600 B.P., when the climate again deteriorated and the terrain stabilized except for minor ice slumping and erosion along the coast. Peat growth was probably greatest between 11 500 and 3600 B.P. and has decreased since.

Care should be taken in the Tuktoyaktuk area to avoid surface disturbance that will lead to thermokarst. Also, coastal erosion will continue at Tuktoyaktuk unless man constructs protective structures along the coast which forms its western edge.

1182 SHEARER, J.M. - 1973
Surficial geology and geomorphology, Mackenzie Bay - Continental Shelf; *in* Report of Activities, Part A: April to October 1972, Geol. Surv. Can., Paper 73-1, Part A, p. 242.

1183 SHEARER, J., and BLASCO, S. - 1975
Further observations of the scouring phenomena in the Beaufort Sea; *in* Report of Activities, April to October 1974, Geol. Surv. Can., Paper 75-1, Part A, pp. 483-493.

1184 STEPHEN, W.J. - 1976
A reconnaissance study of the coastal processes on Banks Island, District of Franklin; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, pp. 271-272.

1185 STEPHEN, W.J. - 1976
Coastal environments of Banks Island, N.W.T.; *Ice*, no. 50, p. 16.

1186 TARNOCAI, C. - 1976
Soils of Bathurst, Cornwallis, and adjacent islands, District of Franklin; *in* Report of Activities, Part B, Geol. Surv. Can., Paper 76-1B, pp. 137-141.

1026 TARNOCAI, C., BOYDELL, A.N., NETTERVILLE, J.A., and DRABINSKY, K.A. - 1977
Biophysical land classification, Boothia Peninsula and Northeast Keewatin; *Geol. Surv. Can.* Open File No. 390.

1187 TARNOCAI, C., and KRISTOF, S.J. - 1976
Computer-aided classification of land and water bodies using Landsat Data, Mackenzie Delta Area, N.W.T., Canada; *Arctic and Alpine Res.*, vol. 8, no. 2, pp. 151-159.

Terrestrial and aquatic environments on Richards Island (Mackenzie Delta) were classified by a computer-implemented pattern recognition technique using LANDSAT (formerly ERTS) data. A clustering sampling procedure applied to a portion of the area divided the data into groups of sample points of similar spectral characteristics. These cluster groups were used as reference or training samples in the classification of each data point on Richards Island into one of 22 spectral classes (14 terrestrial and 8 aquatic). The description of the cluster classes and the evaluation of the classification accuracy were based on data collected at the ground truth sites. The maximum overall classification accuracy was 88%.

1188 TAYLOR, R.B. - 1976
Nearshore observations along the east coast of Melville Island, District of Franklin; *in* Report of Activities, Part B; Geol. Surv. Can., Paper 76-1B, pp. 43-58.

1189 THOMAS, R.D. - 1977
A brief description of the surficial materials of north-central Keewatin, Northwest Territories; *in* Report of Activities, Part B; Geol. Surv. Can., Paper 77-1B, pp. 315-317.

1190 TRETTIN, H.P. - 1976
Geological investigations in Northern Ellesmere Island (Reports 91 to 96) introduction; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, pp. 425-430.

1075 VEILLETTE, J.J., and NIXON, F.M. - 1975
A modified ATV-drill for shallow permafrost coring; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 75-1C, pp. 323-324.

1191 VEILLETTE, J. - 1976
Assessment of terrain performance, Somerset and Prince of Wales Islands, District of Franklin; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, pp. 281-282.

1192 VEIZER, J., LEMIEUX, J., JONES, B., GIBLING, M.R., and SAVELLE, J. - 1977
Sodium: Paleosalinity indicator in ancient carbonate rocks; *Geology*, vol. 5, March 1977, pp. 177-179.

The hypersaline facies of the lower Paleozoic carbonate sequence of Arctic Canada contain $\gtrsim$230 ppm of soluble Na, whereas their open-marine counterparts are characterized by concentrations below this value. This chemical difference, imposed by sedimentary and (or) diagenetic environments, is preserved in spite of the order of magnitude postdepositional redistribution of sodium.

1193 VINCENT, J.S. - 1976
Ground ice on Banks Island, N.W.T.; *Ice*, no. 50, p. 16.

1194 VINCENT, J.S., and GAUTHIER, R.C. - 1976
Inventaire des depots de surface de l'Ile Banks, District of Franklin; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, p. 27.

1195 WAHLGREN, R.V., and LEWIS, C.F.M. - 1977
Estimation of bulk density and water content of Beaufort Sea sediment cores using x-radiographs; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 77-1A, pp. 465-470.

1196 WALKER, B.D. - 1976
Soils of the Truelove Lowland and vicinity, Devon Island, N.W.T.; unpub. Ph.D. Thesis, Univ. Alberta.

The Truelove Lowland and adjacent upland to

the east were investigated to determine kinds and distribution of soils. The tentative Cryosolic Order was used to classify the soils to the subgroup level. Further separations approximating the soil series level of abstraction were based on parent material characteristics. Distributions of soil map units, based on the "soil series" or complexes of "soil series", are depicted on an orthophoto mosaic base with a scale of approximately 1:15,000.

The study area encompasses coastal lowland, not unlike sedge-grass tundra of the Low Arctic, and interior plateau or upland that resembles Polar Desert areas of the High Arctic. Consequently, soil cover of the Lowland is much more complex than that of the upland. Soil subgroups correlate best with drainage and vegetation patterns until severely restricted drainage conditions are encountered.

Soils with relatively free drainage (rapidly to moderately well drained) include Regosolic Static Cryosols (Ahk-Ck-Cz horizon sequence) and Brunisolic Static Cryosols (Ahk-Bmk-Ck-Cz horizon sequence). These soils are associated with cushion plant-lichen, cushion plant-moss, and dwarf shrub heath-moss plant communities and occur on raised beaches and in small, warm habitats of crystalline rock outcrops.

Imperfectly to poorly drained soils include Regosolic Turbic Cryosols, Brunisolic Turbic Cryosols, and Gleysolic Turbic Cryosols that are associated with cushion plant-lichen and cushion plant-moss communities with frost-boils and frost-boil sedge-moss meadow community. Raised beaches, Lowland moraine, and undifferentiated plains are landforms in which these soils of patterned ground meshes (circles, nets, or stripes) develop. A Gleysolic Turbic Cryosol that lacks organic matter accumulation mantles the upland portion of the study area and is associated with moss-herb (Polar Desert) vegetation.

Wet soils (poorly to very poorly drained) include Gleysolic Static Cryosols (Of-Ckg-Cz horizon sequence) of undifferentiated plains, Lowland moraine, floodplains, and alluvial-lacustrine plains and Fibric Organo Cryosols (Of-Oz horizon sequence) of undifferentiated plains. Hummocky sedge-moss meadow and wet sedge-moss meadow are characteristic plant communities. A drier Glacic Fibric Organo Cryosol mantles high-centered, ice-cored, ice-wedge polygons.

Miscellaneous soil map units include unconsolidated, fragmental beach, outwash, alluvial, colluvial, and morainal deposits and two types of bedrock.

Generally, soils of the study area are alkaline, calcareous, base saturated, nonsaline, and coarse textured (sandy loam to sand) with variable coarse fragment contents. Organic layers and soils are generally quite fibrous and slightly acid to neutral in reaction.

1197 WEST, R.M., and DAWSON, M. - 1976
Fossils found in the Eureka Sound Formation; *Arctic Circular*, vol. XXIV, pp. 7-8.

The Eureka Sound Formation is a thick sequence of sedimentary rocks comprising marine and terrigenous deposits. This folded and faulted complex represents twenty to twenty-five million years of early tertiary history. Drs. Robert West and Mary Dawson spent three field seasons examining selected areas of this formation in western Ellesmere Island. They have discovered a wide variety of vertebrate fossils within these beds.

1198 WEST, R.M. - 1977
Warm-climate life on ancient Ellesmere Island; *GEOS*, Winter 1977, pp. 9-11.

At first glance Ellesmere Island does not seem to be an appropriate place to search for remains of warm-climate life. However, paleontologists are finding evidence that diverse animals and plants lived on warm, almost subtropical Ellesmere Island during the Eocene Epoch some 45 to 50 million years ago.

1199 YOUNG, G.M., and JEFFERSON, C.W. - 1975
Late Precambrian Shallow Water Deposits, Banks and Victoria Islands, Arctic Archipelago; *Can. J. Earth Sci.*, vol. 12, no. 10, pp. 1734-1748.

The upper Precambrian succession of the southern tip of Banks Island comprises about 900 m of sedimentary rocks intruded by thick gabbro sills. The lowest unit exposed is a cherty stromatolitic carbonate. This is overlain by a thicker unit of sandstones and mudstones. Most of the sequence is considered to be correlative with the Glenelg Formation, which is the basal formation of the late Precambrian Shaler Group of the Minto Arch on Victoria Island. A thick shale unit at the top of the Banks Island Precambrian succession may be correlative with the basal part of the Reynolds Point Formation on Victoria Island.

Paleocurrent measurements from the Banks Island rocks indicate transport essentially to the northwest. An abundantly cross-bedded sandy limestone unit in the upper part of the Reynolds Point Formation in the Minto Inlet area of Victoria Island gives a polymodal paleocurrent pattern. This unit was probably deposited in a shallow marine environment under tidal influence. Tidalites have been recognized in the lower clastic unit of the Reynolds Point Formation at several localities in the Minto Arch. Stromatolites form the lower part of the Shaler Group suggest that these rocks are early Upper Riphean (latest Helikian to early Hadrynian). The stromatolite forms appear to occur in a non-repetitive sequence that provides a powerful means of intrabasinal correlation.

The depositional area is envisaged as a large embayment of the sea, comparable in scale, shape, and sedimentary fill, to the younger Michigan Basin. The northwest margin of the basin is tentatively interpreted as a breached arch, shedding terrigenous clastics to the NW in the Banks island area, and to the east at the north end of the Minto Arch. Northeasterly elongation of stromatolites in the upper Glenelg Formation at the north end of the Minto Arch may reflect tidal currents. Circulation in the basin became progressively restricted, culminating in deposition of the evaporite-bearing sequence of the upper part of the Shaler Group.

1200 YOUNG, G.M. - 1976
Stratigraphic correlations between the Northern Cordillera and the Northwestern Canadian Shield; *Abstract in* Geol. Assoc. Can., 1976 Annual Meeting, Ed., Alta.

Most of the Late Proterozoic rocks of Banks Island, Brock Inlier and the Coppermine area are thought to be correlative with the Glenelg Formation, which is the lowest unit of the Shaler Group of Victoria Island. On the basis of stromatolite assemblages, the Shaler Group is considered to be equivalent to the lower part of the Upper Riphean of the U.S.S.R. The succession of formations in the Shaler Group is similar to that of the "older Proterozoic sequence" of the Mackenzie Mountains in the northern part of the Cordillera, which has been considered correlative with the Belt-Purcell of the southern Canadian Cordillera. Correlation of the Shaler with the older Proterozoic sequence of the Mackenzie Mountains region would invalidate its correlation with the Belt-Purcell, for the latter sequence is thought to be Helikian. Limited paleocurrent data from the Mackenzie Mountain older Proterozoic suggests westerly transport of terrigenous clastic debris. This fact, together with the easterly thickenning of the Shaler Group in Brock Inlier suggests the presence of a weak positive area between these two areas at the time of sedimentation. The proposed correlations resolve a paleoclimatic problem; namely the former correlation of the Rapitan Group (which contains abundant evidence of glacial activity) with the Shaler Group which is characterised by red beds, evaporites, stromatolitic dolomites and oolites, which probably indicate warm climatic conditions.

1201 YOUNG, G.M., and LONG, D.G.F. - 1976
Stromatolites and basin analysis: an example from the Upper Proterozoic of Northwestern Canada; *Palaeogeogr., Palaeoclimatol., Palaeoecol.*, vol. 19, pp. 303-318.

Stromatolites have been used for inter-basinal biostratigraphic correlation, rock-stratigraphic correlation within individual sedimentary basins and for palaeoecological studies of various kinds. In the northern part of Victoria Island stromatolites are abundant in the uppermost part of the Glenelg Formation, which is the lowest unit of the upper Proterozoic Shaler Group. Measureable attributes of these stromatolites include elongate mounds, intermound channel fillings, ridges and grooves, elongate columns and inclined columns. In a widespread stromatolitic bank that forms the upper part of the Glenelg Formation, and also in stromatolites of the overlying Reynolds Point Formation, several of these features show a preferred orientation in a northeasterly direction. Herringbone cross-beds in associated sandy oolitic limestones show a northeast - southwest bimodal-bipolar distribution that is probably related to tidal activity. This similarity of directional features suggests that the stromatolite orientations are also likely to have been tidally influenced. If each stromatolitic bank were deposited diachronously then the northeasterly preferred orientation may be explained as being due to tidal currents active at a migrating shoreline that trended in a northwest - southeast direction. Alternatively, if, in the absence of metazoan competitors, the stromatolite builders contemporaneously occupied a large part of the basin floor, their northeasterly orientation may reflect tidal currents parallel to the length of an elongate embayment of the Precambrian sea, analogous in many ways to the present-day Persian Gulf. Such an interpretation, involving parallelism between coastline and elongate stromatolites, would differ from those of most earlier reports, in which elongate stromatolites have generally been assumed to have been oriented normal to the ancient shoreline.

1030 ZOLTAI, S.C., and TARNOCAI, C. - 1975
Perennially frozen peatlands in the western Arctic and subarctic of Canada; *Can. J. Earth Sci.*, vol. 12, no. 1, pp. 28-43.

1031 ZOLTAI, S.C., and WOO, V. - 1976
Soils and vegetation of Somerset and Prince of Wales Islands, District of Franklin; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1B, pp. 143-145.

GEOPHYSICS

1202 ANNAN, A.P., DAVIS, J.L., and SCOTT, W.J. - 1975
Impulse radar profiling in permafrost; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 75-1, Part C, pp. 343-351.

1203 ANNAN, A.P., DAVIS, J.L., and SCOTT, W.J. - 1975
Impulse radar wide angle reflection and refraction sounding in permafrost; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 75-1, Part C, pp. 335-341.

1204 ANNAN, A.P. - 1976
Density of ice samples from "Involuted Hill" test site, District of Mackenzie; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1C, pp. 91-95.

1205 ANNAN, A.P., and DAVIS, J.L. - 1976
Impulse radar sounding in permafrost; *Radio Science*, vol. 11, no. 4, pp. 383-394.

A VHF impulse radar system operating on the ground is a viable technique for mapping the near-surface geological structure and electrical properties of permafrost. A fixed antenna configuration transported over the surface yields a reconnaissance map of two-way travel times for subsurface reflectors. Wide-angle reflection and refraction (WARR) sounding determines propagation velocity versus depth when performed in layered areas. To obtain a WARR sounding, one measures travel time versus antenna separation. These techniques were field tested in the Tuktoyaktuk region of the Mackenzie River delta, N.W.T. Data recording was on a graphic display for initial field analysis

and on analog magnetic tape for subsequent processing. Reconnaissance surveying has mapped structural features at various depths between 3 and 30 m. The electrical loss of the soils at a site limits the penetration depth. Clays and silts attenuate the radar signal more than sands and gravels. WARR soundings have determined dielectric constant versus depth in layered areas. While impulse radar is useful in delineating geological structure, core drilling is required to determine the geological composition.

1206 ANNAN, A.P., and DAVIS, J.L. - 1977
Impulse radar and time-domain reflectrometry experiments in permafrost terrain during 1976; *in* Report of Activities, Part B; Geol. Surv. Can., Paper 77-1B, p. 67.

1207 ANONYMOUS - 1976
AIDJEX Main Experiment Completed; *Arctic Bull.*, vol. 2, no. 9, p. 165.

The main experiment culminated 5 years of planning and pilot studies, with data collected to test the dynamic ice model being developed by AIDJEX. Investigators hope to learn more about the effect of air-sea-ice interactions in the Arctic on the world's climate. When the model is validated, it should improve ice forecasting techniques, which presently use wind-driven models that do not account for stress in the ice and for influence of boundaries.

During the main experiment, the manned camps and their circle of data buoys tracked generally to the southeast (contrary to the anticipated westerly drift) and into an area of active ice movement. Big Bear, the original main camp, was evacuated in early October 1975 when its ice floe split apart in a series of cracks. The main camp was relocated at Caribou, formerly one of three satellite camps.

0916 APOLLONIO, S. - 1961
Report of the field leader, April-September 1961 in "The Devon Island Expedition"; *Arctic*, vol. 14, no. 4, pp. 253-254.

1096 APOLLONIO, S. - 1961
The Devon Island Expedition; *Arctic*, vol. 14, no. 4, pp. 252-265.

1208 APOLLONIO, S. - 1962
The Devon Island Expedition 1960-1964; *Arctic*, vol. 15, no. 4, pp. 317-321.

1105 BURKE, K.B.S., and HOBSON, G.D. - 1975
A seismic study of surficial deposits in the Winkler Area, Manitoba; *Geol. Surv. Can.*, Paper 75-44, 13 p.

1209 CAMPBELL, W.J., WEEKS, W.F., RAMSEIER, R.O., and GLOERSEN, P. - 1975
Geophysical studies of floating ice by remote sensing; *J. Glaciology*, vol. 15, no. 73, pp. 305-328.

This paper presents an overview of recent remote-sensing techniques as applied to geophysical studies of floating ice. The current increase in scientific interest in floating ice has occurred during a time of rapid evolution of both remote-sensing platforms and sensors. Mesoscale and macroscale studies of floating ice are discussed under three sensor categories: visual, passive microwave, and active microwave. The specific studies that are reviewed primarily investigate ice drift and deformation, and ice type and ice roughness identification and distribution.

1210 CAMPBELL, W.J., GLOERSEN, P., WEBSTER, W.J., WILHEIT, T.T., and RAMSEIER, R.O. - 1976
Beaufort Sea Ice Zones as Delineated by Microwave Imagery; *J. Geophys. Res.*, vol. 81, no. 6, pp. 1103-1110.

During April 1972, microwave and infrared data were obtained from the NASA CV-990 research aircraft over the Beaufort Sea ice from the shoreline of Harrison Bay northward to a latitude of almost 81°N. The data acquired aboard the aircraft were compared with microwave data obtained on the surface at the test site of the Arctic Ice Dynamic Joint Experiment at an approximate position of 75°N, 150°W. Over this north-south transect of the polar ice canopy it was discovered that the sea ice could be divided into five distinct zones. The shorefast sea ice was found to consist uniformly of first-year sea ice. The second zone was found to be a mixture of first-year sea ice, medium size multi-year floes, and many recently refrozen leads, polynyas, and open water; considerable shearing activity was evident in this zone. The third zone, in which aircraft and surface data were compared, was a mixture of first-year and multi-year sea ice which had a uniform microwave signature because the multi-year ice floes were smaller than the instantaneous field of view of the airborne microwave radiometer. The fourth zone was found to be a mixture of first-year sea ice and medium-to-large size multi-year floes which was similar in composition to the second zone. The fifth zone was almost exclusively multi-year ice extending to the North Pole. Zones 3, 4 and 5 are also clearly distinguishable in microwave images obtained from the Nimbus 5 satellite.

1211 CARSEY, F.D. - 1976
The AIDJEX acoustic radar and some preliminary results; *AIDJEX Bull.*, Univ. Wash., Seattle, no. 31, pp. 1-19.

The AIDJEX acoustic radar system is described, and the standard values of system parameters are listed. The relationship between acoustic backscatter source and boundary layer meteorology is discussed with the tentative conclusion that the backscatter source height is the planetary boundary layer height for the time period of interest. This is related to the air stress modelling for AIDJEX purposes via the Brown simple momentum integral model, but a problem with the wind profile assumption in that model points up the need for a more complicated model. Stress values and acoustic radar condensed data for Spring 1975 and some wind profile calculations are presented.

1064 CAULFIELD, D.D., and LIRON, A. - 1975
Preliminary report on Bancqes sub-bottom Tuktoyaktuk tests; *Geol. Surv. Can.*, internal report, 72 p.

1065 CAUFIELD, D.D., LIRON, A., LEWIS, C.F.M., and HUNTER, J.A. - 1976
Preliminary test results of the "Bancqes" through-ice sub-bottom acoustic profiling system at Tuktoyaktuk, Northwest Territories; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, pp. 503-510.

1066 CRUTCHLOW, M.R. - 1976
Tracked Vehicle Sounding Over Ice; *Light House*, J. of the Can. Hydrographers' Assoc. no. 14, pp. 16-18.

1212 DAVIS, J.L., SCOTT, W.J., MOREY, R.M., and ANNAN, A.P. - 1976
Impulse radar experiments on permafrost near Tuktoyaktuk, Northwest Territories; *Can. J. Earth Sci.*, vol. 13, no. 11, pp. 1584-1590.

Field trials with a VHF impulse radar have been undertaken in the Tuktoyaktuk, N.W.T. area during the summer of 1973 and the spring seasons of 1974 and 1975. The radar transmits a wavelet with a centre frequency of 110 MHz and a pulse duration of 18 ns. Separate transmitter and receiver antennas were used.

Preliminary interpretation of the data obtained at the Involuted Hill test site indicates that ice/sand interfaces were detected to ranges greater than 30 m. In icy sand, ice lenses separated by 3 m were resolved. Clay-till/ice interfaces were not detected at ranges greater than about 3 m. At other sites near the village of Tuktoyaktuk, sand/clay-till interfaces were detected at ranges greater than 5 m.

Wide angle reflection and refraction sounding yields estimates of reflector depths and propagation velocities. Radar has proven useful in delineating geologic structure, but borehole control is required for identification of the geological composition of the structure.

1213 DOAKE, C.S.M., GORMAN, M., and PATERSON, W.S.B. - 1976
A further comparison of glacier velocities measured by radio-echo and survey methods; *J. Glaciology*, vol. 17, no. 75, pp. 35-38.

A comparison has been made between ice velocities that were measured by the radio-echo technique and by a survey method on the Devon Island ice cap, Arctic Canada (lat. 75°23'N, long. 82°23'W.). Results were 2.58 $\pm$ 0.11 m a^{-1} by radar and 2.17 $\pm$ 0.20 m a^{-1} by survey. The discrepancy between the two measurements is within the limits of statistical significance, and the methods are considered to give comparable results.

1214 DYCK, A.V., HOOD, P.J., HUNTER, J.A., KILLEEN, P.G., OVERTON, A., JESSOP, A.M., and JUDGE, A.S. - 1975
Borehole geophysics applied to metallic mineral prospecting: a review; *Geol. Surv. Can.*, Paper 75-31, A.V. Dyck, Ed., 66 p.

This report presents a review of the literature on borehole geophysical methods and applications most relevant to prospecting for and evaluation of metalliferous mineral deposits. Seismic, electrical, gravimetric, magnetic, nuclear, temperature measurement and directional surveying techniques are discussed; a brief review of borehole geophysical methods in permafrost concludes the review.

It is apparent from the literature that the electrical and magnetic methods have been used in boreholes for the past twenty-five years for the purpose of directly detecting deposits missed by the borehole; many successful applications are evident. Other techniques have seen more limited use; in these cases various possibilities exist. Those methods with inherently shallow depth of penetration fill the complementary role of in situ determination of rock properties and metal content.

1119 FALCONER, R.K.H. - 1977
Marine geophysical and geological research in Baffin Bay and the Labrador Sea, CSS Hudson 1976; *in* Report of Activities, Part B; Geol. Surv. Can., Paper 77-1B, pp. 255-260.

1215 GREENHOUSE, J.P. - 1961
Measurements of electrical resistivity of ice-formations (The Devon Island Expedition); *Arctic*, vol. 14, no. 4, pp. 259-265.

