ICE, OPEN WATER, AND WINTER CLIMATE IN THE EASTERN ARCTIC OF NORTH AMERICA: PART II

By **F. Kenneth Hare and Margaret R. Montgomery**

PART II: THE PATTERN OF WINTER ICE. *By Margaret R. Montgomery*

VERY little information is available on ice conditions in the Arctic seas during the months from October to May. Until recent years, when winter reconnaissance by aircraft became possible, the only records to be found were in the journals of overland travellers or in the logs of ships that had become frozen-in. None of these early observers were able to note conditions over any great distance at one time.

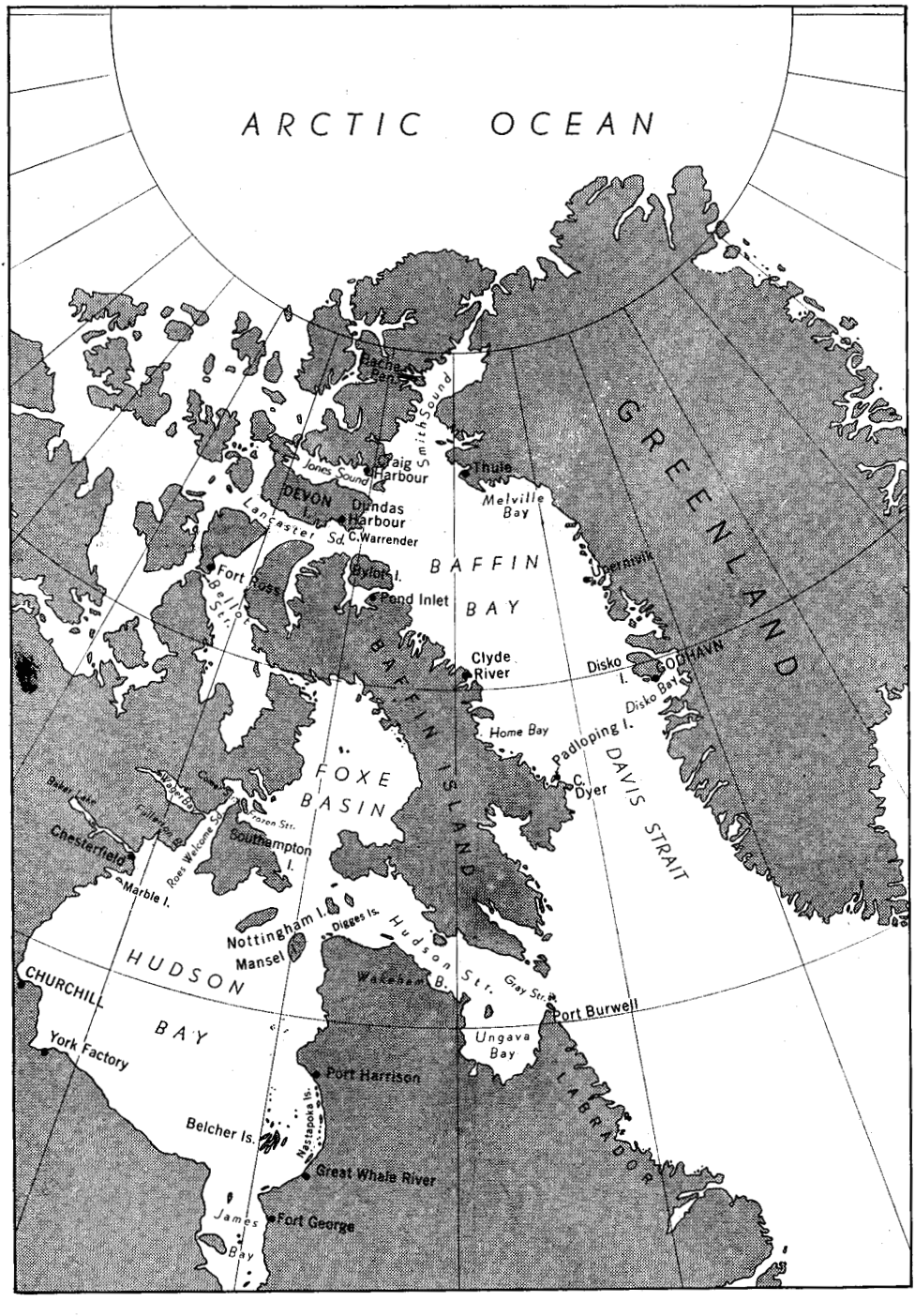
In spite of the many winter flights to Greenland during and since the last war, no reports of the ice conditions observed in Baffin Bay appear to have been published. For this region information is therefore limited to the findings recorded by observers on land and at sea. Ice reconnaissance along Hudson Strait was carried out by the Royal Canadian Air Force during an entire year in 1927-28, and similar observations were made at intervals over Hudson Bay during the winters of 1948 and 1949. The routes followed by these flights are indicated on Fig. 1. The authors have had access to the reports of all these flights and were fortunate in being observers on several of those over Hudson Bay. The photographs taken give an excellent idea of the ice conditions observed.

The following account is a summary of what is known concerning winter conditions in each of the gulfs of warmth discussed in Part I of this paper (*Arctic*, Vol. 2, No. 2, pages 79-89).

Davis Strait and Baffin Bay

A pattern of the ice distribution in Davis Strait and Baffin