This is a preliminary report on the field work carried out by the geophysical party under Dr. Kurt Vögtli during the summer season of 1961. A description of the techniques has been added since, although they are well-known geophysical survey methods, prior to the last 2 or 3 years few attempts had been made to adapt them to use with ice. The recent development of a sensitive voltmeter with a very high input resistance to replace the more cumbersome potentiometer is the most notable innovation in the present work.

1216 GREENHOUSE, J.P. - 1963
Geophysics, summer 1962, (The Devon Island Expedition 1960-64); *Arctic*, vol. 16, no. 1, pp. 66-71.

During the 1962 field season the three-man geophysical party carried out a varied program which included: a gravity traverse of the ice-cap; studies of the electrical properties of snow, ice, and firn; and a movement survey of a previously established line of stakes on the Sverdrup Glacier.

1217 HALLIDAY, R.J., SHANNON, W.E., LOMBARDO, F. and COMPTON, B. - 1977
Canadian Seismograph Operations - 1975; *Energy, Mines & Res. Canada*, Seismological Service of Canada, Earth Phys. Br., Seismological Series No. 75, 65 p.

During 1975 the Division of Seismology and Geothermal Studies, of the Earth Physics Branch, Department of Energy, Mines and Resources operated or contracted the operation of 21 standard seismograph stations, 12 regional stations, 2 telemetered networks based at Ottawa and Victoria, a medium aperture array at Yellowknife, a strong-motion seismograph network on the West

Coast and several special or temporary seismographs. This report gives the characteristics of the various systems and describes the format and availability of the recorded data.

1218 HOBSON, G.D. - 1975
A buried bedrock channel outlined by the seismic method near Beauceville, Quebec, 21 L/2 east half; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 75-1C, pp. 221-226.

1219 HOBSON, G.D. - 1975
Cavendish geophysical test range, Ontario (NTS 31 D/16W); hammer refraction seismic survey; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 75-1C, pp. 191-196.

1220 HOBSON, G.D., and GAGNÉ, R.M. - 1975
Seismic refraction survey, eastern Niagara Peninsula, Ontario 30L,M; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 75-1C, pp. 227-229.

1221 HUNTER, J.A., and JUDGE, A.S. - 1975
Geophysical investigations of sub-sea permafrost in the Canadian Beaufort Sea; *in* Proc. 3rd Int. Conf. Port & Ocean Eng. under Arctic Conditions, Univ. Alaska, Fairbanks, Alaska, August 11-15 1975; II, pp. 1025-1057.

The presence of extensive frozen sediments beneath the seafloor of the southern Beaufort Sea has been predicted on theoretical grounds, interpreted from seismic surveys, and confirmed by drilling at several locations.

Theoretically it has been predicted that permafrost is probably present beneath water depths of up to 60 m, that it is thick (up to 600 m) in the near-shore areas but gradually thins into deeper water. Much of the permafrost is believed to have grown during emergence of the land surface and it is probably not continuous in extent; its presence and thickness is dependent on the surface history and morphology of the previous land surface. As a consequence of that history, a large part of the frozen material is relict in nature, although permafrost may be growing in submerged lake beds which remained unfrozen during emergence.

Reflection and refraction seismic surveys have been used extensively to detect the presence or absence of frozen horizons and the configuration of the top of those horizons. Studies of the attenuation of refracted signals can give a general idea of the thickness. The seismic results illustrate very well the local variability and hetero geneity of the frozen horizons. Observations made as part of offshore drilling programmes have confirmed the seismic interpretation. Sub-sea bottom temperatures have been measured as a part of the drilling programmes. These have given insight into the thermal character of the permafrost indicating, in the non-coastal areas, its marginally sub-zero temperatures and the probable presence of unfrozen horizons and water movement within them. Such drilling programmes have recovered cores of high ice content although excess ice is apparently not as common as in onshore sediments.

Through both field determinations of seismic properties and laboratory measurements on recovered drill-cores and cuttings, some data is available on the physical properties of sub-sea bottom materials. Such data is important as input for numerical modelling of mechanical and thermal conditions of offshore conditions.

The existence of substantial thicknesses of generally degrading frozen sediments of high ice content and temperatures marginally below zero creates many concerns in the development of offshore resources additional to those encountered in more temperate regions. Problems are faced in all phases of resource development, from mineral exploration to the eventual production and the transportation of the product to shore.

Any enhancement of our understanding of the present distribution and nature of sub-sea permafrost will require the development of further geophysical techniques, particularly for the detection of the base of the frozen horizon, and considerably more drilling.

1222 HUNTER, J.A.M., JUDGE, A.S., MacAULAY, H.A., GOOD, R.L., GAGNÉ, R.M., and BURNS, R.A. - 1976
The occurrence of permafrost and frozen subseabottom materials in the southern Beaufort Sea; Beaufort Sea Technical Report No. 22, April 1976, 174 p.

Permafrost conditions exist beneath most of the Beaufort Sea shelf area. As a result of large changes in the surface thermal régime in the recent geological past, non-equilibrium conditions are probably found in most areas; hence permafrost is both aggrading and degrading. Permafrost is generally at much higher temperatures offshore than the equivalent permafrost conditions onshore and as a result is much more susceptible to thawing by a thermal disturbance.

The occurrence of ice-rich sub-seabottom sediments over large areas of the shelf has been interpreted from seismic data. Such sediments are potentially susceptible to hazardous thermal degradation.

Because of low sediment temperatures, natural gas in shallow sediments may be found in the form of clathrate hydrates, which may cause additional technical problems for exploratory drilling. No such shallow occurrences have been documented in offshore drilling done to date; however, these deposits are seismically indistinguishable from ice-bonded sediments.

1223 HUNTER, J.A., and VEILLETTE, J. - 1976
Borehole density logging in permafrost, Tuktoyaktuk, District of Mackenzie; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, p. 417.

1224 HUNTER, J.A., and HOBSON, G.D. - 1977
Reflections on shallow seismic refraction records; *Geoexploration*, vol. 15, pp. 183-193.

Reflections from the overburden - bedrock interface have been interpreted from hammer seismic refraction records and substantiated by conventional wiggle-trace records. In the

areas studied, the bedrock reflection appears to be a prominent and persistent later event where overburden is thick (>30 m). Record analyses utilizing both reflected and refracted events may result in greater reliability of interpretations in shallow seismic prospecting.

1225 HYNDMAN, R.D. - 1963
Gravity survey, summer 1962 (The Devon Island Expedition 1960-1964); *Arctic*, vol. 16, no. 1, pp. 71-72.

The gravity work was aimed at determining ice thicknesses and underlying topography of the western half of the Devon Island Ice-Cap.

1226 HYNDMAN, R.D. - 1965
Gravity measurements on the Devon Island Ice Cap and an adjoining glacier; *J. Glaciology*, vol. 5, no. 40, pp. 489-496.

Gravity measurements have been used to determine ice thicknesses across the western part of the Devon Island ice cap in the Canadian Arctic. A detailed profile of the ice-cap edge and a profile across an adjoining glacier are also given. The ice cap has been found to have a largely rock core with ice thicknesses generally less than 500 m. A deep valley has been found in the bedrock beneath the ice cap some 15 km. from the start of a draining glacier. The measured depths on the ice cap should should be within 15 per cent and those on the glacier within 20 per cent of the true values.

1069 IIZUKA, K., OGURA, H., YEN, J.L., NGUYEN, V., and WEEDMARK, J.R. - 1976
A Hologram Matrix Radar; *in* Proc. of the IEEE, vol. 64, no. 10, pp. 1493-1504.

1227 JUDGE, A. - 1972
Geothermal studies conducted in conjunction with the Geological Survey of Canada Drilling Project at Fort Good Hope, N.W.T.; *in* Proc. Can. Northern Pipeline Res. Conf., NRC Tech. Mem. CRCC 12498, pp. 161-162.

1228 JUDGE, A. - 1972
Predicting the Depth of Permafrost; *Oilweek*, July 17, 1972,

The exploitation of natural mineral resources has played, and will continue to play, a very important role in the development of the Canadian north.

Such resources operations must be carried out in areas of frozen ground or permafrost, and are thus subject to many special problems. In the oil and gas industries particular problems encountered, which require some approximate knowledge of permafrost thicknesses, are the interpretation of geophysical measurements, the safe placing of surface casing in wells during drilling, and the design of future production wells.

The problem of permafrost is, of course, not unique to the oil and gas industry. The mining industry also faces increased costs in open-pit operations and dangers from ventilation-induced thawing around drifts and slopes underground.

1229 JUDGE, A.S. - 1973
The thermal regime of the Mackenzie Valley; observations of the natural state; Report Environ.-Social Comm. Northern Pipelines, Report No. 73-38, 175 p.

Relatively small amounts of material are available in the published literature which relate directly to the thermal regime of the area under study or to the thermal properties of frozen soils. The results that have been reported by the authors mentioned above are discussed in greater detail in the relevant Sections of the body of the report.

1230 JUDGE, A.S. - 1975
Geothermal studies in the Mackenzie Valley by the Earth Physics Branch; *Energy, Mines & Res. Canada*, Geothermal Service of Canada, Earth Phys. Br., Geothermal Series No. 2, 12 p.

As part of the Environmental-Social Program, Northern Pipelines, the Earth Physics Branch of the Department of Energy, Mines and Resources has carried out field observations of both the shallow and deep thermal regime of the Mackenzie Valley, conducted laboratory measurements of the thermal properties of subsurface soils and rocks, both frozen and unfrozen, has examined theoretically the thermal effects resulting from changes in the surface energy balance and compared these results with some observed temperature profiles.

Such studies are necessary for an adequate assessment of the environmental impact of proposed northern construction and development.

Through the existing program of the Earth Physics Branch, the work on the thermal behaviour of permafrost areas will continue to add to the volume of available data and enhance our understanding of the phenomena.

1231 JUDGE, A.S., and HUNTER, J.A. - 1975
The occurrence of permafrost beneath the sea-bottom of Kugmallit Bay, Beaufort Sea, Canada; *Abstract in* Geol. Soc. Amer., vol. 7, pp. 793-794.

The presence of frozen sediments beneath the sea-floor of the southern Beaufort Sea was first established by the Arctic Petroleum Operators Group in 1970. Mackay and Judge have suggested on theoretical grounds that several hundreds meters of permafrost may exist beneath the Beaufort Sea. Hobson and Hunter have suggested that refraction seismic methods can be used to detect the top of the frozen section and provide evidence of thickness.

In the Spring 1974, the Geological Survey of Canada supported an offshore drilling programme in Kugmallit Bay near Tuktoyaktuk. Four holes were drilled to depths of 85 m. to confirm the nature of the seismic refractor, to recover sub-sea-bottom materials and determine their lithology, engineering and thermal properties, and to determine the thermal character of the permafrost. The permafrost was observed in three of the four holes thus confirming the seismic results. An analysis of the observed temperature profiles indicates that the permafrost has been degrading for a few thousand years and is continuing to do so at present.

The existence of great thicknesses of degrading frozen sediments of high ice content and temperatures marginally below 0°C creates several problems in the development of offshore resources.

1232 JUDGE, A. - 1976
Permafrost, hydrates and the offshore thermal regime; *Energy, Mines & Res. Canada*, Geothermal Service of Canada, Earth Phys. Br., Internal Report No. 76-7, 19 p.

The results described here form part of a continuing study of the subsurface thermal regime across Canada. Hopefully as the opportunity arises further temperature measurements will be made in offshore wells, thus refining our understanding of the physical processes acting now and in the past in the offshore areas. This paper is confined to observations in the Beaufort Sea adjacent to the Mackenzie Delta.

1233 JUDGE, A. - 1976
The thermal character of the sediments beneath the Beaufort Sea and the implications for offshore drilling; *Energy, Mines & Res. Canada*, Geothermal Service of Canada, Earth Phys. Br., Internal report No. 76-3, 11 p.

The two additional hazards to normal offshore drilling are, of course, the presence of permafrost, in particular ice-bonded permafrost, and of gas hydrates. Strictly, both of these phenomena are theoretically possible in the sea-bottom of more southerly areas and, in fact, very thick accumulations of gas hydrates have been predicted beneath the deep oceans. Although both ice-bonded permafrost and gas hydrates are present in the northern onshore, a different surface history between on- and offshore has led to differences in the thermal and hence the physical character of the two areas.

1234 JUDGE, A.S., HUNTER, J.A., GOOD, R.L., COWAN, J., and ROBB, G. - 1976
Thermistor cable installation in permafrost materials with a water-jet drilling method; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, pp. 479-480.

1235 JUDGE, A.S., MacAULAY, H.A., and HUNTER, J.A. - 1976
An application of hydraulic jet drilling techniques to mapping of sub-seabottom permafrost; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, pp. 75-78.

1236 JUDGE, A.S., MacAULAY, H.A., and HUNTER, J.A. - 1976
Anomalous shallow seismic velocities in Mackenzie Bay, Northwest Territories; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, pp. 481-484.

1237 JUDGE, A., and TAYLOR, A. - 1976
Preservation of arctic wells for subsurface temperature observations; *Energy, Mines & Res. Canada*, Geothermal Service of Canada, Earth Phys. Br., Internal Report No. 76-1, 21 p.

Since 1962 a total of 65 wells drilled for northern oil and gas exploration have been preserved for subsurface temperature observations. The majority of these preservations, some 56, have been made since 1970. To date the total cost of preservations has been $120,862 or an average of $1860 per well. In the past several years an increasing number of the wells made available to us have been financed entirely by industry with a consequent reduction of average preservation costs to E.M.R. per well in 1975, for example, to $610.

1238 KOERNER, R.M., and PATERSON, W.S.B. - 1975
Queen Elizabeth Islands; *Ice*, No. 47, p. 3.

1239 KOZIAR, A., and STRANGWAY, D.W. - 1975
Magnetotelluric Sounding of Permafrost; *Science*, vol. 190, no. 4214, pp. 566-568.

The audio-frequency magnetotelluric method was used to sound a permafrost region in the Mackenzie delta in the Northwest Territories. A simple two-layer model consisting of a high electrical resistivity layer overlying less resistive material gave interpreted depths in agreement with those determined by drilling. The summer active layer was transparent even at high sounding frequencies.

1143 KURFURST, P.J., and HUNTER, J.A. - 1976
Geological and geophysical surveys - Willowlake River, Northwest Territories; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, pp. 161-164.

1146 LEWIS, C.F.M., BORNHOLD, B.D., and BLASCO, S.M. - 1976
Cruise Report No. 76025, Part 1, C.S.S. Hudson; Bed. Inst. Ocean., Dartmouth, 37 p.

1147 LEWIS, C.F.M., BLASCO, S.M., BORNHOLD, B.D., HUNTER, J.A.M., JUDGE, A.S., KERR, J.W., McLAREN, P., and PELLETIER, B.R. - 1977
Marine geological and geophysical activities in Lancaster Sound and adjacent fiords; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 77-1A, pp. 495-506.

1240 MacAULAY, H.A., HUNTER, J.A., and HOBSON, G.D. - 1975
Mapping permafrost in the Beaufort Sea by seismic methods; paper presented at Soc. Expl. Geoph., Denver, October 1975.

For the first time, it has been possible to obtain an overview of the configuration of subseabottom permafrost in a large area of the southern Beaufort Sea, by means of seismic techniques. Several oil companies have made over 8,000 line-miles, comprising approximately 40,000 seismic records, available to the Geological Survey of Canada for this study. Refraction data have been analysed and interpretations confirmed by other shallow refraction profiles and drill holes. This paper is a report of progress.

Continuous permafrost areas, those completely free of permafrost, and taliks (localized thaw

zones), have been mapped. One areal boundary is particularly noteworthy and probably associated with the ancient and modern delta boundary.

The top of permafrost is identifiable at variable depths beneath the sea floor; a map showing top of permafrost is in preparation.

It is anticipated also that a general thickness-of-permafrost map will evolve from this project. This study will be based upon amplitude measurement of the refracted signal, since attenuation rate with source-hydrophone distance is thought to be governed by the thickness of permafrost.

In general, the velocities associated with permafrost, 2,800 to 3,600 metres/sec. in Beaufort Sea, suggest ice saturated, medium-to-coarse-grained sands.

1241 MacAULAY, H.A., JUDGE, A.S., HUNTER, J.A., ALLEN, V.S., GAGNÉ, R.M., BURGESS, M., NEAVE, K.G., and COLLYER, J. - 1977
A study of sub-seabottom permafrost in the Beaufort Sea, Mackenzie Delta by hydraulic drilling methods; *Geol. Surv. Can.*, Open File 472, *Earth Phys. Br.*, Internal report No. 77-3, 78 p.

During the six-week period of March 1, to April 16, 1977, twenty-two holes were drilled from the sea-ice to maximum depths of 60 m beneath the sea-bottom of the Beaufort Sea. Each of the holes, drilled with a novel low-cost hydraulic drilling technique was instrumented with several temperature sensors which were subsequently monitored as the thermal disturbance due to the jetting dissipated. Plastic casing was installed in three holes enabling seismic and radioactive logs to be run prior to installation of the temperature cables. Preliminary results show the widespread distribution of permafrost in the sea-bottom but show additionally that it is highly variable in temperature and ice-content.

1242 MÜLLER, F., BLATTER, H., and KAPPENBERGER, G. - 1975
Remote sensing; *Ice*, No. 47, p. 6.

1243 MÜLLER, F., BLATTER, H., and KAPPENBERGER, G. - 1975
Temperature measurements of ice and water surfaces in the North Water area using an airborne radiation thermometer; *J. Glaciology*, vol. 15, no. 73, pp. 241-250.

Ice and water surface temperatures were measured with an airborne radiation thermometer PRT-5 over the North Water polynya during three missions between late winter and early summer 1974. Error corrections, problems of data analyses and mapping are discussed. Attempts are made to relate the main types of sea ice to temperature ranges, which then are used in conjunction with satellite pictures to produce surface temperature maps.

1244 OLHOEFT, G.R. - 1977
Electrical properties of natural clay permafrost; *Can. J. Earth Sci.*, vol. 14, no. 1, pp. 16-24.

The resistivity, dielectric constant, and loss tangent of natural clay permafrost samples that have never been thawed have been measured as functions of temperature, applied uniaxial confining load, and applied electric field strength. DC resistivities are on the order of 10^5 ohm-m at $-10^{\circ}C$, with the complex resistivity becoming strongly frequency dependent within and above the range of 10 to 10^3Hz (resistivity decreasing with increasing frequency). Below 10^3Hz, the electrical properties are slightly dependent upon applied electric field, and below 10^5Hz, the electrical properties are very strongly dependent upon applied uniaxial confining load. Several different mechanisms are responsible for the observed properties, including ionic conduction, a colloidal response that is similar to a Maxwell-Wagner type of effect, the relaxation of Bjerrum defects in ice, the relaxation of the unfrozen water molecules, and a possible relaxation of organic molecules in the unfrozen water sheath surrounding clay particles.

1245 OSWALD, G.K.A. - 1975
Investigation of sub-ice bedrock characteristics by radio-echo sounding; *J. Glaciology*, vol. 15, no. 73, pp. 75-87.

Qualitative inspection of the results of the 1971/72 S.P.R.I. - N.S.F. Antarctic radio-echo sounding programme shows that it is possible to infer some characteristics of the lower face of the ice from the form of received echoes. We confirm the existence of lakes of liquid water beneath the east Antarctic ice by inspection of the top and bottom surface gradients of the ice, and suggest that basal melting occurs over a wide area in this region.

Quantitative studies in Devon Island indicate that small-scale irregularities in the bedrock are characterized by slopes of about 1 : 40, with some higher gradients present, possibly indicating the presence of morainal boulders. We deduce that a geological boundary was crossed between 25 and 40 km west of the base camp, the rock to the west of the boundary having lower permittivity, and higher surface slopes than that to the east.

The question of the usefulness of the spatial fading of the echo in deducing surface characteristics is briefly discussed. We conclude that measurements of the fading are indeed useful, especially in the case of echoes with short "tails".

1246 OSWALD, G.K.A. - 1975
Radio echo studies of polar glacier beds; Unpub. Ph.D. Thesis, Univ. Cambridge.

This thesis is an attempt to bridge the gap existing between the theory and practice of radio echo sounding of glaciers, in connection with the interpretation of the observed behaviour of echoes from the base of the ice.

The theory of reflections of electromagnetic waves from rough surfaces has been dealt with, in this specific connection, by C.H. Harrison (1972), and M.V. Berry (1973), and we shall draw heavily on their results.

Our intention is, however, in the light of experimental analysis of echoes, to distil from

their general mathematical discussions a more physical understanding of the processes from which the echo behaviour results. We hope in this way to describe the echo in situations where the overlapping of different physical regimes makes rigorous mathematical analysis difficult, and to form a link between analytical results for limiting cases, and numerical solutions for intermediate cases. For the latter, we shall make extensive use of the results of E.N. Bramley and M. Young (1967).

It is possible to deduce some characteristics of the lower boundary of the ice with only qualitative information concerning the form and behaviour of the received echoes. Several conclusions have been drawn concerning the state of the base of the East Antarctic ice sheet, without benefit of quantitative records of the echo. These are the most important geophysical results obtained in the course of this work. However, very much more information is available, with appropriate adaptations of the basic echo sounding apparatus.

The uses of this information are to be found in academic geophysics, prospecting, climatology, paleo-climatology, and predictive speculation. It is extremely expensive to obtain, and we hope to provide a manageable analysis, applicable to real field situations, and requiring a minimum of technological sophistication.

1247 OVERTON, A. - 1976
Ice reconnaissance on the Beaufort Sea; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, p. 419.

1248 OVERTON, A. - 1976
Seismic techniques for reconnaissance studies in difficult ice-covered offshore areas; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, pp. 73-74.

1249 OVERTON, A., BURNS, R.A., GAGNÉ, R.M., and GOOD, R.L. - 1976
Seismic instrument tests in Kugmallit Bay, District of Mackenzie; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, p. 25.

1089 PELLETIER, B.R. - 1976
Outline for a marine science atlas of the Beaufort Sea; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, pp. 325-331.

1250 PICKLYK, D.D. - 1968
Regional gravity survey of eastern Devon and southern Ellesmere Islands, Canadian Arctic Archipelago; Unpub. B.Sc. Thesis, Carleton Univ., 35 p.

The results of a regional gravity survey of eastern Devon and southern Ellesmere Islands, made in 1967, are presented in the form of a Bouguer anomaly map. The observations are correlated with magnetic and geologic information. Three profiles are drawn to analyze major features of the Bouguer anomaly field. In general, the Bouguer anomaly field correlates well with the known geology and physiography. Major negative anomalies are interpreted as the result of the combined effects of structures and gypsum in the underlying rocks. Large positive anomalies are related to structures and structural trends, but the composition of the causative bodies is unknown.

1251 RAMSEIER, R.O., VANT, M.R., ARSENAULT, L.D., GRAY, L., GRAY, R.B., and CHUDOBIAK, W.J. - 1975
Distribution of the ice thickness in the Beaufort Sea; Beaufort Sea Technical Report No. 30, December 1975, 98 p.

Although it was not possible to measure sea ice thickness directly, monthly maps indicating the distribution of first-year and multiyear ice for the entire Beaufort Sea region were prepared from Nimbus 5 passive microwave imagery. Detailed investigation of the shear zone was performed using 13.4 GHz scatterometer and X-band SLR imagery for April 1975. A description of the various sensors employed and an outline of the development of a UHF radar for direct measurement of sea ice thickness are included.

1252 RAMSEIER, R.O. - 1976
Remote sensing of floating ice; *Ice*, No. 50, p. 13.

1253 RAMSEIER, R.O., GRAY, L., and CAMPBELL, W.J. - 1977
Scatterometer and imaging radar results obtained over Big Bear, AIDJEX 1975; presented at "Symposium on Sea Ice Processes and Models", Seattle, Washington, September 1977, 10 p.

During 13 - 21 April 1975 three remote sensing aircraft (CCRS C-47, DND ARGUS, NASA CV-990) overflew the main Arctic Ice Dynamics Joint Experiment (AIDJEX) remote sensing test site at Big Bear (76° 29'N, 144° 24"W). All three aircraft had active microwave sensors on board. The Canadian Center for Remote Sensing C-47 was equipped with a 13.3 GHz scatterometer, the Department of National Defence ARGUS had a real aperture side looking airborne radar (SLAR) on board, and the National Aeronautics and Space Administration CV-990 operated a L-band synthetic aperture radar (SAR). Two approximately 12 km-long ground lines were overflown, profiled and imaged. Surface measurements of ice types based on physical properties of sea ice were obtained along certain segments of these lines. The results obtained with the scatterometer have shown systematic changes in microwave backscatter which have a strong correlation with fairly gross ice type categories. In particular, multiyear ice showed significantly higher backscatter than first year ice. The typical differences in backscatter were 8 - 10 db for the like-polarized signals, and 15 - 18 db for the cross-polarized signals. On the other hand, imagery obtained from both the imaging radars have shown that there can be ambiguities and overlap in the magnitude of the backscatter from regions of first year and multiyear sea ice over much of the imaged swath. This observation appears to be consistent with the fact that the surface roughness of both forms of sea ice is highly variable and one of the dominant mechanisms re-

lated to microwave backscatter is the surface roughness and relief. Some of these results, together with supporting passive microwave profiles, visible and infrared imagery, will be used to illustrate the variation in backscatter with incidence angle, and to compare and discuss the sensitivity to ice types.

1254 ROBIN, G. de Q. - 1975
Velocity of radio waves in ice by means of a bore-hole interferometric technique; *J. Glaciology*, vol. 15, no. 73, pp. 151-159.

Radio waves of fixed frequency, which had passed through ice and firn from a transmitting antenna lowered down a bore hole, were monitored on the surface. By mixing the received signal with the fixed frequency, the beats which were produced as the antenna was lowered gave a value for the wavelength in ice at the depth of the antenna. This was multiplied by the frequency to give the velocity of radio waves in ice. Measurements averaged over 10 m and longer intervals were related to density values from bore holes in the same location. Results above 50 m were difficult to interpret, but at greater depths the velocities fitted a linear relationship between refractive index and density. A small extrapolation gives a velocity of radio waves in pure ice of 167.7 $\pm$ 0.3 m/µs at -20°C.

1255 SCOTT, W.J. - 1976
Involuted Hill Test Site, Tuktoyaktuk, N.W.T.; *Ice*, No. 50, p. 15.

1256 SCOTT, W.J., and HUNTER, J.A. - 1976
Applications of geophysical techniques in permafrost regions; *Can. J. Earth Sci.*, vol. 14, no. 1, pp. 117-127.

This paper reports the results of some recent experiments carried out in the Arctic with a variety of methods. In the Beaufort Sea, seismic refraction profiles obtained with both source and receivers on the seabottom indicate the presence of discontinuous near-bottom high-velocity (4200 m/s) material interpreted to be presently aggrading permafrost. Springtime resistivity soundings taken through the ice in Kugmallit Bay, Beaufort Sea, show the top of permafrost at about 50 m below the bottom. Even for 5-km spreads, the base of permafrost was not observed.

Off the southeast coast of Melville Island, refraction seismic profiles shot on the seabottom and resistivity soundings made through summer ice yielded data which correlate with known subbottom geology, but which gave no clear indication of either presence or absence of permafrost.

Seismic and resistivity measurements made at a number of control sites in the Arctic Islands yielded typical velocities of 3500 m/s and resistivities of 1 x 10^6 ohm-m for ice-saturated sands. Some correlation was observed between seismic velocity and moisture contents in the range from 10% to 40%.

Seismic and resistivity results in IOL Lake at the Involuted Hill test site, Tuktoyaktuk Peninsula, suggest the absence of permafrost under some parts of the lake bottom. On the hill itself, seismic up-hole shooting and VLF resistivity profiling give interpretations of ice distribution which correlate well with drill control. Gamma-gamma logs taken in some of the drill holes correlate well with ice content logged during drilling.

1257 SHANNON, W.E., LOMBARDO, F., COMPTON, B., and HALLIDAY, R.J. - 1975
Canadian Seismograph Operations - 1974; *Energy, Mines & Res. Canada*, Seismological Service of Canada, Earth Phys. Br., Seismological Series No. 70, 71 p.

This bulletin, formerly called the Seismological Bulletin, is published annually as part of the Seismological Series of the Earth Physics Branch. It contains summary information on the seismograph installations operated by or for the Division of Seismology and Geothermal Studies, Earth Physics Branch, Department of Energy, Mines and Resources. This information includes a brief description of the various types of seismograph installations, the data produced, the data processing procedures and the availability of station data and records. Summary information on instrumental changes in the Network and calibration curves for the standard and regional seismograph stations are included in the later pages of the Bulletin.

From 1964 to 1971 the Seismological Bulletin contained a chronological list of P-phase arrival times, ground amplitudes, periods and directions of first motion. Since this information is now routinely printed in the monthly Bulletins of the International Seismological Centre (ISC), the P-phase information has been deleted from the 1972 and subsequent annual editions of the bulletin.

1258 SINHA, A.K. - 1976
A field study for sea-ice thickness determination by electromagnetic means; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, pp. 225-228.

1187 TARNOCAI, C., and KIRSTOF, S.J. - 1976
Computer-aided classification of land and water bodies using Landsat Data, Mackenzie Delta Area, N.W.T., Canada; *Arctic and Alpine Res.*, vol. 8, no. 2, pp. 151-159.

1259 TAYLOR, A.E., and JUDGE, A.S. - 1975
Canadian Geothermal Data Collection - Northern Wells 1974; *Energy, Mines & Res. Canada*, Geothermal Service of Canada, Earth Phys. Br., Geothermal Series No. 3, 127 p.

The assessment and solution of many problems which may occur in the development of northern regions require a knowledge of subsurface temperatures. This volume supplements the first in this series, and reports new measurements at 25 of the sites listed in the first volume and observations from nine new sites. A total of 59 determinations of permafrost thickness have been reported in the collection to date. Determined thicknesses in the Arctic Islands range from 140 m to 675 m, in the Mackenzie Delta from 60 m to 700 m and in the remainder of the Northern Mainland from 0m to in excess of 500 m.

1260 TAYLOR, A.E., and JUDGE, A.S. - 1976
Canadian Geothermal Data Collection - Northern Wells 1975; *Energy, Mines & Res. Canada*, Geothermal Service of Canada, Earth Phys. Br., Geothermal Series No. 6, 142 p.

The assessment and solution of many problems which may occur in the development of northern regions require a knowledge of subsurface temperatures. This volume supplements two earlier volumes in this series, and it reports new measurements at 22 of the sites listed in the previous volumes and observations from 19 new sites. A total of 78 determinations of permafrost thickness have been reported in the collection to date. Determined thicknesses in the Arctic Islands range from 140 m to 720 m, in the Mackenzie Delta from 0 m to 700 m and in the remainder of the Northern Mainland from 0 m to in excess of 700 m.

1261 TAYLOR, A.E., and JUDGE, A.S. - 1976
Permafrost distribution in the Far North is subject of ongoing research; *The Northern Miner*, July 15 1976, pp. 16-17.

1262 TAYLOR, A.E., and JUDGE, A.S. - 1976
Permafrost studies provide data for future Arctic developments; *Oilweek*, August 23 1976, pp. 12-16.

1263 VANT, M.R. - 1976
A combined empirical and theoretical study of the dielectric properties of sea ice over the frequency range 100 MHz to 40 GHz; Ph.D. Thesis, Carleton Univ., 438 p.

A systematic investigation into the dielectric properties of sea ice is presented. It is shown that the classical dielectric mixture equations yield formulas applicable to the sea ice modelling problem. Included in this discussion is an explanation both of the frequency range of applicability of the equations and of the role played by conductivity effects. A preliminary measurement program, performed at 10 and 30 to 34 GHz, is described. Based on these measurements, an evaluation of several of the classical formulas, and an investigation of the measurement problems involved, is made. The dielectric behaviour of ϵ_r' and ϵ_r'' is described in detail, i.e. they are shown to vary appreciably with age, salinity, and temperature, increasing with temperature and salinity, and decreasing with age. This description is followed by an outline of the design of a novel type of wideband (100 MHz to 7.5 GHz) "coaxial-cage" transmission line. This outline includes an analysis of the errors due both to the line itself and to its integration in the total system. Primary errors are demonstrated to be due to the short electrical length of the sea ice sample. A description is also given of dielectric measurements, employing the "coaxial-cage" line, which were performed on location, in the Beaufort Sea, during the Arctic Ice Dynamics Joint Experiment (AIDJEX). This unique set of measurements incorporates the investigation of a wide range of first-year sea ice samples (salinities between 5.1 and 10.5 $^{o}/_{oo}$, and temperatures between -5°C and -40°C) over a wide range of frequencies (100 MHz to 7.5 GHz). A somewhat less comprehensive set of measurements, made on multiyear sea ice, is also described. It is seen that the AIDJEX measurements allowed the formulation of highly successful empirical and theoretical models. These models are shown to be applicable over the frequency range 100 MHz to 7.5 GHz (for the empirical model) and 400 MHz to 40 GHz (for the theoretical model). The theoretical model is demonstrated to be able to correctly predict the experimental measurements of the author and other workers, over the above frequency range. Also given is a description of artificial sea ice dielectric measurements which were performed in the laboratory. It is shown that both ϵ_r' and ϵ_r'' increase with the deviation of the probing wavefront from normal incidence. These measurements also allow a comparison to be made of the empirical model, based on the artificial sea ice measurements, with the empirical and theoretical models, based on the first-year sea ice measurements. The agreement between the various models is seen to be within the limits of the natural variability of the sea ice. Following this comparison, a discussion of the applicability of the various models to the description of multiyear sea ice is outlined. However, the discussion is demonstrated to be inconclusive due to the small number of samples of multiyear sea ice measured and the difficulties in performing representative sea ice measurements. In addition, various remote sensing applications of the models are discussed briefly, and recommendations for further research are made.

1264 VOEGTLI, K. - 1961
Measurement of electrical resistivity of ice (The Devon Island Expedition); *Arctic*, vol. 14, no. 4, pp. 255-256.

Measurements of the specific resistance of the ice of the Devon Island ice-cap (approx. 75° 30'N. 83°W) and of an outlet glacier discharging into Jones Sound gave values of 50,000 to 100,000 ohm-metres and they were about ten times higher for the underlying bedrock. This large difference makes it possible to measure accurately the thickness of the ice-cap or of the glaciers by an electrical method.

1265 VÓGTLI, K. - 1967
Resistivity soundings on Devon Island, N.W.T., Canada; *J. Glaciology*, vol. 6, no. 47, pp. 635-642

Ice thickness and resistivity of an Arctic glacier have been systematically investigated by the geoelectrical method. Further measurements were carried out on the ice cap. Favourable conditions for soundings were encountered, since the ice masses proved to be generally homogeneous, and there was a sufficient difference between the resistivities of ice and bedrock, while the surface layer differed only very little from the ice mass. A higher resistivity was found for bedrock than for the ice.

1266 WALFORD, M.E.R. - 1976
Recent Work, United Kingdom, Canada; *Ice*, No. 51, p. 8.

A three-man team from the H.H. Wills Physics Laboratory, Bristol University spent five weeks

during May-June 1976 on the Devon Island Ice Cap in the Canadian North West Territories. Field trials and measurements were made with a new Phase-Sensitive Radio Echo Sounding equipment developed with the financial support of a National Environment Research Council Research Grant. Excellent field support was provided by the Canadian Polar Continental Shelf Project. The main objective of the work was to measure both the amplitude and phase of radio echoes returned from the bed of the ice cap. This was successfully carried out in the vicinity of a Borehole Station located near the crest of the ice cap. Careful impedence-matching, calibration and other ancillary measurements essential to the proper interpretation of the results were made. The sites were carefully surveyed both by radio echo sounder and theodolite and various markers were buried in the snow. It is intended that this will enable a second visit to be made to the same sites after a few years which will yield information about the rate of movement and of thickening or thinning of the Ice Cap.

1267 WASHKURAK, S. - 1977
Meteorological satellites aid airborne operations in remote regions; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 77-1A, pp. 93-94.

1268 WEBER, J.R., and ERDELYI, M. - 1976
Ice and ocean tilt measurements in the Beaufort Sea; *J. Glaciology*, vol. 17, no. 75, pp. 61-71.

During the AIDJEX pilot study 1972 in the Beaufort Sea, the tilt changes of the fluid ocean surface and of the sea ice were measured with a hydrostatic level. Preliminary results indicate a tilt range of $\pm$ 5 μrad for the water surface and of $\pm$ 30 μrad for the sea ice. The tilt change of the sea ice $\Delta\delta$ appears to be directly proportional to the component of the velocity change of the ice drift parallel to the hydrostatic level ΔU_d, according to the relationship $\Delta\delta = 180\ \Delta U_d$ μrad $m^{-1}s$. It is concluded that the ice tilt is wind induced, and that the ice sheet tilts downward in the drift direction as a result of the moment exerted on it by wind and water drag. It is postulated that this tilt causes the ice to break at right angles to the drift direction. The tilt is a function of the length of an ice floe (or of the unbroken distance between two cracks), of the average ice thickness, of the average drag coefficients, and of wind and current velocities. Calculation of the ice tilt using a simple model of a floating, rigid ice slab gives values which are very much smaller than the observed tilts. If the discrepancy between theory and observation can be resolved, or if an empirical formula between wind velocity and tilt angle can be deduced from continuous tilt observations which will be carried out during the AIDJEX main experiment, it will be possible, for a given wind, to estimate the maximum length of an unbroken ice sheet from its estimated thickness, drag coefficients, and tensile strength. It should also be possible to calculate the average drag coefficients of a free-floating ice pan, or of an ice island, from tilt, wind, and current measurements. The curious relationship between tilt angle and atmospheric pressure gradient that Browne and Crary observed on the ice island T-3 in 1952 is explained as being the wind-induced tilt of the ice island rather than that of the fluid ocean surface.

1269 WONG, J., ROSSITER, J.R., OLHOEFT, G.R., and STRANGWAY, D.W. - 1977
Permafrost: electrical properties of the active layer measured *in situ*; *Can. J. Earth Sci.*, vol. 14, no. 4, part 1, pp. 582-586.

The dielectric constant and apparent conductivity of the active layer on Involuted Hill near Tuktoyaktuk, N.W.T., were measured *in situ* for both summer and winter. Measurements were made using resonating antennas near 100 MHz. The apparent values for the dielectric constant were 26 to 64 in the summer, and about 7 in the winter; for the conductivity, values of 0.012 to 0.12 mhos m^{-1}(0.012-0.12 S m^{-1} in summer, and about 10^{-4} mhos m^{-1} (10^{-4}S m^{-1}) in winter, were obtained. The low losses observed in winter indicate that EM sounding should be possible in the area when the active layer is frozen. It is concluded that the antenna method is a quick and inexpensive means of making *in situ* electrical measurements near 100 MHz.

GLACIOLOGY

1032 ALT, B.T. - 1975
The energy balance climate of Meighen Ice Cap, N.W.T.; *Polar Cont. Shelf Proj.*, vols. 1 & 2, 168 p.

0916 APOLLONIO, S. - 1961
Report of the field leader, April-September 1961 in "The Devon Island Expedition"; *Arctic*, vol. 14, no. 4, pp. 253-254.

1096 APOLLONIO, S. - 1961
The Devon Island Expedition; *Arctic*, vol. 14, no. 4, pp. 252-265.

1208 APOLLONIO, S. - 1962
The Devon Island Expedition 1960-1964; *Arctic*, vol. 15, no. 4, pp. 317-321.

1270 ARNOLD, K.C. - 1975
Queen Elizabeth Islands, N.W.T.; *Ice*, no. 47, p. 2.

1271 ARNOLD, K.C., CHRISTIAN, D.M., SHERSTONE, D.A., and TERROUX, A.C.D. - 1976
Aerial photography; *Ice*, no. 50, p. 7.

1099 BARR, W., and KOERNER, R.M. - 1966
Devon Island Programs, 1965; *Arctic*, vol. 19, no. 2, pp. 201-204.

1272 CLARKE, G.K.C., NITSAN, U., and PATERSON, W.S.B. - 1977

Strain Heating and Creep Instability in Glaciers and Ice Sheets; *Reviews of Geophys. and Space Phys.*, vol. 15, no. 2, pp. 235-247.

Creep instability, the runaway increase of internal temperature and deformation rate, may affect the boundary condition at the base of glaciers and ice sheets and thus influence their flow and dimensions. We consider a simple slab model of heat transport in which three dimensionless parameters determine the relative importance of strain heating, ice advection normal to the surface, and boundary conditions. We find that an ice mass will be unstable if the strain-heating parameter exceeds a critical value which depends strongly on advection and boundary conditions. Critical values over the range of parameters appropriate to natural ice masses are presented. Accumulation (downward advection) or ablation (upward advection) affects the critical value by up to 5 orders of magnitude: ablation tends to reduce stability, and accumulation increases it. For an ice mass frozen to its bed, instability eventually raises the basal ice to melting point. This can restore thermal stability, but the ice mass will start to slide over its bed. If the strain-heating parameter exceeds a second, higher critical value, a layer of basal ice at melting point will form. We find that the conditions for instability are likely to exist in the accumulation and ablation zones of certain glaciers and ice sheets. However, times calculated for instability to develop are in the range 10^2 - 10^3 yr for glaciers and 10^3 - 10^4 yr for ice sheets. As these times exceed the normal residence time for ice in the ablation zone, it appears that instability is most likely to develop in the accumulation zone. This conclusion is reinforced by the fact that ablation increases the growth time for instability, whereas accumulation decreases it. The growth times quoted above are longer than the periods of most glacier surges, and thus creep instability is an unlikely surge mechanism. Unstable conditions may, however, obtain in East Antarctica and may have existed in the central part of ice age ice sheets. Surges of ice sheets triggered by creep instability may be possible.

1273 CRESS, P., and WYNESS, R. - 1961
Observations of glacial movement (The Devon Island Expedition); *Arctic*, vol. 14, no. 4, pp. 257-259.

Observations of the movements of an outlet glacier of the Devon Island ice cap were made during the summer of 1961 to help arrive at an estimate of the amount of ice entering Jones Sound each year. The particular glacier selected (tentatively named "Sverdrup Glacier") is one of the two largest outlets west of Belcher Point and into Jones Sound proper.

1213 DOAKE, C.S.M., GORMAN, M., and PATERSON, W.S.B. - 1976
A further comparison of glacier velocities measured by radio-echo and survey methods; *J. Glaciology*, vol. 17, no. 75, pp. 35-38.

1274 ENGLAND, J. - 1976
Late Quaternary Glaciation of the Eastern Queen Elizabeth Islands, N.W.T., Canada; Alternative Models; *Quaternary Res.*, vol. 6, pp. 185-202.

It has been suggested that during the last glaciation the Innuitian Ice Sheet existed over the eastern Queen Elizabeth Islands. This is based on the pattern of postglacial emergence over this area and the timing of driftwood penetration into the interisland channels. Alternative interpretations of both sets of data raise questions about the presence of the Innuitian Ice Sheet at this time. Field observations on northeastern Ellesmere Island, plus additional data pertaining to the presence of multiple tills and "old" radiometric dates on lacustrine deposits, shelly tills, and raised marine features suggest that the maximum glaciation over this region, equivalent to the Innuitian Ice Sheet, predates the last glaciation. Palaeoclimatic conditions are also discussed in relation to these data. It is suggested that during the last glaciation of the Queen Elizabeth Islands there was a convergent but not coalescent advance of the existing upland icefields. This noncontiguous ice cover over the Queen Elizabeth Islands is termed the Franklin Ice Complex. It is suggested that the term Innuitian Ice Sheet be reserved for contiguous older glaciations over this same area.

1118 ENGLAND, J. - 1976
Postglacial isobases and uplift curves from the Canadian and Greenland High Arctic; *Arctic and Alpine Res.*, vol. 8, no. 1, pp. 61-78.

1037 FISHER, D.A. - 1976
A study of two $\delta(O^{18})$ records from Devon ice cap, Canada, and comparison of them to Camp Century δ record, Greenland; unpub. Ph.D. Thesis, Geophysical Isotope Laboratory, Copenhagen, Denmark, 287 p.

1038 FISHER, D. - 1977
Final report on the melt feature stratigraphy from the Devon Island Ice Cap drill site; *Polar Cont. Shelf Proj.*, internal report, 33 p.

1215 GREENHOUSE, J.P. - 1961
Measurements of electrical resistivity of ice-formations; *Arctic*, vol. 14, no. 4, pp. 259-265.

1216 GREENHOUSE, J.P. - 1963
Geophysics, summer 1962, (The Devon Island Expedition 1960-64); *Arctic*, vol. 16, no. 1, pp. 66-71.

1275 HOLDSWORTH, G. - 1975
Ice flow measurements of D'Iberville Glacier, Ellesmere Island, N.W.T.; Inland Wtrs. Div., *Dept. Env. Can.*, unpub. manuscript, 7 p.

This report is intended to provide information relating to the question of how much ice/water discharge there is from D'Iberville Glacier into D'Iberville Fiord.

1276 HOLDSWORTH, G. - 1975
Measurement of small strain-rates over short time periods; *J. Glaciology*, vol. 14, no. 71, pp. 317-324.

A laser interferometer has been used to measure small relative displacements between two reference points spaced up to 99.76 m apart and fixed in an ice surface. Strain-rates of order 10^{-11} s^{-1} can be detected easily within a 24 h period and possibly within an 8 h period.

1277 HOLDSWORTH, G. - 1977
Ice flow and related measurements of D'Iberville Glacier, Ellesmere Island, N.W.T., Canada; *Dept. Env. Can.*, Inland Wtrs. Div., unpub. manuscript, 28 p.

An earlier report on D'Iberville Glacier (Holdsworth, unpublished manuscript, 1975) used data obtained photogrammetrically to determine the rate of discharge of glacier ice into the head of D'Iberville Fiord. In the present report, aerial photography of D'Iberville Glacier, taken on July 7, 1975, has enabled a determination of the full annual displacement of the ice constituting the floating terminal section of the glacier. Carbonnell and Bauer (1968) exploited the same methods in a study of some Greenland outlet glaciers.

A sea ice feature is discussed which lends support to the previous result that glacier ice is probably being melted from the lower surface of the glacier throughout the year. The sea ice surrounding ice bergs that are trapped in the fiord during the winter, shows a system of depressions and cracks that is revealed in the late spring or early summer after the snow cover has been removed. The presence of a well developed, water filled depression surrounding every ice berg, regardless of size, strongly suggests sinking of the sea ice attached to the ice berg. Such a situation is most likely produced by melting of the underside of the ice berg, and hence the sinking of it, throughout the winter. Surface ablation during this period would be insufficient by an order of magnitude to account for the necessary buoyancy adjustments of the ice berg.

An estimate of ice and water input into the fiord is necessary for determining the water balance for the fiord hydrological system.

1278 HOLDSWORTH, G. - 1977
Tidal interaction with ice shelves; *Ann. Geophys.*, vol. 33, Fasc. 1/2, pp. 133-146.

Ice shelves and tongues occur extensively in the Antarctic although some significant, isolated occurrences can be found in the Arctic. In locations with sufficient ice discharge and negligible melting at the coastline for ice tongues or shelves to form, all gradations are observed: from an actively calving ice cliff at the grounding line to long tongues or wide ice shelves. A review of tidal data in those areas reveals that most ice shelves and tongues occur where tidal ranges (large tide value) are smaller than ~1.0 - 2.0 m in the Antarctic and 0.2 m in the Arctic. Tides with larger ranges tend to inhibit the growth of tongues and unprotected or laterally unbounded shelves. An analysis of the flexure of floating ice, restrained at one end, shows that for increasing lengths, the hinge-line bending stress increases, then slowly reaches a limiting value at lengths near π/λ where $1/\lambda$ is the characteristic length. Once the shelf or tongue has grown to a length $\geqslant\pi/\lambda$ under a given tidal regime, the stability of it is more governed by other processes.

The bending of a model ice tongue is analysed for the elastic, viscous, and transient creep cases. The results are discussed collectively.

1225 HYNDMAN, R.D. - 1963
Gravity survey, summer 1962 (The Devon Island Expedition 1960-64); *Arctic*, vol. 16, no. 1, pp. 71-72.

1226 HYNDMAN, R.D. - 1965
Gravity measurements on the Devon Island ice cap and an adjoining glacier; *J. Glaciology*, vol. 5, no. 40, pp. 489-496.

1279 IKEN, A. - 1973
Schwankungen der oberflächen-geschwindigkeit des White Glacier, Axel Heiberg Island; *Zeitschrift für Gletscherkunde und Glazialgeologie*, Bd. IX, Heft 1-2, pp. 207-219.

During the melt season, in periods of fair weather, distinct diurnal variations of the surface velocity were observed in the ablation area of the White Glacier. The surface velocity increased strongly after heavy rainfalls when a drainage system into moulins and crevasses had developed. In order to test indirectly the hypothesis that the velocity variations are variations of the velocity of sliding over the glacier bed, caused by variations of the water pressure in a subglacial network of cavities and channels, water pressure in moulins was measured simultaneously with the glacier surface velocity.

1280 IKEN, A. - 1974
Velocity fluctuations of an arctic valley glacier, a study of the White Glacier, Axel Heiberg Island; *McGill Univ. Axel Heiberg Is. Res.*, Glaciology Report No. 5, 116 p.

The movement of the White Glacier has been observed at several locations since 1959 by members of the McGill University expeditions to Axel Heiberg Island. In the ablation area the winter velocities were always smaller than the summer velocities and the latter were not uniform over shorter periods of measurements. Even though the White Glacier is not a temperate glacier, the most promising hypothesis to explain these fluctuations appeared to be the assumption that the glacier is not frozen to its bed but glides over it and meltwater produces a lubricating effect.

1281 KOERNER, R.M. - 1961
Glaciology (The Devon Island Expedition); *Arctic*, vol. 14, no. 4, pp. 256-257.

The work involved a study of accumulation and ablation on the Devon ice-cap and on a selected valley outlet glacier (the "Sverdrup Glacier"), with particular attention to runoff on the glacier.

1282 KOERNER, R.M. - 1963
Glaciology, summer 1962 (The Devon Island Expedition 1960-64); *Arctic*, vol. 16, no. 1, pp. 72-76.

The glaciological program for the summer of 1962 was basically a continuation and extension of work started in 1961. The greater part of the program was divided between a study of the mass balance of the ice-cap and run-off measurements, using the chromate-dilution method, on the Sverdrup Glacier.

1283 KOERNER, R.M. - 1963
Glaciology, winter 1961-62 (The Devon Island Expedition 1960-64); *Arctic*, vol. 16, no. 1, pp. 57-62.

During the winter of 1961-62 work was divided between studies of glacier-, lake-, and sea-ice.

1238 KOERNER, R.M., and PATERSON, W.S.B. - 1975
Queen Elizabeth Islands; *Ice*, no. 47, p. 3.

1284 KOERNER, R.M. - 1976
Bylot Island; *Ice*, no. 50, p. 8.

1285 KOERNER, R.M. - 1976
Devon Island; *Ice*, no. 50, p. 8.

1286 KOERNER, R.M. - 1976
Meighen Island; *Ice*, no. 50, p. 8.

1287 KOERNER, R.M. - 1976
Melville Island; *Ice*, no. 50, p. 8.

1039 KOERNER, R.M., and TANIGUCHI, H. - 1976
Artificial radioactivity layers in the Devon Island ice cap, Northwest Territories; *Can. J. Earth Sci.*, vol. 13, no. 9, pp. 1251-1255.

1040 KOERNER, R.M. - 1977
Devon Island Ice Cap: Core Stratigraphy and Paleoclimate; *Science*, vol. 196, no. 4285, pp. 15-18.

1042 MacKINNON, P.K. - 1976
The oxygen isotope technique and its application to ice and sea cores; unpub. manuscript, Carleton Univ., 117 p.

1288 MÜLLER, F., and BARR, W. - 1966
Postglacial isostatic movement in northeastern Devon Island, Canadian Arctic Archipelago; *Arctic*, vol. 19, no. 3, pp. 263-269.

Raised marine features of the lowlands in the vicinity of Cape Sparbo were investigated. The carbon^{14} dates of marine shells indicate that the area was clear of ice as early as 15,500 before present and that the most rapid isostatic uplift (approx. 6.5 m. per century) took place between 9,000 and 8,000 years ago; the total isostatic rebound having been about 110 m. The two oldest dates (15,000 and 13,000 B.P.), if correct, give a rare indication of the slow onset of the isostatic uplift.

1289 MÜLLER, F., and KEELER, C.M. - 1969
Errors in short-term ablation measurements on melting ice surfaces; *J. Glaciology*, vol. 8, no. 52, pp. 91-105.

Rapid changes in time and space in the microrelief of an ablating glacier surface and radiation-induced melt within the uppermost ice layer, termed the "weathering crust", seriously affect the accuracy of the short-term ablation measurements. The various measuring techniques commonly used (stakes, ablatometers, ablatographs) and some new methods (measurement of discharge from a small supraglacial drainage basin, and mass loss directly measured on core samples) are critically reviewed and assessed in the light of this phenomena. The implications for studies of heat and mass balance are discussed.

It appears that the direct measurement of mass flux is the most accurate means of assessing short-term ablation rates. The errors in short-term ablation measurements by any method are largely compensatory and consequently do not influence long-period mass-balance estimates.

1290 MÜLLER, F. - 1975
Mass balance of White Glacier and Baby Glacier; *Ice*, no. 47, p. 6.

1291 MÜLLER, F. - 1975
North Water Glacier - Climatology Project; *Ice*, no. 47, p. 6.

1292 MÜLLER, F. - 1975
Studies on Axel Heiberg Island, N.W.T.; *Ice*, no. 47, p. 5.

1293 MÜLLER, F., and BLATTER, H. - 1975
Thermal regime of White Glacier; *Ice*, no. 47, p. 6.

1045 MÜLLER, F., BLATTER, H., BRAITHWAITE, R., ITO, H., KAPPENBERGER, G., OHMURA, A., SCHROFF, K., and ZUST, A. - 1975
Glaciological and climatological investigation of the North Water Polynya in Northern Baffin Bay; A progress report on North Water Activities, October 1, 1974 to September 30, 1975, internal report, 149 p.

1294 MÜLLER, F., and KAPPENBERGER, G. - 1975
"Laika" Glacier mass balance and movement; *Ice*, no. 47, p. 7.

1295 MÜLLER, F., and STAUFFER, B. - 1975
Accumulation patterns on surrounding ice masses; *Ice*, no. 47, p. 7.

1296 MÜLLER, F., STAUFFER, B., and SCHRIBER, G. - 1975
Environmental isotopes; *Ice*, no. 47, p. 7.

1297 MÜLLER, F. - 1976
Axel Heiberg Island; *Ice*, no. 50, p. 8.

1298 MÜLLER, F. - 1976
On the thermal regime of a high-arctic valley glacier; *J. Glaciology*, vol. 16, no. 74, pp. 119-133.

The 10 m temperatures were measured over several years at 16 sites on the White Glacier (lat. 80°N.), Axel Heiberg Island, Canadian Arctic Archipelago. At three sites deep profiles were made using a new drilling technique, reaching a maximum depth of 280 m. Large differences in the 10 m temperatures between locations and from year to year were observed. The deviations of these temperatures from the almost isothermal mean annual air temperature over the glacier are discussed. The heating effect of the melt water in the lower percolation zone was found to be very important. A conceptual model is developed to assess the influence of these irregularities in the energy input at the upper boundary on the thermal regime of the entire glacier. So far a quantitative analysis has been made only for the relatively simple 30 m temperature profile measured on the tongue of the glacier.

1048 MÜLLER, F., BACHMANN, W., BERGER, P., BLATTER, H., BRAITHWAITE, R., CRAWFORD, J., DUTTER, C., ITO, H., ITO, S., KAPPENBERGER, G., MÜLLER, H., OHMURA, A., SCHRIBER, G., SCHROFF, K., SIEGENTHALER, H.U., ZUST, A., and WEISS, J. - 1976
Glaciological and Climatological Investigations of the North Water Polynya in Northern Baffin Bay; A Report on North Water Project Activities, October 1, 1975 to September 30, 1976, internal report, 128 p.

1051 OHMURA, A. - 1975
Heat balance and meso-climate; *Ice*, no. 47, p. 6.

1245 OSWALD, G.K.A. - 1975
Investigation of sub-ice bedrock characteristics by radio-echo sounding; *J. Glaciology*, vol. 15, no. 73, pp. 75-87.

1246 OSWALD, G.K.A. - 1975
Radio echo studies of polar glacier beds; unpub. Ph.D. Thesis, Univ. Cambridge.

1299 PATERSON, W.S.B. - 1974
Thermal core drilling in ice caps in Arctic Canada; *in* Ice Core Drilling, ed. John F. Splettstoesser, Univ. Nebraska Press, Lincoln, Nebraska, pp. 113-116.

The CRREL shallow-hole thermal coring drill has been used to drill a 121-m borehole through the Meighen Ice Cap and three holes (230, 299 and 299 m) in the ice cap on Devon Island. Three of the four holes reached bedrock; in the 230-m hole, the drill became frozen in and was lost. Operating conditions, the performance of the drill, and problems encountered are described.

1053 PATERSON, W.S.B. - 1976
Climatic interpretations from glacier ice cores; *Abstract in* American Quaternary Association, Abstracts of the fourth biennial meeting , October 9 and 10, 1976, Tempe, Arizona, pp. 16-19.

1300 PATERSON, W.S.B. - 1976
Radioactive waste disposal in Antarctica: some glaciological aspects; *Modern Geology*, vol. 6, pp. 37-42.

To sum up, I think that the proposal to dump radioactive waste in Antarctica may well turn out to have fewer drawbacks than any of the alternatives. However, present knowledge of the Antarctic Ice Sheet is inadequate for assessing the risks. Some of the things to be done before coming to a decision are: 1) Obtain more knowledge of the effect of water at the bed of an ice sheet on its flow; 2) understand the cause and mechanism of surges; 3) understand the circumstances in which temperature instability may be important; 4) computer modelling of the ice sheet in a non-steady state including effect of any conceivable climatic change; and 5) make many more measurements of temperatures within the ice and at the bed.

1301 PATERSON, W.S.B. - 1976
Temperatures in the Devon Island Ice Cap, Arctic Canada; *J. Glaciology*, Reports on Current Work, Abstract only, vol. 16, no. 74, p. 277.

Temperatures have been measured in a 299 m bore hole that reaches the base of the ice near the divide of the main ice cap on Devon Island in the Canadian Arctic Archipelago. Temperature ranges from - 23°C at a depth of 20 m to -18.4°C at the bottom. The difference between surface and bottom temperatures is about 1.5 deg less than expected for a steady state. Recent climatic warming seems the most likely explanation of the discrepancy. The temperature gradient in the lowest 50 m is approximately linear and corresponds to a geothermal heat flux of 1.5 h.f.u. This value may be invalid, however, because temperatures at and below this depth have probably been perturbed by changes of surface temperature during the past several thousand years, particularly by the warming at the end of the last glaciation. A detailed analysis of the results is in progress.

1054 PATERSON, W.S.B. - 1976
Vertical strain-rate measurements in an arctic ice cap and deductions from them; *J. Glaciology*, vol. 17, no. 75, pp. 3-12.

1302 PATERSON, W.S.B. - 1977
Extent of the Late-Wisconsin Glaciation in Northwest Greenland and Northern Ellesmere Island: A Review of the Glaciological and Geological Evidence; *Quaternary Res.*, vol. 8, pp. 180-190.

In the Camp Century core, the difference in oxygen isotope ratio between Wisconsin and Holocene ice seems too large to be purely a climatic effect. A more likely interpretation is that the Wisconsin ice originated at an elevation of at least 500 m above the present station. Total gas content measurements on the core suggest that the elevation difference was about 1300 m. These results are inconsis-

tent with the present ice flow pattern. Three hypotheses are considered: (1) The Wisconsin ice originated near the crest of a high ridge connecting the Greenland ice sheet with an ice sheet on Ellesmere Island. (2) The Wisconsin flow pattern was similar to the present one but ice was much thicker and the ice margin considerably in advance of its present position. (3) The Wisconsin ice originated near the main Greenland ice divide whereas the Holocene ice originates within 50 km of the station. Glacial-geological data are sparse but do not appear to support the first hypothesis, while the uplift data have been interpreted in two widely different ways. The second hypothesis might explain the oxygen isotope values but not the gas content measurements. The third hypothesis is thus considered the most likely one. Differences between Wisconsin and Holocene flow patterns might result from changes in positions of the ice margins as a consequence of lowered sea level in the Wisconsin.

1303 PATERSON, W.S.B. - 1977
Secondary and Tertiary Creep of Glacier Ice as Measured by Borehole Closure Rates; *Reviews of Geophys. and Space Phys.*, vol. 15, no. 1, pp. 47-55.

Published and previously unpublished measurements of closure rates of five boreholes in polar ice caps are reviewed. The data cover effective shear stresses between 0.15 and 1.0 MN m^{-2}, temperatures between -16^{o} and $-28^{o}C$, and strains up to 2.2. Curves of strain at the borehole wall (logarithm of the ratio of hole diameter to its initial diameter) against time show a stage of constant closure rate corresponding to secondary (steady state) creep of the ice followed by accelerating closure rate attributed to recrystallization of the ice (tertiary creep). Curves for low stresses also show an initial transient stage of decreasing closure rate. The onset of tertiary creep is largely determined by the strain; critical values range from 0.03 to 0.10, and the lower the temperature, the higher the critical value. Secondary creep rates in the different boreholes are consistent with each other; the data yield a creep activation energy of 54 kJ/mol and a flow law index close to 3. The borehole data reduced to a common temperature of $-22^{o}C$ are compared with the results of two laboratory experiments at this temperature. For a given stress the strain rates measured by Steinemann (1958a,b) are 2-3 times those in the boreholes, and for the experiments of Barnes et al. (1971) the factor is about 8. Differences between laboratory and glacier ice, probably in grain size, may explain the differences between the borehole data and the results of Steinemann. Some evidence is presented that the creep rates measured by Barnes et al. at this temperature may contain a significant component of transient creep; this might account for the large difference between their results and those of Steinemann. The ratio of tertiary to secondary creep rate increases approximately linearly with the strain. No steady state tertiary creep rate is observed even at a strain of 1.5, at which point the ratio of tertiary to secondary creep rate is about 10. However, the ice is not strained uniformly during borehole closure. Even if recrystallization has been completed in the ice near the borehole wall, the ice further away, having been strained less, may still be recrystallizing. This may account for the failure to observe steady state tertiary creep. Near the bottom of one borehole, creep rates (tertiary) are about 4 times those in the ice immediately above. The boundary between the two deformation regions corresponds closely to the boundary between ice deposited during the Wisconsin glaciation and ice deposited since that time. The crystals in the Wisconsin ice are smaller, much less variable in size, and more nearly equidimensional than those elsewhere. Moreover, the Wisconsin ice has a much higher microparticle content and a much lower content of salts of marine origin. It is suggested that one or more of these differences make the Wisconsin ice 'softer' than the remainder of the ice. The decrease in grain size is considered to be the most likely factor.

1055 PATERSON, W.S.B., KOERNER, R.M., FISHER, D., JOHNSEN, S.J., CLAUSEN, H.B., DANSGAARD, W., BUCHER, P., and OESCHGER, H. - 1977
An oxygen-isotope climatic record from the Devon Island ice cap, arctic Canada; *Nature*, vol. 266, no. 5602, pp. 508-511.

1254 ROBIN, G. de Q. - 1975
Velocity of radio waves in ice by means of a bore-hole interferometric technique; *J. Glaciology*, vol. 15, no. 73, pp. 151-159.

1264 VÖEGTLI, K. - 1961
Measurement of electrical resistivity of ice (The Devon Island Expedition); *Arctic*, vol. 14, no. 4, pp. 255-256.

1265 VÖGTLI, K. - 1967
Resistivity soundings on Devon Island, N.W.T., Canada; *J. Glaciology*, vol. 6, no. 47, pp. 635-642.

1266 WALFORD, M.E.R. - 1976
Recent Work, United Kingdom, Canada; *Ice*, no. 51, p. 8.

HISTORY

1304 HAYCOCK, M. - 1976
Beechey Island Expedition, 1975; *Polar Record*, September 1976, pp. 312-313.

On Beechey Island, Arctic Canada, there are several historic sites associated with Sir John Franklin's ill fated North-west Passage expedition of 1845-48 and the ensuing search expeditions. Franklin spent his first winter there, and the remains of his shore installations and the graves of three of his men still exist, as do remnants of a storehouse, Northumberland House, built in 1852 by Commander W.J.S. Pullen of the search vessel *North Star*. They are the

most famous historic sites in the eastern Arctic and are extremely attractive to tourists and souvenir hunters. They lie within 120 km of Resolute, are easily accessible by air and sea from that base, and are therefore very vulnerable to looting and desecration.

1305 HOBSON, G.D., HAYCOCK, M.H., SEBERA, D.K., and HEYLAND, J.D. - 1975
The 1975 reconnaissance of the Franklin Encampment Area, Beechey Island; *Polar Cont. Shelf Proj.*, internal report, 37 p.

In 1845, Sir John Franklin sailed from Greenwich with two ships, H.M.S. Erebus and H.M.S. Terror and 133 officers and men. Franklin's expedition was the largest and best equipped party ever sent to the Arctic to search for the Northwest Passage. At the same time, it was probably one of the most meagerly recorded of all Arctic voyages. Beechey Island, the 1845-46 wintering location for Franklin, may be regarded as the most famous historic site in the eastern Arctic; it is also extremely attractive to tourists and souvenir hunters. In 1975, a small party spent 8 days on Beechey Island to identify and map precisely the remains of structures and other artifacts associated with the Franklin encampment of 1845-46.

HYDROGRAPHY

1062 ANONYMOUS - 1977
Bathymetry sounding system devised; *Oilweek*, February 28, 1977, pp. 44-45.

1063 BANISTER TECHNICAL SERVICES - 1976
Final Report, development and testing of production through ice survey techniques; D.S.S. Contract 1SZ5-0401, 181 p.

1066 CRUTCHLOW, M.R. - 1976
Tracked vehicle sounding over ice; *Light House*, J. of the Can. Hydrographers' Assoc., no. 14, pp. 16-18.

1070 KERR, A. - 1977
Developments in through-the-ice hydrographic surveying; presented at Int. Cong. Surveyors, Stockholm, June 1977, 13 p.

1306 STATEMAN, M.J. - 1977
Data available from the Arctic Ice Dynamics Joint Experiment as of 1 May 1977; *AIDJEX Bull.*, Univ. Wash., Seattle, no. 36, pp. 203-210.

The AIDJEX Data Bank is the primary repository for data acquired on the Beaufort Sea pack ice during the AIDJEX pilot study in 1972 and the AIDJEX main experiment in 1975-76. AIDJEX Bulletin No. 19 (March 1973) shows the data sets from the first period. This note outlines the data which have been validated and entered into the AIDJEX Data Bank from the main experiment. In addition to the source data, there are some post-processed data sets and several supplementary supportive data sets supplied by outside sources.

1307 THOMPSON, E.F. - 1976
Final Field Report, P.C.S.P., Survey Belcher Channel and Penny Strait; Proj. File No. 6600-76-1, March-May 1976; *Polar Cont. Shelf Proj.*, internal report, 82 p.

Project Instructions called for a bathymetric survey of Belcher Channel and Northern Penny Strait. In conjunction with this program, closely spaced soundings were to be taken in a corridor through Belcher Channel and along two proposed pipeline crossings (one between Grinnell Peninsula and Cornwall Island, and one between Bathurst Island and Grinnell Peninsula).

The above projects were completed with a total of 8705 spot soundings taken.

1308 WILSON, J.H. - 1975
Arctic surveys Nares Strait, Proj. no. 6600-76-1, March-April 1975; *Env. Can.*, Can. Hydro. Serv., Central Region, Final Field Report, Burlington, Ontario, 49 p.

The 1975 hydrographic survey of Nares Strait was the culmination of the survey which was started in 1972 by Mr. G.E. Wade and party. Mr. Wade established horizontal control along the Greenland coast of Nares Strait and we used this control in conjunction with established topographic control and our own 1975 established control, to accurately position bathymetric data over Nares Strait.

HYDROLOGY

1309 ANDERSON, J.C., and MacKAY, D.K. - 1973
Preliminary results from Boot Creek and Peter Lake watersheds, Mackenzie Delta Region, Northwest Territories; *in* Hydrologic Aspects of Northern Pipeline Development, Environmental-Social Committee Northern Pipelines, Task Force on Northern Oil Development, Report No. 73-3, Infor. Canada Cat. No. R27-172, pp. 33-70.

Two small drainage basins, Peter Lake basin and Boot Creek basin, on the east side of the Mackenzie Delta, were selected for study as representative watersheds. In this study, emphasis is placed on the hydrology, and more specifically, the water balance of these two watersheds. Surficial geology, vegetation cover and permafrost features are also noted.

Methods and equipment used in the field are described. Data from two summers for Boot Creek basin and one summer for Peter Lake basin are analysed. Summer precipitation is observed to be light in total amount. Supporting data from the Inuvik airport suggest that monthly rainfall and snowfall amounts can vary greatly from year to year.

Most runoff occurs from late May until early October, peaking in the spring as snowmelt takes place. Direct runoff from three summer

storms in Boot Creek basin is computed and found to be minimal. Runoff ratios for the same basin show considerable variation from month to month. The ratios for four months range between 5% and 57%.

1310 ANDERSON, J.C. - 1975
Hydrologic studies at Boot Creek and Peter Lake Basins, N.W.T., during 1974; *in* Further Hydrologic Studies in the Mackenzie Valley, Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development, Report No. 74-35, Infor. Canada, Ottawa 1975, Cat. No. R57-4/1975, 37 p.

Boot Creek and Peter Lake, small drainage basins located to the east of the Mackenzie Delta, N.W.T., are being studied to obtain data for the assessment of pipeline and highway designs and to investigate water supply conditions. Instruments are set up in the basins during the summer field season to gather information on precipitation and runoff. Results from 1974 are presented, and a summary of former years' work is given. The most noteworthy event of the 1973-74 water year is the low spring runoff. Boot Creek peaked at only 0.75 m^3/s. The maximum at Peter Lake basin was only 0.57 m^3/s. High storage depletions in the former water year, followed by low winter snowfall, are regarded as the most important causes for this low runoff. A summer storm in early July brought higher runoff rates at Boot Creek basin than those that had occurred during the spring. A small storage depletion is thought to have developed at that basin in 1973-74.

1311 ANDERSON, J.C., and DURRANT, R.L. - 1976
Hydrologic reconnaissance, Thomsen River Basin, Banks Island, District of Franklin; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 76-1A, pp. 221-227.

1312 ANDERSON, R.J., and MacKAY, D.K. - 1973
Preliminary Study of the Seasonal Distribution of Flow in the Mackenzie Delta, Northwest Territories; *in* Hydrologic Aspects of Northern Pipeline Development, Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development, Report No. 73-3, Infor. Canada Cat. No. R27-172, pp. 71-109.

In recent years, the Mackenzie Delta has become an important petroleum exploration area. Historically, the delta is a significant trapping area and, moreover, a wildfowl breeding region. For these reasons, it was considered desirable to initiate a study of its hydrologic behavior beginning with a detailed analysis of the delta streamflow distribution.

Runoff from a basin area of 1,801,600 km^2 passes into the delta and on to the Beaufort Sea. Flow is through a channel and lake maze which empties into the sea at many locations along the outer delta perimeter. Within the maze, delta stations have been located on major channels in order to examine the regional character of streamflow. Measurements at these stations have been made by Glaciology Division in the summer months of 1971, and by Glaciology and Water Survey of Canada Divisions in March, 1972.

Channel parameters consisting of cross-sectional area, width, mean velocity and mean depth are studied in relation to discharge. The resulting four hydraulic geometry equations represent an average interrelationship among these factors during a mid-summer period in the delta. Cross-sectional area and width can be used to calculate discharge from the hydraulic geometry equations only for relatively low summer stages.

A detailed March distribution study is presented as are trends in delta ice thicknesses. The study shows that 78 percent of delta inflow remained in Middle Channel as far north as Langley Island near Tununuk Point. Ice thicknesses greatly alter the flow distribution pattern over the winter season. Ice thicknesses in the Delta increased latitudinally despite the fact that snowfall distribution was somewhat different than during past winters.

1313 BALLANTYNE, C.K. - 1975
River terraces, sea level and glacial chronology - Hydrologic and geomorphic investigations at the western margin of the Ellesmere Ice Cap, in the vicinity of Vendom Fiord, 1972-74; Abstract of paper presented to Ont. Assoc. Geomorph., Carleton Univ., March 7 1975.

Present knowledge of the chronology of deglaciation and uplift on Ellesmere Island is limited. In the Vendom Fiord area, Hodgson (1972) found that the marine limit is relatively low (70 m), and listed evidence of a late-glacial readvance prior to 7000 B.P. which he suggested may correspond to the well-documented Cockburn stage on Baffin Island.

More detailed investigations support the occurrence of a late-glacial readvance or stillstand. Examination of the relationship between glacial forms and glaciofluvial terraces suggests that sea level was at or just below the 70 m marine limit at the time of the readvance. During the ensuing retreat phase, extensive areas were covered by glacial outwash deposits which now constitute a widespread terrace graded to a sea level of 50-60 m. Evidence of a further minor readvance of the "Schei Glacier" lobe has been related to a terrace which is graded to a sea level of 4-6 m. These investigations demonstrate the value of employing river terraces as a link between glacial stages and former sea levels.

1314 BLACHUT, S.P. - 1975
Behaviour of ice-dammed lakes - Hydrologic and geomorphic investigations at the western margin of the Ellesmere Ice Cap, in the vicinity of Vendom Fiord, 1972-74; Abstract of paper presented to Ont. Assoc. Geomorph., Carleton Univ., March 7 1975.

A series of marginal lakes dammed against the Ellesmere Ice Cap was studied in 1973 and 1974. The main lake, "McMaster Lake", which was observed to partially drain in both years, is up to 200 m deep, and water temperatures were found to be near isothermal at 0.1°C. Lake level changes were monitored, and 5 m and 3 m drops in level were recorded for August 1973 and 1974 respectively. Outflow from the lakes system was gauged on the "Sverdrup" River and in

1974 a recorder was maintained on "Siphon Creek", just downstream of the outlet. The ice-dam controlling the behaviour of "McMaster Lake" appears to be a large section of floating shelf ice. Surveying results confirm that the ice mass is floating and Thorarinsson's (1939) concept of barrier floatation is invoked to explain the mechanisms responsible for drainage of "McMaster Lake".

1315 COGLEY, J.G. - 1975
Hydrologic regimes of the "Sverdrup River" and "Schei River" - Hydrologic and geomorphic investigations at the western margin of the Ellesmere Ice Cap, in the vicinity of Vendom Fiord, 1972-74; Abstract of paper presented to Ont. Assoc. Geomorph., Carleton Univ., March 7 1975.

The "Sverdrup River" has a drainage area above the recording cross section of 1280 km^2, of which 775 km^2 are covered by glacier ice; the "Schei River" is tributary to the "Sverdrup" (below the "Sverdrup" recorder section) and drains 105 km^2, 52 km^2 of which are glaciated. Both streams have mixed glacial-nival regimes. They flow only in summer, starting in June, and peak discharges occur in July or August (observed maxima are 190 $m^3 s^{-1}$ for the "Sverdrup", [?] 50 $m^3 s^{-1}$ for the "Schei"). Flow probably ceases in September or October. Discharge fluctuates considerably each day in response to changes in incoming radiation.

The two streams were chosen for study because i) the ice-dammed lakes in the upper basin of the "Sverdrup" were identified as probable hydrological hazards and ii) the "Schei" was promising as a manageable control or norm with which to compare the less predictable "Sverdrup". At least two jökulhlaups have been observed on the "Sverdrup"; they are known to have issued from the ice-dammed lakes, but some aspects of the stream's behaviour at about the time of the jökulhlaups are still unexplained. The hydrograph of the "Schei" contains anomalies, unsuspected at the outset, which are also related to damming by ice, and which are if anything less predictable and potentially more dangerous than the jökulhlaups on the "Sverdrup".

The two streams carry loads of suspended sediment which are large by any standards, with maximum concentrations exceeding 2000 ppm. The evidence suggests that little of the sediment load originates immediately from within or beneath the glacier. Work is still in progress on the estimation of solute and bed material loads.

1316 DAVIES, K.F. - 1975
Mackenzie River input to the Beaufort Sea; Beaufort Sea Technical Report No. 15, December 1975, 72 p.

Comprehensive descriptions of the gauging sites and methods used are included in the report. Distribution of flow in the main channels as a percentage of total flow has been determined on a month-by-month basis for the period July 1974 to June 1975.

Suspended sediment transport, ice thickness, and water temperature in the Delta are also discussed and the results shown.

1111 DAY, T.J., and ANDERSON, J.C. - 1976
Observations on river ice, Thomsen River, Banks Island, District of Franklin; *in* Report of Activities, Part B, Geol. Surv. Can., Paper 76-1B, pp. 187-196.

1317 DAY, T.J., and ANDERSON, J.C. - 1976
River hydrology, Banks Island, N.W.T.; *Ice*, no. 50, p. 12.

1113 DAY, T.J., and LEWIS, C.P. - 1977
Reconnaissance studies of Big River, Banks Island, District of Franklin; *in* Report of Activities, Part A, Geol. Surv. Can., Paper 77-1A, pp. 75-86.

1318 JASPER, J.N. - 1975
Hydrologic studies at Twisty Creek in the Mackenzie Mountains, N.W.T., Summary Report 1972-74; *in* Further Hydrologic Studies in the Mackenzie Valley Canada, Environmental-Social Committee, Northern Pipelines, Report No. 74-35, Infor. Canada Cat. No. R57-4/1975, pp. 61-80.

The study of relationships among precipitation, runoff, and erosion at Twisty Creek, a small sub-arctic upland watershed in the Mackenzie Mountains, was completed in 1974. Results for the 1974 field season are presented with a summary of previous results. Precipitation and runoff in 1974 were greater than in previous years, however the peak discharge (8.40 m^3/s or 1.21 $m^3/s/km^2$) was the lowest of the three annual summer peak flows. This is attributed to the generally medium intensity, long duration nature of rainfall and absence of thunderstorm activity during the 1974 field season. Analysis of computed basin sediment yield and streamflow duration curves indicates that high discharges during the peak floods of each year are the major agent of total watershed erosion, due to rapid increase of sediment movement with discharge.

1319 JASPER, J.N. - 1976
A Mackenzie Valley watershed study for assessment of hydrologic design at stream crossings; *Env. Can.*, 1975-76 Report for the Hydraulic Design Assessment Committee, Environmental Working Group, Mackenzie Highway, February 1976, 64 p.

Streamflow and precipitation data were collected during 1975 in 21 small drainage basins along the route of the Mackenzie Highway. Analyses of study results suggest that, despite above average snow accumulation in several areas since 1972, the melt period weather conditions have not produced extreme flood peaks. Consequently most of the data plotted within a narrow band on diagrams relating peak flow and drainage areas to predicted 50 year design flows. Several cases of floods close to or exceeding the design flows have been observed, however, suggesting that estimates of design flows by highway consultants may be less conservative than previously assumed.

Culvert performance at a number of stream crossings have been examined and generally found to fall below fish passage requirements. The main conditions responsible for their poor

performance include high velocities resulting from culvert icing or even blockage, and the formation of plunge pools and outlet waterfalls when the culvert invert is installed above the stream channel bed. Observation of flow velocities, icings, and bed mobility at future bridge or culvert sites suggest that similar conditions will occur in other areas, unless effective remedial measures are developed and implemented.

1320 JASPER, J.N., and ANDERSON, J.C. - 1977
An assessment of hydrologic design at stream crossings on the Mackenzie Highway; *Fish. and Env. Can.*, 1976-77 Report for the Hydraulic Design Assessment Committee, Environmental Working Group, Mackenzie Highway, April 1977, 99 p.

Hydrologic investigations were continued during 1976 in a number of small watersheds along the route of the Mackenzie Highway. Peak discharges recorded during the spring and summer of 1976 were generally well below those experienced in 1975 and were, in some cases, the lowest on record since 1972 or 1973. The low peak spring flows have generally been attributed to below normal winter snowfall and a prolonged snowmelt period resulting from above normal temperatures in early spring. As well, there was a sudden return to colder weather during the height of the snowmelt flood in the Mackenzie Delta region. In the Wrigley-Norman Wells Region, the same weather extended the snowmelt runoff recession.

Investigation of the fish passage performance of existing culverts in the Inuvik region was continued, with culvert performance "improving" over the 1975 spring flood period. This was largely due to lower discharges and a lesser degree of culvert icing than in 1975.

Consideration of the 1972-1976 study period data, with respect to recommended design discharge - drainage area relationships proposed by the highway hydrology consultants, suggests that flood estimates may have to be revised upwards towards the curve proposed by Bolter, Parish & Trimble. An elementary method of data extension is demonstrated, showing the complementary use of short and long term streamflow data.

1321 MacKAY, D.K. - 1973
Hydrologic aspects of northern pipeline development; *in* Hydrologic Aspects of Northern Pipeline Development, Environmental-Social Committee Northern Pipelines, Task Force on Northern Oil Development Report No. 73-3, April 1973, Infor. Canada Cat. No. R27-172, pp. 5-18.

Hydrologic factors can be of considerable importance in the selection of routes for proposed oil and gas pipelines linking the hydrocarbon reservoirs of Alaska and the northwest mainland of Canada with southern markets. The Canadian section of any such pipeline would cross many rivers and watersheds between the Yukon-Alaska boundary or the Mackenzie Delta and the southern limits of the Mackenzie River Valley. Some of the rivers and basins pose greater risks from a hydrological point of view than others and, in some areas, the cumulative effect of such risks could suggest that one pipeline route alternative is better than another or, conceivably, that all proposed routes should be abandoned in favour of a new one.

The general intent of our studies is to assess the magnitude and acceptability of the hydrological risks inherent in pipeline construction and maintenance within the broad Mackenzie River Valley and the northern sector of the Yukon Territories. Further, the intent is to offer meaningful advice in the selection or abandonment of particular pipeline routes. In a more specific sense, the objectives of our hydrologic studies can be met through: a) measurement of extreme flood and ice shove levels on rivers; b) determination of the location and character of river ice jamming; c) collection of river scour and fill data; d) documentation of bank stability and slope failure; and e) examination of the watershed characteristics and hydroclimatic processes affecting pipeline development in the North.

The substance of both routine and special data collection and analysis is engendered in the assessment of the hydrological risk. Such an assessment relies to some degree on the experience of the research personnel involved. The acceptability of the risk and the possible environmental consequences must be weighed against the many other considerations related to the environmental-social impact of northern oil and gas development.

1322 MacKAY, D.K., FOGARASI, S., and SPITZER, M. - 1973
Documentation of an extreme summer storm in the Mackenzie Mountains, N.W.T.; *in* Hydrologic Aspects of Northern Pipeline Development, Environmental-Social Committee Northern Pipelines, Task Force on Northern Oil Development Report No. 73-3, April 1973, Infor. Canada Cat. No. R27-172, pp. 191-221.

Documentation of a severe rainstorm in the Mackenzie Mountains during July 1970 is presented on the basis of limited data. The basic atmospheric processes giving rise to the excessive precipitation, the runoff response in certain west-bank tributaries of the Mackenzie River and the storm-caused changes in river flood plains are examined and discussed. Tree-ring data suggest that a storm of similar intensity and magnitude has less than 1% chance of happening in any given year. Lesser storms, however, are common and these have important implications for gas or oil pipeline construction and maintenance, tourism and other activities of man.

1323 MacKAY, D.K., and MACKAY, J.R. - 1973
Break-up and ice jamming of the Mackenzie River, Northwest Territories; *in* Hydrologic Aspects of Northern Pipeline Development, Environmental-Social Committee Northern Pipelines, Task Force on Northern Oil Development Report No. 73-3, April 1973, Infor. Canada Cat. No. R27-172, pp. 223-232.

The Mackenzie River is navigable by shallow-draft vessels over its 1,600-km length between

Great Slave Lake and the Beaufort Sea. The navigation season is normally from early June to late September. The waterway is actively used to supply river and arctic coastal settlements, and to an increasing extent in the past several years, oil and gas exploration needs in the western Arctic. It is the purpose of this paper to discuss some aspects of break-up and ice jamming in the river. Further data may be found in the selected bibliography.

The Mackenzie River does not break-up sequentially from south to north. Navigation from Hay River to the entrance to the Mackenzie River is often delayed by the presence of ice on Great Slave Lake. In addition, Great Slave Lake ice may run for a week or more past Fort Providence and thus retards barge traffic even though downstream portions are ice-free.

1324 MacKAY, D.K., and MACKAY, J.R. - 1973
Locations of spring ice jamming on the Mackenzie River, N.W.T.; *in* Hydrologic Aspects of Northern Pipeline Development, Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development Report No. 73-3, April 1973, Infor. Canada Cat. No. R27-172, pp. 233-257.

Historical observations of ice jamming are detailed for the Mackenzie River. Such evidence of ice jamming as the distribution of river ice stranded on banks, ice shove levels and driftwood levels are reported with reference to the physical characteristics of the Mackenzie main channel. Major ice jam sites are noted and some conclusions are drawn as to the influence of the Liard River, the significance of river stage at spring break-up and the relevance of ice jam data to the location of pipeline and highway crossings. It is evident that a crossing of the Mackenzie above its junction with the Liard is much less risky insofar as break-up and ice jamming are concerned than a crossing below it.

1325 McCANN, S.B., JAMES, W., COGLEY, J.G., and TAYLOR, R.B. - 1972
A hydrological and coastal reconnaissance of south central Ellesmere Island; *Dept. Env.*, Water Resources Br., Glaciology Div., Proj. No. G-72-16, Contract KW412-2-1162, 125 p.

South central Ellesmere Island was visited in July 1972 to reconnoitre hydrological and marine conditions in general, and in particular those likely to affect construction and safe maintenance of an oil pipeline through the area, and of a marine terminal on Makinson Inlet. The report summarizes what is known of the geology, geomorphology and climate of the area, and presents the findings of the reconnaissance on drainage and channel characteristics, sedimentation, hydrological regimes, sea and beach ice conditions, and coastal morphology.

The most difficult pipeline engineering problems of a hydrological nature will be associated with the large streams draining the 'Ellesmere Land Ice Cap'. These streams flow in wide, braided channels in which rates of sediment transport and redistribution, both in suspension and along channel beds, appear to be considerable. Possible difficulties due to the impounding and sudden release of meltwater in proglacial lakes require closer investigation.

The high rugged coastline of Makinson Inlet provides only one or two really adequate locations for a marine terminal, the most favoured being on the southern shore of Swinnerton Peninsula on the southwest arm of the inlet. Available information on ice cover indicates that a strong barrier of multi-year ice is usually present at the entrance to the inlet, and that the navigation season within the inlet may only be of the order of 30-35 days.

It is recommended 1) that monitoring of the hydrological regime of Ellesmere Island be begun with dispatch, 2) that a programme of research on analysis and modelling of the hydrological regime be conducted in the near future, 3) that the sedimentary regimes of channel networks be investigated in a similar manner, 4) that the behaviour of proglacial lakes be examined more closely, 5) that more detailed bathymetry be obtained for Makinson Inlet, especially of the nearshore zone near Swinnerton Peninsula, 6) that frequent aerial sea-ice observations and photography be conducted over Smith Bay-Makinson Inlet, 7) that tidal conditions within the various inlets be monitored and modelled, 8) that field reconnaissance studies of beach and nearshore conditions at alternative sites be carried out.

1326 McCANN, S.B., COGLEY, J.G., WOO, M-K., and BLACHUT, S.P. - 1974
Hydrological studies, south central Ellesmere Island; Report on Investigations undertaken in the Vendom Fiord Area in 1973; *Env. Can.*, Water Resources Br., DSS SPI. KW412-3-1514, Serial OSP3-0181, 153 p.

Results of the first full season of field work investigating the hydrological conditions along part of the western margin of the Ellesmere Ice Cap are reported. The study was carried out from a base camp at the head of Vendom Fiord (78° 03'N, 82° 17'W) during the period June 20-August 23, 1973.

The main focus of the work concerned the hydrologic regimes of the two principal streams, the "Sverdrup River" and the "Schei River", which drain from the ice cap into the head of Vendom Fiord. Rates and amounts of seasonal water and sediment flow for both rivers are presented and analysed. The "Schei" is the smaller stream (6 km long, maximum discharge 50 m^3s^{-1}) and carries most of the drainage of the "Schei Glacier" tongue: it is a relatively simple system without marginal lakes. The "Sverdrup" (30 km long, maximum discharge 148 m^3s^{-1}), however, is a more complex system and an important component of the discharge in 1973 resulted from the drainage on August 1 of one of a series of five ice marginal lakes. Such occurrences (jökulhlaup) are the most important and potentially the most hazardous aspects of the hydrology of the "Sverdrup River". An exceptional rainfall of 54 mm (2.15") in the period 21-23 July produced the highest discharge on the "Schei River" and a corresponding peak in the "Sverdrup" hydrograph. Both rivers occupy

complex braided floodplains (sandur) and basic observations and surveys were made to examine the responses in floodplain and channel characteristics to the rapid variations in discharge.

Observations on the nature of the ice margin and marginal drainage conditions, and in particular on the series of marginal lakes, are presented, which provide a sound basis for further investigation of this key problem in 1974. A pilot study of the hydrologic conditions of the active layer, in preparation for a more intensive project in 1974, yielded information relating to active layer depths and drainage of surface water which is analysed and discussed. A system of terrain classification, based on the character of surface material, was devised in the field and a map and descriptions of the terrain types in the study area are presented.

1327 McCANN, S.B. - 1975
Introduction and aims - Hydrologic and geomorphic investigations at the western margin of the Ellesmere Ice Cap, in the vicinity of Vendom Fiord, 1972-74; Abstract of paper presented to Ont. Assoc. Geomorph., Carleton Univ., March 7 1975.

Following a reconnaissance of the western margin of the Ellesmere Ice Cap between Makinson Inlet and Strathcona Fiord in 1972, the Vendom Fiord area (78°N, 82°W) was selected as the site for investigations of the hydrologic and geomorphic conditions typical of the ice margin. The series of short papers reports on some of the results obtained in two 10-week field seasons in 1973 and 1974. The work has been supported throughout by Glaciology Division, Environment Canada.

The main aims of the project have been to determine the regimes (discharge and sediment) of the two principal streams, the 'Sverdrup' and 'Schei' Rivers, which drain from the ice margin into the head of Vendom Fiord, and to examine the drainage characteristics of a series of ice dammed lakes, which were expected to add irregular and unusually large flood discharges to the 'Sverdrup'. Subsequently, attention has also been directed to two other topics. The first, which was investigated in both 1973 and 1974, concerns drainage conditions in the active layer; the second, investigated in 1974, concerns the different contributions of water and sediment from glacial and nival sources to the 'Schei' River. Observations have also been made which relate to flood plain, sandur and channel characteristics and deposits, and to the geomorphic history of the area.

1328 McCANN, S.B., COGLEY, J.G., BLACHUT, S.P., BALLANTYNE, C.K., and BENNETT, B.G. - 1975
Hydrology and sediments of the 'Sverdrup' and 'Schei' rivers with particular reference to ice marginal drainage conditions - Hydrological studies, south central Ellesmere Island; Section A of a Report on Investigations undertaken in the Vendom Fiord Area in 1974; *Dept. Env.*, Inland Waters Dir., DSS File No. 01SU-KL398-4-0331, 283 p.

Results of a second field season investigating the hydrological conditions along part of the western margin of the Ellesmere Ice Cap are presented, and compared with the previous season. The study was carried out in the area at the head of Vendom Fiord, (78° 03'N, 82°17'W) during the period June 19-August 21, 1974.

The main focus of the work concerned the hydrologic regimes of the two principal streams, the Sverdrup River and the Schei River, which drain from the ice cap into the head of Vendom Fiord, and with the nature and drainage behaviour of a series of ice margin lakes which contribute to the Sverdrup system. The 1974 season was much drier than 1973 (12 mm precipitation v 91 mm) and the seasonal hydrographs for the two streams show no dramatic responses to precipitation, such as were recorded in the earlier year. The Sverdrup hydrograph exhibits an early phase of high flow between 12-16 July, with a maximum discharge of 228 $m^3 sec^{-1}$ on 13 July, and a late season glacier melt peak between 27 July and 5 August, together with high flows on particular days until 19 August. The ice margin lake drainage commenced on 13 August (c.f., 1 August in 1973) and the volumes of water involved were much smaller than in the earlier year. In the light of the 1974 observations the discharge figures cited in an earlier report for the Sverdrup River during and after the jökulhlaup of 1 August, 1973 have been modified.

The ice margin lake system was examined in detail throughout the 1974 season. A full data set of meteorological, limnological, glaciological and hydrological observations provides a record of the filling and drainage behaviour of the principal lake, and allows conclusions to be drawn about the nature of the ice dam and the drainage mechanisms.

The hydrograph of the Schei River exhibits a similar seasonal pattern to that of the larger Sverdrup River. Separate hydrographs were obtained in 1974 for the three tributaries of the Schei River, which enable the different components of total discharge to be separated: glacier melt *per se* accounted for 55% of the total runoff in 1974. The more intensive investigation of the Schei River and its drainage basin in 1974 also involved studies of sediment load and availability, and of the characteristics of the Schei sandar. Sandar are an important dynamic landscape unit in the study area and the observations on the Schei are considered representative of similar conditions elsewhere along the ice margin.

1329 McCANN, S.B., WOO, M-K, COGLEY, J.G., BALLANTYNE, C.K., and BLACHUT, S.P. - 1976
Hydrological investigations in south-central Ellesmere Island; *Ice*, no. 50, p. 7.

1330 RYDÉN, B.E. - 1976
Water Availability to Some Arctic Ecosystems; *Nordic Hydrology*, vol. 7, pp. 73-80.

Water in permafrost areas is available to the organisms during a short time and in a restricted space. Models of soil water occurrence and flow are applicated as basis for analysis of

moisture in the environment of organisms. Soil moisture, available for the transpiration process, has been calculated as to soil in permafrost. The seasonal variation of soil moisture is shown.

1058 SMITH, M.W. - 1975
Numerical Simulation of Microclimatic and Active Layer Regimes in a High Arctic Environment; *Indian and Northern Affairs*, North of 60, ALUR 74-75-72, INA Publication No. QS-8039-000-EE-A1, 29 p.

1331 WEDEL, J.H., and WAY, J.G. - 1976
Eastern Arctic Islands Pipeline Project, Spence Bay to Sabine Peninsula; *Env. Can.*, Inland Waters Western Region Interim Report (1975) Hydrologic Regimes Freshwater Project No. 1, January 22 1976, 325 p.

This report summarizes the work carried out during 1975 by the Hydrologic Regimes component of the Freshwater Program of the Arctic Islands Pipelines Study Group, under the auspices of the Environmental-Social Program of the Department of Indian Affairs and Northern Development. The objective of the Hydrologic Regimes component (FP-1) was to obtain an overview of hydrology along the pipeline corridor north of Spence Bay, in order to provide data for an adequate assessment of the proponent's application. Because of the paucity of knowledge concerning hydrologic processes and events in the study area and because of the uncertainties of pipeline routing, it was deemed necessary in 1975 to collect data over a broad geographic base. This spatial distribution is Phase One of FP-1's study and will be related to Phase Two, planned for 1976 (the chronologic distribution of hydrologic events).

As fluvio-morphometric concerns are inextricably linked to hydrologic parameters, they must become part of any data set. For this report, it was possible to make only qualitative assessments of these concerns as a minimum of field time was spent on site in order to provide extensive geographic coverage. In any case, attempts have been made to relate the hydrologic and geomorphic data to pipeline concerns, both environmental and those of engineering design. The subjective conclusions and qualitative assessments made in this interim report will no doubt be revised as more data becomes available.

Appended to this report are a survey equipment listing, a detailed catalogue, and an FP-1 funded report on water quality parameters from the Water Quality Branch, Environment Canada, Winnipeg. Because of time constraints, snow reports from Glaciology Division will appear as independent papers.

One major recommendation that the authors of this report would like to make is the need for the establishment of a user-oriented centralized hydrologic data bank. Since the greatest volume of hydrologic data for the study area is in scientific research papers and many times is only peripheral information necessary to the development of the papers' main theme, a centralized data bank would perform a useful function. The writers feel the establishment of a data bank could best be accomplished by the incorporation of research data from universities and other in-government agencies and departments into the central data banks of the Inland Waters Directorate, Environment Canada.

1332 WOO, M-K. - 1975
Active layer hydrology; Section B of a Report on Investigations undertaken in the Vendom Fiord Area in 1974; *Dept. Env.*, Inland Waters Dir., DSS File no. 01SU-KL398-4-0331, May 1975, 103 p.

The active layer at the head of Vendom Fiord reaches an average depth of 0.4-0.5 m. During the summers of 1973 and 1974, water level in the active layer was studied in relation to several factors - snowmelt, rainfall, evaporation and position of the frost table. Lowering of the frost table corresponds with a drop in the water level and a drying out of the ground surface, but high water level is maintained if summer rainfall is high. Water level rises in response to rainfall and snowmelt, the latter producing a pronounced diurnal effect. Diurnal rhythm due to evaporation is also noticeable in late summer and it is likely that water loss by evaporation can be substantial.

The runoff pattern of a small non-glacierized basin (area 2.3 km^2) strongly reflects the influence of active layer drainage. A shallow active layer reduces basin storage, resulting in a rapid response of streamflow to snowmelt regime. A recession of the basin snow cover brought about gradual changes in the spatial distribution of surface runoff and a variable meltwater source area concept is formulated to describe this phenomenon. An estimated excess of evaporation over rainfall during the 1974 summer is confirmed by the cessation of streamflow soon after meltwater supply was depleted.

1333 WOO, M-K. - 1975
Active layer hydrology - Hydrologic and geomorphic investigations at the western margin of the Ellesmere Ice Cap, in the vicinity of Vendom Fiord, 1972-74; Abstract of paper presented to Ont. Assoc. Geomorph., Carleton Univ., March 7 1975.

1334 WOO, M-K. - 1976
Evaporation and water level in the active layer; *Arctic and Alpine Res.*, vol. 8, no. 2, pp. 213-217.

A simplified form of McIlroy's combination model was used to compute bihourly evaporation for a High Arctic site. The computed evaporation values reveal diurnal and seasonal patterns which show a close relationship with water levels in the active layer. The excess of evaporation over summer rainfall input to a small basin led to a rapid cessation of streamflow, confirming the importance of evaporation in the water balance of small arctic drainage basins.

1335 WOO, M-K. - 1976
Hydrology of a small Canadian High Arctic basin during the snowmelt period; *CATENA*. vol. 3, no. 2, October 1976, pp. 155-168.

Investigations were carried out in a small Canadian High Arctic basin to determine the influence of snowmelt on the hydrologic behaviour of the active layer and on basin discharge. The snowpack was characteristically thin but rapid melting in late June released a substantial amount of water to a thinly-thawed active layer, resulting in overland flow or standing water conditions. Owing to an uneven distribution of basin snow cover, the meltwater source area was highly variable both in time and in space, thus giving rise to different active layer hydrologic regimes in different parts of the basin. Slopes with a snowbank often had a high water table while the water table in the slopes bared of snow showed a gradual decline. Since streamflow represents a basinwide integration of these two active layer hydrologic regimes, there was a progressive reduction in daily peak flow accompanied by a prolonged lag time between daily discharge and snowmelt as the basin snow storage decreased. Spatially, inhomogeneity of snow cover also affected the downstream changes in discharge so that the ratio of discharge between two gauging stations depends on the relative magnitudes of snowmelt, evaporation and storage requirements of the two subbasins. Rapid melting of an unevenly distributed Arctic snowpack therefore strongly influences the hydrologic behaviour of the active layer which in turn affects the streamflow regime.

1336 WOO, M-K., and MARSH, P. - 1976
Active Layer Hydrology; Section B of a Report on Investigations undertaken in the Vendom Fiord Area in 1975; *Dept. Env.*, Inland Waters Dir., DSS File No. 01SU-KL398-5-0385, May 1976, 166 p.

The active layer at the head of Vendom Fiord reaches an average depth of 0.4-0.5 m. During the summers of 1973, 1974 and 1975, water level in the active layer was studied in relation to several factors - snowmelt, rainfall, evaporation and position of the frost-table. Lowering of the frost-table corresponds with a drop in the water level and a drying out of the ground surface, but high water level is maintained if summer rainfall is high. Water level rises in response to rainfall and snowmelt, the latter producing a pronounced diurnal effect. Diurnal rhythm due to evaporation is also noticeable in late summer and over the season, water loss by evaporation is substantial.

The runoff pattern of a small non-glacierized basin (area 2.3 km) strongly reflects the influence of active layer drainage. A shallow active layer during the melt period reduces basin storage, resulting in a rapid response of streamflow to snowmelt regime. A recession of the basin snow cover brought about gradual changes in the spatial distribution of surface runoff and a variable meltwater source area concept is formulated to describe this phenomenon. After the melt period, channel storage becomes increasingly important and this affects the hydrograph response to rainfall. In late summer, an excess of evaporation over rainfall is confirmed by the cessation of streamflow. Further evidence on the importance of evaporation is provided by the water-balance of an internal drainage basin (area 0.5 km) which losses 90 per cent of its rainfall input to the atmosphere within a period of six weeks. A small tundra pond within the basin is found to derive the bulk of its water supplies from active layer drainage.

The hydrochemistry of stream water indicates very high concentrations in hardness and in bicarbonate. This is related to a large supply of carbon dioxide produced by biogenic activities in the soil. Active layer drainage enables a transfer to this vegetation effect to the stream.

1337 WOO, M-K., and MARSH, P. - 1977
Determination of snow storage for small Eastern High Arctic Basins; Paper presented at the 34th Eastern Snow Conference, February 1977, Belleville, Ont., 16 p.

A snow survey was carried out before the melt season of 1976 in four small basins near Resolute, Cornwallis Island, N.W.T. The study was undertaken to determine the error involved in estimating basin snow storage using climatological data. Results indicate that basin storage was about twice the amount recorded by the climatological station. The explanation for such a discrepancy lies in the variability of snow depth and density over different types of terrains. The climatological station was representative of only the more exposed flat-lying areas. Elsewhere in the basins, there was a systemmatic snow storage increase from hilltops to flats, to slopes, to gullies and valleys. The possibility of relating snow depth and density to terrain characteristics offers a means of computing basin snow storage based on a sampling of snow conditions over a selected number of terrain types.

1029 WOO, M-K., and MARSH, P. - 1977
Effect of vegetation on limestone solution in a small High Arctic basin; *Can. J. Earth Sci.*, vol. 14, no. 4, (Part 1); pp. 571-581.

METEOROLOGY

1338 ALT, B., and INKSTER, B. - 1977
Meteorological observations from selected stations in the Canadian Arctic and an example reduction with the Hunting River Station; *Polar Cont. Shelf Proj.*, internal report, 19 p.

The proposal considered the operational and research needs for meteorological and climatological information in the Queen Elizabeth Islands and presented a program to *collect* and *analyze* data critical to these needs.

1207 ANONYMOUS - 1976
AIDJEX Main Experiment Completed; *Arctic Bull.*, vol. 2, no. 9, p. 165.

0916 APOLLONIO, S. - 1961
Report of the field leader, April-September 1961 in "The Devon Island Expedition"; *Arctic*, vol. 14, no. 4, pp. 253-254.

1208 APOLLONIO, S. - 1962
The Devon Island Expedition 1960-1964; *Arctic*, vol. 15, no. 4, pp. 317-321.

1339 BANKE, E.G., and SMITH, S.D. - 1975
Measurement of form drag on ice ridges; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 28, pp. 21-27.

The form drag on five snow-covered ice ridges in Robeson Channel was measured using static pressure ports to sense air pressure differences between the upwind and downwind slopes. The ridges were smoothed by melting and by drifted snow and had lower form drag coefficients than earlier estimates suggested. These preliminary results indicate that the form drag coefficient tends to increase with the slope of the ridge.

1340 BANKE, E.G., SMITH, S.D., and ANDERSON, R.J. - 1976
Recent Measurements of Wind Stress on Arctic Sea Ice; *J. Fish. Res. Board Can.*, vol. 33, no. 10, pp. 2307-2317.

Eddy flux measurements of wind stress on the arctic pack ice have been made in summer and winter in terrain ranging from flat to hummocked. Parameterization by a drag coefficient dependent on a surface parameter is suggested. Reduced values of the drag coefficient were observed in highly stable stratification. The coefficient for sensible heat flux is lower than the drag coefficient. Wind drag on ice ridges has been measured by a pressure differential method.

1341 BANKE, E.G., SMITH, S.D., and ANDERSON, R.J. - 1976
Wind stress measurements over Arctic Sea Ice; *Ice*, no. 50, pp. 12-13.

1033 BERRY, M.O., DUTCHAK, P.M., LALONDE, M.E., McCULLOCH, J.A.W., and SAVDIE, I. - 1975
A study of weather, waves and icing in the Beaufort Sea; Beaufort Sea Technical Report No. 21, December 1975, 143 p.

1211 CARSEY, F.D. - 1976
The AIDJEX acoustic radar and some preliminary results; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 31, pp. 1-19.

1342 CARSEY, F., and LEAVITT, E. - 1977
Pibal/acoustic radar data in measurement and computation of air stress over pack ice; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 36, pp. 87-128.

The use of planetary boundary layer thickness derived by acoustic radar in the estimation of air stress over pack ice is discussed. Pilot balloon winds are normalized and evaluated through this thickness prior to momentum integration of the Ekman force balance equation and prior to the construction of seasonal mean profiles. Examination of individual and constructed mean profiles leads to a stress relation $\tau = (0.5 \pm 0.1)\ \rho f Z_i G \sin \alpha$, where stress τ is obtained from Coriolis parameter f, inversion height (boundary layer thickness) Z_i, geostrophic wind speed G, and total wind turning α. The direction of mean stress from the integrated profiles over the entire year is significantly skewed some 16° to the left of the surface wind. When this skewing is interpreted as error due to baroclinic wind, a boundary layer thermal gradient parallel to the pressure gradient is indicated.

1343 CLARKE, M., BELL, D., and LEAVITT, E. - 1977
Field calibration report, AIDJEX Meteorology Program, April 1975 - April 1976; *AIDJEX Bull.*, Univ. Wash, Seattle, No. 36, pp. 129-155.

This report summarizes meteorological data collected during routine systems calibrations and three special calibration visits to AIDJEX ice camps in spring 1975, summer-fall 1975, and spring 1976. The report lists the factory calibration values for the sensors and describes offsets introduced by the data reading and recording. A set of equations is given for transforming the measurements into physical units.

1344 CLODMAN, J., and MULLER, F.B. - 1975
Real-time environmental prediction system; Beaufort Sea Technical Report No. 20, December 1975, 138 p.

The purpose of the Beaufort Sea Prediction System Design Study includes the design of such a system and the examination of its benefits for environmental prediction and operational efficiency in offshore oil drilling. The system design involves the extension of current AES Forecast and Observational Systems to provide a variety of forecasts to support offshore drilling including frequent updates of high space- and time-resolution forecasts of the motion of floes, waves, storm surges, wind and weather. Key components of the design include a Computerized Prediction Support System (CPSS) involving a complex set of computerized modules and procedures, an extension of forecast capability at the Arctic Weather Central in Edmonton, a Beaufort Advance Base to be an interface between the forecasters and the oil-drilling companies and to provide close-up support, a network of automatic weather stations to the northwest of the Beaufort Sea, a Very High Resolution Radiometer (VHRR) satellite reception capability, an ice-monitoring system based on aircraft, ships, radar and transponder devices, and, finally a Research and Development Capability.

The overall design of the system has been completed although a number of components of the CPSS still require work and the prototype automatic station still needs testing. The full design could have been completed ready for implementation in the late spring of 1976 as originally planned and thus provide comprehensive support for offshore drilling in 1976. However, as agreed in Government talks with Canmar, the only company which will be drilling

in 1976, a reduced system will be implemented for the 1976 season. This version will exclude most of the automatic weather stations, the VHRR station, part of the CPSS, most of the support strength at the Arctic Weather Central and the R. & D. upgrade capability. The resulting deficiencies in providing support to the oil drilling can be reviewed based on 1976 experience to see whether the full system should be implemented. Potential improvements in the full system which have been identified include the prediction of near-surface currents for improved ice movement forecasts, products to support oil cleanup in the event of a spill and the prediction of superstructure icing on rigs and vessels from spray.

In general, tests, including specially organized 1975 Summer Trials, reveal that the full system can be expected to function at design levels. The system can be readily modified to provide support for other users in the area.

1345 GILL, A. - 1963
Meteorology, Winter 1961-62 (The Devon Island Expedition 1960-64); *Arctic*, vol. 16, no. 1, pp. 62-63.

1346 HERLINVEAUX, R.H., De LANG BOOM, B.R., and WILTON, G.R. - 1976
Salinity, temperature, turbidity and meteorological observations in the Beaufort Sea: Summer 1974, Spring and Summer 1975; *Env. Can.*, internal report, Inst. of Ocean Sciences, Pacific Marine Science Report 76-26, 244 p. *UNPUBLISHED MANUSCRIPT.*

Salinity, temperature, turbidity and meteorological observations were carried out in the Beaufort Sea during the summer of 1974, and the spring and summer of 1975. Salinity and temperature were determined from a conductivity-temperature-pressure instrument. Turbidity observations were carried out over a 1 metre path length. Meteorological observations were observed from standard meteorological instruments. The summer observations were carried out from shipboard, and the spring observations were taken at ice camps through approximately 2 metres of ice at three locations.

1347 JOHNSON, A. - 1976
First Data Report; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 32, 71 p.

Bulletin No. 32, the first in a series of data reports, contains data summaries for the period 11 April-29 June 1975, an 80-day sequence. The next data report will cover the next 80 days and perhaps backtrack to catch some projects absent from this one. We dedicate the data reports to the copy machine that reduces all those numbers to dinky little things that can go thousands to a page, and to the makers of transparent tape, miles of which went into this Bulletin. However, even with their help, putting out a data report is -- to borrow Heinrich Böll's simile - a lot like being condemned to eat a sack of flour with a spoon.

1306 STATEMAN, M.J. - 1977
Data available from the Arctic Ice Dynamics Joint Experiment as of 1 May 1977; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 36, pp. 203-210.

1267 WASHKURAK, S. - 1977
Meteorological satellites aid airborne operations in remote regions; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 77-1A, pp. 93-94.

OCEANOGRAPHY

1207 ANONYMOUS - 1976
AIDJEX Main Experiment Completed; *Arctic Bull.*, vol. 2, no. 9, p. 165.

1208 APOLLONIO, S. - 1962
The Devon Island Expedition 1960-1964; *Arctic*, vol. 15, no. 4, pp. 317-321.

1348 APOLLONIO, S. - 1963
Oceanography, winter 1961-62 (The Devon Island Expedition 1960-64); *Arctic*, vol. 16, no. 1, pp. 63-66.

This preliminary report describes the winter cycle of biological, chemical, and physical oceanographic events in Jones Sound, N.W.T.

1349 BARBER, F.G. - 1976
A note on the oceanography of Eclipse Sound; *Polar Cont. Shelf Proj.*, internal report, 60 p.

Sources of oceanographic data in Eclipse Sound are few, but these few data indicate certain similarities in distributions with adjacent areas, particularly Lancaster Sound. Tidal processes are seen to provide a small but persistent coupling to these areas. Currents are generally small, and mainly tidal, with a small eastward bias at least in the near-surface. Local seasonal processes are recognized in a surface layer to 50m. A contribution to the deeper water of Baffin Bay from peripheral systems like Eclipse Sound is indicated.

1033 BERRY, M.O., DUTCHAK, P.M., LALONDE, M.E., McCULLOCH, J.A.W., and SAVDIE, I. - 1975
A study of weather, waves and icing in the Beaufort Sea; Beaufort Sea Technical Report No. 21, December 1975, 143 p.

1350 FROZEN SEA RESEARCH GROUP - 1976
Oceanographic data report D'Iberville Fiord, Ellesmere Island, N.W.T., March to April 1975, September 1976; *Env. Can.*, internal report, Inst. of Ocean Sciences, Pacific Marine Science Report 76-19, 166 p. *UNPUBLISHED MANUSCRIPT.*

This is the third oceanographic data report listing information obtained from d'Iberville Fiord, Ellesmere Island, N.W.T. The first report (F.S.R.G., 1973) covers the period March

to April, 1973; the second report (F.S.R.G., 1975) covers the period March to April, 1974, and August, 1974.

D'Iberville Fiord is an appendage to the Nansen Sound - Greely Fiord system on northwestern Ellesmere Island. The fiord, is located at 80° 30'N, 79° 00'W and is about 35 km by 6 km with an area of 213 km^2. A longitudinal section of the fiord is also shown in Figure 1. A sill near the mouth of the fiord reaches a maximum depth near 200 meters. The sill isolates the deep water within the fiord which is marked by values of salinity and temperature significantly different than those at similar depths outside the fiord. The maximum depth within the fiord is just inside the sill where it reaches a depth near 560 meters.

D'Iberville Glacier terminates in a floating ice shelf at the head of d'Iberville Fiord. The glacier has a marked effect on the temperature structure of the fiord water above 100 meters, the probable maximum depth of the ice shelf. The coldest temperatures measured in the fiord (-1.7°C) were found at 80 m about 1 km west of the ice shelf which was the closest one could reasonably approach. The mean flow rate of the glacier has been measured as 1.1 m day^{-1} (Holdsworth, 1976). The advancing glacial ice fractures and displaces the sea ice adjacent to its snout making close approach both difficult and dangerous.

During the period September to July, the fiord is completely covered by sea ice which remains landfast until shore leads develop in June. The sea ice cover normally consists of extensive young (annual) ice with patches of second-year ice and some rafted and hummocked ice. The fiord was partially ice free in August 1974 when some oceanographic data were obtained (F.S.R.G., 1975) and had a normal sea ice cover in the spring of 1975. In the spring the sea ice was covered with a layer of snow 20 to 40 cm thick. The inner two-thirds of the fiord is relatively protected from wind by the surrounding mountains so that the snow there is typically light, powdery and has the greatest thickness. The more exposed areas at the mouth of the fiord and in Greely Fiord are covered with dense wind packed snow (sastrugi). The sea ice thickness reflects this variation in the density and depth of the insulating snow cover.

The physical oceanography of the area has been reported on by Ford and Hattersley-Smith (1965), Hattersley-Smith and Serson (1966), Lake and Walker (1973), and Lake and Walker (1976). Data included in this report are pressure, temperature, salinity, sigma-T and sound velocity. Other data collected but not reported here are meteorological parameters, water levels (tides), current profiles and current time series measurements, snow characteristics and time lapse photography of ice movement. The locations of experiment sites are given in Figure 1 and the experiment number at each of the sites is listed in Table 1.

1351 FROZEN SEA RESEARCH GROUP - 1976 Oceanographic data report D'Iberville Fiord, Greely Fiord, Eureka Sound, Ellesmere Island, N.W.T., March 1976; *Env. Can.*, internal report Inst. of Ocean Sciences, Pacific Marine Science Report 76-20, 201 p. *UNPUBLISHED MANUSCRIPT.*

This is the fourth oceanographic data report listing information obtained from d'Iberville Fiord, Ellesmere Island, N.W.T. The first report (F.S.R.G., 1973) covers the period March to April, 1973; the second report (F.S.R.G., 1975) covers the period March to April, 1974, and August, 1974; the third report (F.S.R.G., 1976) covers the period March to April, 1975. In addition to d'Iberville Fiord, data are presented in this report from Greely Fiord and the northern end of Eureka Sound. All data were obtained during March, 1976.

The physical oceanography of the area has been reported on by Ford and Hattersley-Smith (1965), Hattersley-Smith and Serson (1966), Lake and Walker (1973), Herlinveaux (1974) and Lake and Walker (1976).

D'Iberville Fiord is located near the eastern end of Greely Fiord at 80° 30'N, 79° 00'W and is 35 km long. Greely Fiord is situated on an east-west line along the latitude 80° 30'N between the longitudes of 79° 30'W and 86° 30'W, a distance of 140 km. The main fiord system continues in a northwesterly direction along Nansen Sound for a further 175 km where it meets the Arctic Ocean. Eureka Sound extends southward from the junction of Greely Fiord and Nansen Sound and connects this fiord system to Norwegian Bay in the south and is the sole route into the area for marine shipping. Those geographic areas covered by the oceanographic survey are shown in Figure 1.

A longitudinal section of the Greely Fiord system, including d'Iberville Fiord and the northern portion of Eureka Sound is shown on Figure 2. A sill which obtains a maximum depth of 200 m lies across the mouth of d'Iberville Fiord isolating the deep water within. The maximum depth inside the fiord is about 560 m. Greely Fiord is a deep fiord with depths near 700 meters along all but the eastern end of the fiord. While large portions of the fiord remain unchartered the maximum depth found is 805 m. Greely Fiord contains no sills but the water below 450 m is isolated by a sill at the north end of Nansen Sound. Nansen Sound has depths in excess of 900 m. The north entrance to Eureka Sound has a sill with a maximum depth near 250 m after which it deepens to 650 m. Further south the sound becomes shallower until it reaches its shallowest point of 100 m about midway down the sound.

The only tide water glacier in the survey area occurs at the head of d'Iberville Fiord. The ice shelf and icebergs associated with this glacier have a marked effect on the temperature structure of the water within the fiord.

During the period September to July the sea is completely covered with sea ice which remains landfast until shore leads develop in June. The sea ice cover normally consists of extensive young (annual) sea ice with patches of rafted and hummocked ice. Photographic coverage obtained from Landsat 1 and Landsat 2 satellites showed the entire area, with the exception of the north end of Nansen Sound, to be entirely free of ice. The ice cleared by the first week in August and was not evident again until September 8 when a skim of sea ice could be seen

in d'Iberville Fiord. This initial ice cover became general throughout the entire area in September 12. The sea ice disappeared again by September 17 and did not appear widespread again until about September 26 after which time no further satellite coverage of this area was received. It was evident during the field work in March 1976 that the ice in d'Iberville Fiord had broken up and rafted heavily when the ice was 4-5 cm thick. This may have occurred on or about October 9, 1975, when winds in excess of 40 knots were recorded at the Eureka weather station.

Little is known about the general water circulation in d'Iberville and Greely Fiords. It is known however that a significant southgoing current flows from Nansen Sound through Eureka Sound.

Data were collected by traversing the 230 km between the d'Iberville Fiord base and the Eureka weather station in 11 days using two especially equipped tracked vehicles. These vehicles and their associated equipment are described by Lewis (1971).

Data included in this report are limited to conductivity, temperature, pressure and the derived parameters salinity, sigma-T and sound velocity. Other information collected but not reported here concerned meteorological parameters, tides, current profiles, dissolved oxygen, the physics of sea ice and icebergs, and time lapse photography of ice movement.

The experiment sites are shown in Figure 1 and the experiment identification number(s) for each site are listed in Table 1. For convenience the data are grouped into one of three geographic areas, d'Iberville Fiord, Greely Fiord and Eureka Sound.

1352 GRAINGER, E.H., and LOVRITY, J.E. - 1975
Physical and chemical oceanographic data from the Beaufort Sea, 1960 to 1975; *Fish. Mar. Serv.*, Res. Dev. Tech. Report No. 590, 52 p.

Tables of physical and chemical data from 119 station occupations in the south Beaufort Sea include information on temperature, salinity, dissolved oxygen, phosphate, nitrate, nitrite, silicate, chlorophyll a and carbon.

0944 GRAINGER, E.H., LOVRITY, J.E., and EVANS, M.S. - 1977
Biological oceanographic observations in the Eskimo Lakes, arctic Canada. Physical, nutrient and primary production data, 1961-1975; *Fish. Mar. Serv.*, Tech. Report No. 685, 108 p.

1353 HENRY, R.F. - 1975
Storm surges; Beaufort Sea Technical Report No. 19, December 1975, 41 p.

Storm surges, that is, storm induced increases in sea level, of about 1 m in amplitude and lasting for some hours are not uncommon on the Beaufort Sea coast in ice-free summers. Surge levels may even exceed 2 m in some embayments, for instance at Tuktoyaktuk. This report describes a study, involving numerical models, designed to permit prediction of surge levels between Herschel Island and Cape Bathurst and also to check if surge magnitudes at sites well off-shore are ever large enough to pose hazards to drilling operations.

At the coast, surges cause flooding and accelerated beach erosion and are a factor which should be considered in the design of artificial islands. The nesting sites of thousands of seabirds, of economic importance to the native population, can be inundated, and it is conceivable that the bird population might not survive contamination of the nesting grounds due to a surge carrying oil inland from a spill off-shore.

The accuracy of numerical storm surge models has to be verified by simulation of a number of actual surges. Too few surges have been successfully recorded in the Beaufort Sea to permit full quantitative model verification at the present time, but some confidence can be placed in the models in their present state, on account of experience with similar models of other seas. It can be concluded that storm surge amplitudes are much smaller at sites well off-shore than at the coast and are probably far less hazardous to drill-ships than other storm effects such as high winds and short-period waves. As more surge records accumulate, the models will be refined, but a limit to the accuracy of surge level forecasts is imposed by their dependence on forecast surface winds.

Two subsidiary topics discussed are 'negative surges', that is, temporary decreases in sea-level, which may hinder shipping, and winter surges, which though much less frequent than summer surges, should probably be considered during the design of near-shore structures, in view of their potential for causing ice damage.

1354 HERLINVEAUX, R.H., and De LANGE BOOM, B.R. - 1975
The physical oceanography of the south-eastern Beaufort Sea; Beaufort Sea Technical Report No. 18, December 1975, 97 p.

In the Beaufort Sea meteorological and ice conditions play a major role in the distribution of oceanographic properties. Field studies were conducted during the summer of 1974 ("worst ice conditions on record") as well as during the spring and summer of 1975 ("good ice conditions"). The discharge from the Mackenzie River dominates the surface waters of the southern Beaufort Sea, especially during bad ice years. The density distribution is salinity dominated throughout the system. The vertical profiles of salinity, temperature, turbidity and currents are described for summer and spring conditions. In both space and time the distribution of water properties is better known than the currents, although a qualitative description of the surface currents can be given for conditions of westerly or easterly winds together with the resulting temperature and salinity distribution. During the spring, tidally induced movements of the water column were observed only at mid-depth off Kugmallit Bay, and these movements are not considered to be a major factor in the study area. The movement of Mackenzie River water in the Beaufort Sea is predictable to some degree and can be followed by satellite imagery. Although the behaviour of oil is not identical to that of water, the flow of surface water could involve the movement of either crude oil from a blowout or other pollutants.

1346 HERLINVEAUX, R.H., De LANGE BOOM, B.R., and WILTON, G.R. - 1976
Salinity, temperature, turbidity and meteorological observations in the Beaufort Sea: Summer 1974, Spring and Summer 1975; *Env. Can.*, internal report, Inst. of Ocean Sciences, Pacific Marine Science Report 76-26, 244 p. *UNPUBLISHED MANUSCRIPT.*

1355 HERLINVEAUX, R.H., De LANGE BOOM, B.R., and WILTON, G.R. - 1976
Water movements in the Beaufort Sea, Summer 1974, Spring and Summer 1975; *Env. Can.*, internal report, Inst. of Ocean Sciences, Pacific Marine Science Report 76-27, 69 p. *UNPUBLISHED MANUSCRIPT.*

Water movements were observed using various methods during the summer of 1974, the spring of 1975, and the summer of 1975. The ship's position in the ice fields was observed using Decca. Water movements at depth were observed with a specially adapted current meter. Time series observations of water currents from the surface to the bottom of the water column are presented. Ice movements were observed by having radio beacons installed in ice floes. These were then tracked over a period of time using a helicopter.

1356 HUGGETT, W.S., WOODWARD, M.J., STEPHENSON, F., HERMISTON, F.V., and DOUGLAS, A. - 1975
Near bottom currents and offshore tides; Beaufort Sea Technical Report No. 16, December 1975, 38 p.

Our specific objective was to gain some understanding of the bottom currents and offshore tides in the southern Beaufort Sea, their relationship to wind and ice conditions, and to measure storm surges along the coast in the Mackenzie River Delta area. The data obtained in this study, and particularly those on storm surges, are to be used in the fine adjustment of the numerical model described by Henry, (1975).

1357 JOHNSON, G.L. - 1975
Marine Research, Results of the National Research Program; *Arctic Bull.*, vol. 2, no. 8, pp. 42-46.

1358 MacNEILL, M.R., and GARRETT, J.F. - 1975
Open water surface currents in the southern Beaufort Sea; Beaufort Sea Technical Report No. 17, December 1975, 113 p.

The most important aspect of the oceanography of the sea to affect drilling will probably be the movement of water and ice - critical to the prediction of oil movement in the case of a spill and also crucial to the determination of safe drilling methods. Consequently, it was essential to have a greater knowledge of the surface currents in the region of the Beaufort Sea likely to be affected by oil drilling. The chief objective of this study was to determine an overall picture of the offshore near-surface circulation in the Beaufort Sea south of the polar pack from Herschel Island to Cape Dalhousie using the direct observations of drifting drogues. This involved covering a very large geographical area in a limited length of time so that a technique for tracking drogues over a large area using aircraft was evolved.

The overall circulation picture is the result of many factors on several different time scales and it has been the intention of the study to achieve some understanding of the effect of wind, tides, fresh water discharge and pressure fields on the surface currents (1) in the long-term mean over the several months of the study; (2) in day to day variations; (3) in shorter time scale changes in the regime of hours. With the increased understanding of the near-surface currents, an attempt has been made to provide some predictions of the possible and probable movements of oil and ice, and to estimate some of the possible dangers involved in offshore drilling.

1359 McPHEE, M.G. - 1975
The effect of ice motion on the mixed layer under arctic pack ice; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 30, pp. 1-27.

This paper documents the response of the Arctic mixed layer to synoptic weather events during March and April 1972 and indicates how measurements now in progress at four manned drift stations will be used for similar studies.

Time histories of ice motion, rate of working, mixed layer depths, and density, along with the density structure of the upper pycnocline, are presented for the period 24 March - 28 April 1972. Twice during these five weeks the mixed layer rather abruptly shallowed to 30 m and then deepened to 45 m, events which were preceded by ice drift speeds of 15-20 km per day. Since ice growth was small during the period and the speed of the ice relative to the ocean was carefully observed, it was hoped that the measurements might provide useful data on the amount of turbulent energy available for entrainment during the deepening phase of a simple one-dimensional mixed layer model. With this in mind we examined one event closely by comparing the work done by the ice, as inferred from direct Reynolds stress measurements in the oceanic boundary, with changes in the potential energy of the top 60 m of the ocean.

It could be argued from the results that the potential energy increase, which was approximately 10% of the work done, was due to entrainment by mechanical stirring. However, other evidence, including turbulent energy measurements, implies that convergence of mass along the upper layers of the pycnocline in response to Ekman divergence (ice stress curl) near the surface was responsible for the changes, and this hypothesis in conjunction with atmospheric pressure maps is shown to explain qualitatively the subsequent rapid shallowing. This phenomenon, during which the mixed layer thickness decreased by about 10 m in 10 hours, gave rise to appreciable baroclinic currents at depths of 30-60 m. A rapid deepening occurred two days later, causing currents in the opposite sense, and the whole sequence seems to be closely connected to a relatively intense "eddy," documented by Hunkins, localized at about 100 m depth.

Finally, the notion is advanced that synoptic-scale changes in a well-developed mixed layer are dominated by surface-stress curl rather than by mechanical stirring, and a rudimentary outline is given for using the AIDJEX ice model to predict mixed layer characteristics.

1360 McPHEE, M.G. - 1977
A simulation of inertial oscillations observed in the drift of manned ice stations; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 36, pp. 65-85.

A simple model for simulating the motion of pack ice during periods of energetic inertial oscillation is developed by writing an integrated momentum equation for the ice-upper ocean system driven by surface wind stress. Dissipation in the system is modeled by a damping term proportional to the component of mass transport parallel to the wind stress. Ice velocity is related to total transport by considering an idealization of mean boundary layer currents measured at AIDJEX camp Jumpsuit in 1972. The model is used to simulate three periods of drift measured at AIDJEX ice stations in summer and early fall of 1975. It is shown that the model much better reproduces observed inertial velocities than does a similar "free drift" model in which the ocean exerts a passive quadratic drag. At certain times the model predicts too much amplitude for the inertial waves, and this is interpreted as indicating that the internal stress gradient in the ice is then strong enough to inhibit oscillation.

1242 MÜLLER, F., BLATTER, H., and KAPPENBERGER, G. - 1975
Remote sensing; *Ice*, no. 47, p. 6.

1243 MÜLLER, F., BLATTER, H., and KAPPENBERGER, G. - 1975
Temperature measurement of ice and water surfaces in the North Water area using an airborne radiation thermometer; *J. Glaciology*, vol. 15, no. 73, pp. 241-250.

1046 MÜLLER, F. - 1976
North Water; *Ice*, no. 50, pp. 13-14.

1047 MÜLLER, F. - 1976
Problems of an Arctic Polynya - the North Water; *in* Proc. Sym. on Geography of Polar Countries, 23rd Intern. Geographical Conference, Leningrad, U.S.S.R., 22-26 July, 1976, pp. 52-55.

1089 PELLETIER, B.R. - 1976
Outline for a marine science atlas of the Beaufort Sea; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, pp. 325-331.

1361 POUNDER, E.R. - 1976
Ice Research Project Biennial Report 1974-1976; *McGill Univ. Ice Res. Proj.*, internal report, 19 p.

The McGill group manned and operated the synoptic oceanographic programme at station SNOW BIRD, one of the three satellite stations of AIDJEX (Arctic Ice Dynamics Joint Experiment), from April 1975 to May 1976. Data collection on the whole went well despite some almost frantic improvisation as one floe broke up almost entirely and others, especially SNOW BIRD, experienced extensive cracking. Most of the analysis of AIDJEX data remains to be done.

A Kaijo Denki ultrasonic current meter was used successfully in Robeson Channel in 1975 to measure underice roughness and water stress. The average drag coefficient (at 1 m depth) was measured as 1.05 ($\pm$ 0.26) x 10^{-3}. The same equipment was used on three occasions at AIDJEX sites for periods of 2 to 4 weeks.

1362 POUNDER, E.R., LANGLEBEN, M.P., and ADDISON, J.R. - 1976
AIDJEX; *Ice*, no. 50, p. 13.

1363 ROSENEGGER, L.W. - 1975
The movement of oil under sea ice; Beaufort Sea Technical Report No. 28, December 1975, 81 p.

This report presents the results of laboratory tests to determine the interfacial tension and motion of crude oil bubbles under sea ice. Two different crude oils were used in these experiments (Swan Hills and Norman Wells). An assessment has also been made of; a) the ability of oil to penetrate sea ice from beneath, b) the equilibrium thickness of a crude oil film on water under arctic conditions, and c) the redistribution of solutes in the oil.

1364 SHIRASAWA, K., and LANGLEBEN, M.P. - 1976
Water Drag on Arctic Sea Ice; *J. Geophys. Res.*, vol. 81, no. 36, pp. 6451-6454.

A three-component ultrasonic current meter has been used to obtain measurements of current fluctuations in the frictional boundary layer under an ice cover in Robeson Channel, Northwest Territories, Canada, during July 1974. The Reynolds stress against the underside of the ice floe was computed by a time series analysis of the correlation between downflow and vertical fluctuations of current. The average water drag coefficient, referred to a depth of 1 m below the ice and based on six runs in which the mean current was in the range between 12 and 32 cm s^{-1}, was 1.05 x 10^{-3} with a probable error of $\pm$ 0.26 x 10^{-3}. Two runs, made at very low current, yielded much higher values of drag coefficient but are thought to be in error. Spectra of current velocity fluctuations, plotted as a function of frequency, approached the -5/3 slope predicted by the Kolmogoroff law. Cospectra showed no contribution to the momentum flux at frequencies above 1 Hz.

1306 STATEMAN, M.J. - 1977
Data available from the Arctic Ice Dynamics Joint Experiment as of 1 May 1977; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 36, pp. 203-210.

1365 STELTNER DEV. & MFG. CO. LTD. - 1975
Ice - 1st Time Series, Pond Inlet, N.W.T.; *Polar Cont. Shelf Proj.*, internal report, 53 p.

1366 STELTNER DEV. & MFG. CO. LTD. - 1976
Sea-ice studies on the Eclipse Sound, N.W.T. at Pond Inlet 1972-1976; *Polar Cont. Shelf Proj.*, internal report, 12 p.

1074 STELTNER, H.A.R. - 1977
Transportation of personnel, instruments and equipment on first-year sea ice for oceanographic survey and research purposes; paper presented at P.O.A.C. 77, St. John's, Nfld., Sept. 26-30.

1367 WONG, C.S., CRETNEY, W.J., CHRISTENSEN, P., and MACDONALD, R.W. - 1976
Hydrocarbon levels in the marine environment of the Southern Beaufort Sea; Beaufort Sea Technical Report No. 38, August 1976, 113 p.

This report summarizes the objectives of the project, the study area, methods, sources of data and field and laboratory results of the hydrocarbon baseline studies in the Southern Beaufort Sea during the summers of 1974 and 1975. The objectives of the investigation are: (1) to establish the baseline hydrocarbon levels in the Southern Beaufort Sea drilling area by measuring classes of hydrocarbons and identifying some specific hydrocarbons in sea water, marine organisms, fish and surface sediments, (2) to assess the origin of present day hydrocarbons, whether anthropogenic or naturally-occurring, and (3) to understand the probable hydrocarbon pathways in case an oil spill or blow-out occurs in the area. To achieve this, two cruises were conducted: a preliminary cruise on the M.V. THETA in the summer of 1974 and a major cruise on the M.V. PANDORA II in the summer of 1975, covering the summer open-waters from 139°W to 130°W and from the 10 m contour to the ice edge very close to the 100 m contour along 70.5°N to 71.5°N. Shipboard and shore-laboratory measurements of hydrocarbons were made in contaminant-free clean rooms on samples collected by hydrocarbon-free samplers. Results include polycyclic aromatic hydrocarbons and low-molecular weight hydrocarbons in sea water, polycyclic aromatic hydrocarbons and non-polar hydrocarbons in fish, mixed plankton and sediments. The baseline data show that the marine environment in Southern Beaufort Sea is clean in general. No tar or plastic wastes were collected by neuston-net tows on the surface sea water. The levels of polycyclic aromatic hydrocarbons in sea water are low, comparable in cleanliness to uncontaminated oceanic waters in N.E. Pacific Ocean. The levels of low-molecular weight hydrocarbons, with the exception of methane in near-bottom water are low or close to the detectable limits indicating the absence of petrogenic inputs. The high methane is due to natural influx from the sediment. The polycyclic aromatic hydrocarbons in marine organisms appear to be low and levels in marine sediments have a very wide range. There is a paucity of data for organisms and sediments from other world areas for a useful comparison. The non-polar hydrocarbons in fish suggest marginal presence of petroleum hydrocarbons in the tissues, taking into account the small number of samples, the biological variability and the limitation of the analytical technique used. The non-polar hydrocarbons in marine sediments show characteristics typical of a mixture of marine and terrestrial hydrocarbons, suggesting influx of terrestrial plant material via the Mackenzie River, which also flows through areas with known natural seepage and petroleum drillings.

1095 WONG, C.S., MACDONALD, D., and CRETNEY, W.J. - 1976
Distribution of tar and other particulate pollutants along the Beaufort Sea Coast; Beaufort Sea Technical Report No. 13, March 1976, 96 p.

OIL SPILLS

0925 ADAMS, W.A. - 1975
Light intensity and primary productivity under sea ice containing oil; Beaufort Sea Technical Report No. 29, December 1975, 176 p.

0935 BUNCH, J.N., and HARLAND, R.C. - 1976
Biodegradation of crude petroleum by the indigenous microbial flora of the Beaufort Sea; Beaufort Sea Technical Report No. 10, March 1976, 52 p.

0941 GERACI, J.R., and SMITH, T.G. - 1976
Direct and indirect effects of oil on ringed seals (*Phoca hispida*) of the Beaufort Sea; *J. Fish. Res. Board Can.*, vol. 33, pp. 1976-1984.

0949 HSIAO, S.I.C. - 1976
Biological productivity of the southern Beaufort Sea: photoplankton and seaweed studies; Beaufort Sea Technical Report No. 12c, March 1976, 99 p.

1368 LOGAN, W.J., THORNTON, D.E., and ROSS, S.L. - 1975
Oil spill countermeasures for the southern Beaufort Sea; Beaufort Sea Technical Report No. 31a, December 1975, 126 p.

This report discusses the feasibilities of controlling and cleaning up an oil spill in the Beaufort Sea as a result of an exploratory well blowout. It is likely that, in waters with up to 10% ice concentrations, currently available oil spill countermeasures equipment and techniques could be employed in sea conditions up to Beaufort 3. No equipment is available for use in higher sea conditions. If the blowout were to occur in the landfast ice zone, oil that would accumulate at the under-ice surface during winter could be incinerated in place when the oil migrates to the ice surface in the springtime. No viable techniques or proven countermeasures equipment are available for use in the seasonal pack, shear zone and the polar pack zone. The cleanup and restoration of oil contaminated shorelines would be limited to sand beaches and to a lesser extent, shingle beaches, which together comprise 37% of the Beaufort Sea shoreline. Remote sensing of oil spills, although untried in the arctic environment, would be limited to periods of good visi-

bility. In general, the logistical base required to support an effective oil spill countermeasures operation is not available in the areas adjoining the Beaufort Sea.

1369 LOGAN, W.J., THORNTON, D.E., and ROSS, S.L. - 1975
Oil spill countermeasures for the Beaufort Sea Appendix; Beaufort Sea Technical Report No. 31b, December 1975, 102 p.

The findings of the Environmental Protection Service's portion of the Beaufort Sea Project (Oil Spill Countermeasures) are presented in two volumes - Technical Reports 31a and 31b. Technical Report 31a contains the summary information. Technical Report 31b contains the details of the information presented in 31a and should be regarded as the appendix to that report. The abstract pertinent to the combined report is described in 1368 above.

1358 MacNEILL, M.R., and GARRETT, J.F. - 1975
Open water surface currents in the southern Beaufort Sea; Beaufort Sea Technical Report No. 17, December 1975, 113 p.

1370 MARKO, J.R. - 1975
Satellite observations of the Beaufort Sea ice cover; Beaufort Sea Technical Report No. 34, December 1975, 137 p.

Using the NOAA and ERTS series of satellites, observations of the Beaufort Sea and encompassing Canada Basin ice cover have been carried out for the March through October periods of the years 1973-5. The seasonal trends in motion and appearance over each of these years were detailed for the defined landfast-ice, transition and gyral pack zones. The positionings of the summer ice pack boundaries, the leads at the edge of the landfast-ice and other surface features were determined. A systematic eastward progression of north-south leads was seen to be an early step in the spring break-up process. The close association of the individual steps in this progression with easterly wind allignments suggested the over-riding importance to a given ice configuration of the immediately preceding and contemporary atmospheric pressure patterns.

The ubiquitous presence of rectilinear leads in the gyral pack zone, sometimes arranged in macro-scale patterns of great extent and spatial periodicity, was discovered. These were found to be associated with localized, long period or monotonic shearing displacements. Arguments are given in support of the proposition that these features are produced by current shears in the surface water layer associated with propagating planetary waves. Consideration is given to alternative interpretations, specifically including the possibility that the observed patterns represent massive scale strike-slip faulting.

Observations of the patterns of movement of the turbid Mackenzie River water and smaller ice floes were used to determine the extent and directionality of the river's low salinity water distribution and the peculiarities of individual surface flow features such as the Herschel Island convergence. Relatively general studies of the relationship between isolated floe motion and wind were in basic agreement with the results of other workers. An observed anomalous wavelength dependence in the turbid-water reflected-light levels was attributed to the presence of a characteristic formation of thin cloud.

The data on ice movement and positioning in the landfast-ice and transition zones indicated the proposed 1976 drilling sites to be decidedly non-optimum locations in terms of both the likelihood of single-year drilling success and the minimizing of environmental damage from a possible blow-out. A scenario of oil pollutant transport is offered on the basis of the observed surface movements which, in the proposed drilling area, often averaged 5 to 10 km/day. Further data on these motions in the winter darkness period is required and should be available shortly from longer wavelength infrared satellite imagery.

1371 MILNE, A.R., and SMILEY, B.D. - 1976
Offshore drilling for oil in the Beaufort Sea, a preliminary environmental assessment; Beaufort Sea Technical Report No. 39, January 20, 1976, 43 p.

This ASSESSMENT of 20 January, 1976 has been prepared by the staff of the Beaufort Sea Project Office. The contents attempt to reflect faithfully the essence of the technical reports of the Beaufort Sea Project, and where these were not available, the valued distillations from communications with Project Investigators. Acknowledged is the assistance given by the Steering Committee and the Advisory Committee of the Beaufort Sea Project.

Drilling for oil using ice-strengthened drill ships is proposed for ice-free periods starting in the summer of 1976 at two sites. These sites, shown in Figure 1, are inaccessible during the winter and spring to any existing drilling systems. The scale of activities for 1976 is small, therefore the only really major impact on the environment would result from oil discharged into the sea in the event of an underwater blowout. Although the possibility of a blowout occurring is remote, it cannot be ignored. There is a whole series of possibilities and conditions that will determine the severity of the impact of a blowout on the environment.

This report is an *environmental assessment* and by assuming hypothetical oil well blowout scenarios, examines the nature of the transport and fate of oil in the Beaufort Sea and draws conclusions regarding the impact of the oil on the environment, including climate, seabirds, marine mammals and other marine organisms.

0969 NORCOR ENGINEERING AND RESEARCH LIMITED - 1975
The interaction of crude oil with arctic sea ice; Beaufort Sea Technical Report No. 27, December 1975, 202 p.

1089 PELLETIER, B.R. - 1976
Outlinefor a marine science atlas of the Beaufort Sea; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, pp. 325-331.

0972 PERCY, J.A., and MULLIN, T.C. - 1975
Effects of crude oils on arctic marine invertebrates; Beaufort Sea Technical Report No. 11, December 1975, 167 p.

0973 PERCY, J.A. - 1976
Responses of arctic marine crustaceans to crude oil and oil-tainted food; *Environ. Pollut.*, vol. 10, pp. 155-162.

1363 ROSENEGGER, L.W. - 1975
The movement of oil under sea ice; Beaufort Sea Technical Report No. 28, December 1975, 81 p.

0986 SMITH, T.G., and GERACI, J.R. - 1975
The effect of contact and ingestion of crude oil on ringed seals of the Beaufort Sea; Beaufort Sea Technical Report No. 5, December 1975, 66 p.

1372 TOPHAM, D.R. - 1975
Hydrodynamics of an oilwell blowout; Beaufort Sea Technical Report No. 33, December 1975, 52 p.

Two aspects of an under sea oil well blowout have been investigated experimentally. Firstly a full scale blowout was simulated by pumping the equivalent of up to 27 m^3/min of air at atmospheric pressure down to depths of 60 m and 23 m of seawater and measuring the induced flow patterns. These were similar in all cases, a central rising plume with a surface radial flow at the point of impingement. A striking feature of the radial flow pattern was a ring of waves concentric with the plume centre. This marks a division in the directions of the surface radial currents, outwards within, and inwards beyond the ring. This flow system would provide a certain amount of natural containment for the oil.

Secondly, an experiment was carried out to investigate the possibility of stable emulsions being formed close to the well exit. Mixtures of oil and gas were injected under water with appropriate velocities through a common pipe exit. Two specific oils were used to represent extremes of the types expected in the Beaufort Sea; one was known not to form stable emulsions and the other thought likely to form stable water-in-oil emulsions. In both cases the oil was shattered into droplets within a short distance of the pipe exit, with the major part of the oil in droplets 1 mm in diameter. A small proportion, of the order of 1%, was in droplets of 50 microns or less in diameter.

Most of the oil will reach the surface as 1 mm diameter droplets and be swept radially outwards by the induced surface currents and coalesce on the surface within the wave ring. After a critical depth is exceeded the oil will overcome the retaining flows and collect beyond the wave ring. The smaller drops may be carried down to depths of up to 10 m in the case of a 60 m plume and if released into a current would be carried several kilometers downstream.

1373 WADHAMS, P. - 1975
Sea ice morphology in the Beaufort Sea; Beaufort Sea Technical Report No. 36, December 1975, 66 p.

The topography of the Beaufort Sea ice cover has been examined for the summer of 1974 and the early spring of 1975. Airborne laser profiles obtained in September and October 1974 by the Atmospheric Environment Service were analysed, and additional flights were carried out in April, 1975 using an Argus aircraft of Maritime Command. Mean ridge heights and spacings were deduced for the elements of a grid covering much of the Beaufort Sea: in summer the mean ridge height increased linearly with the ridge frequency. For higher ridges the distributions of ridge heights in both seasons followed an identical empirical law of form $P(h) = A \exp(-Bh)$. This law was used together with ice drift information to predict extreme values of ridge height for different time intervals and spatial areas. Tentative predictions of extreme keel draft were made using reasonable factors for freeboard to draft conversion, and compared with depths at which scouring is found on the Beaufort Sea Shelf. A longitudinal profile of a sheer ridge obtained in 1972 by an unmanned arctic research submersible (UARS) of the University of Washington has been analyzed in an attempt to predict the minimum and maximum depths to be expected in a given keel linkage of known mean depth. On the basis of these and other studies of the Beaufort Sea Project a discussion is given of the extent to which sea ice deformation features may govern the long-term spread of oil under ice.

1094 WADHAMS, P. - 1976
Oil and ice in the Beaufort Sea; *Polar Record*. vol. 18, no. 114, pp. 237-250.

1059 WALKER, E.R. - 1975
Oil, ice and climate in the Beaufort Sea; Beaufort Sea Technical Report No. 35, December 1975, 40 p.

1367 WONG, C.S., CRETNEY, W.J., CHRISTENSEN, P., and MACDONALD, R.W. - 1976
Hydrocarbon levels in the marine environment of the southern Beaufort Sea; Beaufort Sea Technical Report No. 38, August 1976, 113 p.

SEA ICE RESEARCH

1374 ANONYMOUS - 1975
Ice cracks upset activities at AIDJEX main camp; *Arctic Bull.*, vol. 2, no. 7, pp. 38-40.

A series of cracks in the ice floe supporting the Big Bear main camp of the Arctic Ice Dynamics Joint Experiment (AIDJEX) during October 1975 forced closure of the camp and relocation of operations to Caribou, formerly a satellite camp. Big Bear was 723 kilometers east northeast of Barrow, Alaska (near 73°41'N., 137° 44'W.), and Caribou was 80 km west southwest of Big Bear (near 73°25'N., 139°57'W.).

1207 ANONYMOUS - 1976
AIDJEX Main Experiment Completed; *Arctic Bull.*, vol. 2, no. 9, p. 165.

0929 APOLLONIO, S. - 1961
The Chlorophyll Content of Arctic Sea Ice; *Arctic*, vol. 14, no. 3, pp. 197-199.

0930 APOLLONIO, S. - 1965
Chlorophyll in Arctic Sea Ice; *Arctic*, vol. 18, no. 2, pp. 118-122.

1339 BANKE, E.G., and SMITH, S.D. - 1975
Measurement of form drag on ice ridges; *AIDJEX Bull.*, No. 28, pp. 21-27.

1340 BANKE, E.G., SMITH, S.D., and ANDERSON, R.J. - 1976
Recent measurements of wind stress on Arctic sea ice; *J. Fish. Res. Board Can.*, vol. 33, no. 10, pp. 2307-2317.

1341 BANKE, E.G., SMITH, S.D., and ANDERSON, R.J. - 1976
Wind stress measurements over Arctic sea ice; *Ice*, no. 50, pp. 12-13.

1209 CAMPBELL, W.J., WEEKS, W.F., RAMSEIER, R.O., and GLOERSEN, P. - 1975
Geophysical studies of floating ice by remote sensing; *J. Glaciology*, vol. 15, no. 73, pp. 305-328.

1210 CAMPBELL, W.J., GLOERSEN, P., WEBSTER, W.J., WILHEIT, T.T., and RAMSEIER, R.O. - 1976
Beaufort Sea Ice Zones as delineated by microwave imagery; *J. Geophys. Res.*, vol. 81, no. 6, pp. 1103-1110.

1211 CARSEY, F.D. - 1976
The AIDJEX acoustic radar and some preliminary results; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 31, pp. 1-19.

1375 COON, M.D., and EVANS, R.J. - 1975
On wind-induced cracking of sea-ice sheets; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 29, pp. 131-134.

The assumption that the ice is rigid is unreasonable. A first approximation to its actual behavior is that of a floating elastic plate, and there is overwhelming evidence to support such an assumed behavior. As will now be shown, the incorporation of elastic flexural behavior into the analysis of the ice considerably changes the conclusions to be drawn.

1376 COOPER JR., P.F. - 1975
Movement and deformation of the landfast ice of the southern Beaufort Sea; Beaufort Sea Technical Report No. 37, December 1975, 16 p.

Every year extensive landfast ice develops along the southern coast of the Beaufort Sea. This formation is considerably more stable north and east of the Mackenzie River Delta and southeast of Herschel Island than it is in between these two areas. Yet even in these apparently stable regions observations indicate that the ice surface moves a considerable distance during a typical winter.

Measurements carried out in the winter of 1969 indicate that ice in the centre of the mouth of Kugmallit Bay, north of Tuktoyaktuk, can move as much as 17 m northward over the period mid-January to mid-May. Results from succeeding years confirm the occurrence of similar movements in the landfast ice of that region. More recently a strain gauge has been developed to observe strains in the ice surface of the order of one part in 10^{-5} or more. Such gauges have detected strain, presumably elastic, on the landfast ice in the open ocean north of Tuktoyaktuk. In two winters, 1972-73 and 1974-75, they have been applied to look for small-scale deformation southeast of Herschel Island. In 1973, crude observations there indicated the presence of changes on a time scale of several months. More satisfactory measurements, made in the winter of 1975 show; a) an apparent overall contraction of the ice surface south of Herschel over the period from early April to late May, as well as, b) an expansion in a direction roughly parallel to the prevailing winds which is coupled with a contraction in the perpendicular direction. These effects were observed on scales of both 30 metres and 1 to 2 kilometres. In all cases the strains were of the order of a few parts in 10^{-4}, of comparable magnitude to those found earlier in Kugmallit Bay.

1377 DIXIT, B., and POUNDER, E.R. - 1975
The specific heat of saline ice; *J. Glaciology*, vol. 14, no. 72, pp. 459-465.

A calorimetric experiment was performed to determine empirically the dependence of the specific heat of ice with salinity 0-10 $^{o}/_{oo}$ over the temperature range from -23°C to the melting point. The experimental results agree with the theoretical model determined by Schwerdtfeger (1963) for calculating the specific heat except within several degrees of the melting point and for very pure ice.

1086 HOBSON, G.D. - 1976
Measuring Arctic ice - a joint experiment; *GEOS*, Fall 1976, pp. 15-17.

1378 ITO, H. - 1975
Sea ice dynamics; *Ice*, no. 47, p. 11.

1379 ITO, H., and MÜLLER, F. - 1976
Horizontal movement of fast ice in the North Water Area; presented at Symposium on Applied Glaciology, Cambridge, September 1976, 18 p.

The understanding of the horizontal movement of fast ice is important for applied sea ice mechanics. A case study, carried out in conjunction with a polynya known as North Water, is presented in this paper. The displacements of the fast ice arches, which separate the polynya from the surrounding ice-covered sea, were measured and found to be small. It is, therefore, confirmed that these arches prevent the influx of large quantities of sea ice into the polynya. The results are then explained

in terms of the external forces (wind and current), the strain-stress situations and some physical characteristics (temperature and thickness) which were measured simultaneously.

1347 JOHNSON, A. - 1976
First Data Report; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 32, 71 p.

1283 KOERNER, R.M. - 1963
Glaciology, winter 1961-62 (The Devon Island Expedition 1960-64); *Arctic*, vol. 16, no. 1, pp. 57-62.

1380 LEAVITT, E., BELL, D., CLARKE, M., ANDERSEN, R., and PAULSON, C. - 1977
Computation of air stress and sensible heat fluxes from surface layer profile data, AIDJEX, 1975; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 36, pp. 157-174.

During spring 1975, mean atmospheric surface layer profiles of wind and temperature were measured at the Big Bear camp of AIDJEX. Surface air stress and sensible heat flux have been computed from these profiles. The mean 10 m drag coefficient is 1.2×10^{-3}, but there is a significant variation of 40% in the coefficient which correlates with wind direction.

1381 LINDSAY, D.G. - 1975
Sea-ice Atlas of Arctic Canada, 1961-68; *Polar Cont. Shelf Proj.*, Infor. Can. Cat. No. M78-4/1975, 213 p.

The results of aerial sea ice observations made by the Polar Continental Shelf Project, Department of Energy, Mines & Resources, at various intervals between March and November, from 1961 through 1968 are shown in this atlas. Most of the observations were made in Parry Channel, and in the general region of the Queen Elizabeth Islands and adjacent Arctic Ocean.

The atlas shows the geographical distribution and extent of the various types of sea ice, and their characteristic features at different specific and identified times throughout the years. The observations recorded on each map were made over as short a period as operationally feasible - usually three to eight days - in order to give a more or less simultaneous overall view of the state and extent of sea ice over the Canadian arctic at selected intervals. The atlas is thus an historical record of the sea ice since 1961; it also provides sequential observations on the dynamic and constantly changing phenomena which dominate the marine areas of arctic Canada.

The basic purpose of the atlas is to make available, in comprehensive cartographic form, the reliable information available about the sea ice in the areas covered, for the periods indicated. The information on the maps has been analysed, interpreted and connected by written descriptions which synthesize the major features of the sea ice cover at the times portrayed and describe the geographical and chronological changes throughout each season; - the progression of break-up, the process of ablation, the pattern of movement and the sequence of freeze-up. It is hoped that this description will increase the usefulness of the information shown on the maps and add to the understanding of the significance of changes or similarities between successive maps or between different years. Such understanding should add to our knowledge of sea ice behaviour and our ability to forecast its extent and characteristics. Another part of the text describes briefly the route taken by the observers, and the observing conditions at the time, so that the reliability and extensiveness of the observations can be assessed if necessary, and information from other sources can be compared or amalgamated with that given here.

The maps comprising the atlas have been arranged in sequence from 1961 to 1968. A seasonal summary is used to introduce each year and the written description for each map faces the map to which it refers. The various types of sea ice information are shown by a combination of colours, line patterns, symbols and numerical expressions.

It is intended that this atlas will be followed by others showing sea ice information obtained since 1968.

1382 LINDSAY, D. - 1977
Patterns of break-up, freeze-up and surface roughness of sea ice in selected channels in the Canadian Arctic; *Polar Cont. Shelf Proj.*, 45 p.

This brief description of the patterns of ice break-up, freeze-up and surface roughness for selected channels in the Canadian Arctic was prepared for the Polar Continental Shelf Project. It is not intended to be a definitive report. Its purpose is to generalize and indicate the typical trends. The Polar Continental Shelf Project has collected a large quantity of detailed information on sea ice conditions during consecutive seasons from 1961 through 1976 and this program is continuing. These records can provide the conscientious user with a great deal of information that, for simplicity, is not included in this summary.

The area considered for this study was selected because of the current interest in these channels. Similar information is available for all channels in the Canadian Arctic.

1043 MARKHAM, W.E. - 1975
Ice climatology in the Beaufort Sea; Beaufort Sea Technical Report No. 26, December 1975, 87 p.

1370 MARKO, J.R. - 1975
Satellite observations of the Beaufort Sea ice cover; Beaufort Sea Technical Report No. 34, December 1975, 137 p.

1383 MAYKUT, G.A. - 1975
Ice Island Reconnaissance - Beaufort Sea; *Ice*, no. 49, pp. 19-20.

1162 McCANN, S.B., and TAYLOR, R.B. - 1975
Beach freezeup sequence at Radstock Bay, Devon Island, Arctic Canada; *Arctic and Alpine Res.*, vol. 7, no. 4, pp. 379-386.

1360 McPHEE, M.G. - 1977
A simulation of inertial oscillations observed in the drift of manned ice stations; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 36, pp. 65-85.

1247 OVERTON, A. - 1976
Ice reconnaissance on the Beaufort Sea; *in* Report of Activities, Part A; Geol. Surv. Can., Paper 76-1A, p. 419.

0969 NORCOR ENGINEERING AND RESEARCH LIMITED - 1975
The interaction of crude oil with arctic sea ice; Beaufort Sea Technical Report No. 27, December 1975, 202 p.

1089 PELLETIER, B.R. - 1976
Outline for a marine science atlas of the Beaufort Sea; *in* Report of Activities, Part C; Geol. Surv. Can., Paper 76-1C, pp. 325-331.

1384 PRITCHARD, R.S. - 1976
An estimate of the strength of arctic pack ice; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 34, pp. 94-113.

During February 1976 strong surface winds (up to 7 m s^{-1}) across the AIDJEX array were unable to move the pack ice. By estimating all forces acting on the ice we have determined a lower bound for the yield strength if a plastic ice model such as the AIDJEX model is to simulate the observed conditions. The best estimate is that yield strength in isotropic compression is at least 1.0×10^8 dyn cm^{-1} and in pure shear it is at least 2.7×10^7 dyn cm^{-1}. These results allow us to check parameters in the AIDJEX ice model that affect the strength and to modify the model so that it can simulate these observed conditions better.

1385 PRITCHARD, R.S., COON, M.D., and McPHEE, M.G. - 1976
Simulation of sea ice dynamics during AIDJEX; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 34, pp. 73-93.

A mathematical model is used to simulate sea ice conditions observed during 15-25 May 1975 as part of the Arctic Ice Dynamics Joint Experiment. Calculated motions and forces within the region are compared with observed values. Ice velocity and tractions exerted on the upper and lower ice surface compare well with observed values. Results of another calculation using different boundary layer parameters help assess the effect of boundary layer models on the computed ice drift. The calculated strain field does not compare with observed strains well enough to allow prediction of stress in the pack ice. Several sources of error have been identified for future study.

1251 RAMSEIER, R.O., VANT, M.R., ARSENAULT, L.D., GRAY, L., GRAY, R.B., and CHUDOBIAK, W.J. - 1975
Distribution of the ice thickness in the Beaufort Sea; Beaufort Sea Technical Report No. 30, December 1975, 98 p.

1252 RAMSEIER, R.O. - 1976
Remote sensing of floating ice; *Ice*, no. 50, p. 13.

1253 RAMSEIER, R.O., GRAY, L., and CAMPBELL, W.J. - 1977
Scatterometer and imaging radar results obtained over Big Bear, AIDJEX 1975; presented at "Symposium on Sea Ice Processes and Models", Seattle, Wash., September 1977, 10 p.

1386 RIGBY, F.A., and HANSON, A. - 1976
Evolution of a large arctic pressure ridge; *AIDJEX Bull.*, Univ. Wash., Seattle, No. 34, pp. 43-71.

Extensive mass balance and structural observations were carried out on a large (10-12 m) pressure ridge during the summer of 1975 at the AIDJEX main camp. The authors drilled a large number of holes through the ridge and, by redrilling previously drilled areas and by monitoring thickness gauges, were able to examine ridge development over a period of several months. Some vertical temperature profiles were taken. The mass loss from the ridge bottom proved to be several times that from the undeformed ice, apparently resulting as much from mechanical erosion as from melting. The lateral extent of the keel was substantially greater than that of the sail and the pattern of isostatic compensation of the ridge changed with time.

1364 SHIRASAWA, K., and LANGLEBEN, M.P. - 1976
Water Drag on Arctic Sea Ice; *J. Geophys. Res.*, vol. 81, no. 36, pp. 6451-6454.

1387 SOBCZAK, L.W. - 1977
Ice movements in the Beaufort Sea 1973-1975: determination by ERTS imagery; *J. Geophys. Res.*, vol. 82, no. 9, pp. 1413-1418.

Remote sensing (ERTS) imagery has been used to map the distribution of leads in the sea ice over the Beaufort Sea during late February through early April in 1973, 1974 and 1975. A comparison of the bearings and speeds of ice movements obtained from ERTS-based maps with those of geostrophic winds calculated from average daily and weekly atmospheric pressure charts indicates that the ice drifts at about 1/100 of the speed of the geostrophic winds in a direction about 20° to the left of them. During early March 1973, before excessive ice break-up, the sea ice moved slowly, about 0.3 km/d, but during periods of rapid ice fracturing (March and April 1975) the sea ice moved at rates as high as 18.2 km/d.

1306 STATEMAN, M.J. - 1977
Data available from the Arctic Ice Dynamics Joint Experiment as of 1 May 1977; *AIDJEX Bull.*, Univ. Wash., Seattle, no. 36, pp. 203-210.

1365 STELTNER DEV. & MFG. CO. LTD. - 1975
Ice - 1st Time Series, Pond Inlet, N.W.T.; *Polar Cont. Shelf Proj.*, internal report, 53 p.

1366 STELTNER DEV. & MFG. CO. LTD. - 1976
Sea-ice studies on the Eclipse Sound, N.W.T. at Pond Inlet 1972-1976; *Polar Cont. Shelf Proj.*, internal report, 12 p.

1074 STELTNER, H.A.R. - 1977
Transportation of personnel, instruments and equipment on first-year sea ice for oceanographic survey and research purposes; paper presented at P.O.A.C. 77, St. John's, Nfld., Sept. 26-30.

1388 TAYLOR, R.B. - 1976
Sea ice ridges, Somerset Island; *Ice*, No. 50, p. 13.

1389 TROWBRIDGE, R. - 1976
The Arctic Ice Dynamics Joint Experiment (AIDJEX); *Naval Res. Reviews*, May 1976, pp. 8-17.

The Arctic Ice Dynamics Joint Experiment (AIDJEX) is a U.S. - Canadian cooperative research program aimed at advancing man's understanding of the large-scale response of sea ice to its environment. It is highly focused and coordinated program of data acquisition and mathematical modeling. It's specific purpose is to find a quantitative relationship between large-scale stress and strain fields in sea ice. The state of stress in the ice and the ice velocity fields can be determined given suitable methods of determining the external stresses exerted on the ice by wind and water currents. From this it will be possible to interpret a synoptic atmospheric pressure map diagnostically to estimate ice convergence, divergence, or shear - information which will be needed for off-shore drilling and surface shipping in ice covered seas. Using forecasts of atmospheric pressure fields, it also should be possible to predict ice motion and stress to the extent that atmospheric pressure fields can be forecast.

1390 UNTERSTEINER, N. - 1974
Arctic Ice Dynamics Joint Experiment; *Arctic Bull.*, vol. 1, no. 4, pp. 145-159.

1391 UNTERSTEINER, N. - 1975
Arctic Ocean; *in* McGraw-Hill Yearbook of Science and Technology 1975 Review, 1976 Preview, pp. 111-115.

1263 VANT, M.R. - 1976
A combined empirical and theoretical study of the dielectric properties of sea ice over the frequency range 100 MHz to 40 GHz; Ph.D. Thesis, Carleton Univ., 438 p.

1373 WADHAMS, P. - 1975
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During the past several years the writer has been involved in a series of field projects concerned with various aspects of mapping, position fixing, and surface navigation in the Arctic. These projects have been designated Project Nord, and one of their objectives in addition to determining map errors in northern Greenland has been to ascertain the accuracy and reliability of geographic position fixes obtained by astronomic observations. Atmospheric refraction corrections applied to observed zenith angles have long been considered the largest source of error in polar astronomic observations; a previous article (3) by the writer, however, presented evidence to the effect that refraction corrections may be more reliable than generally believed. Project Nord 73 was initiated to further substantiate this evidence, and the results presented herein represent work carried out for the project in 1973 at a Canadian station on the northeast coast of Ellesmere Island.

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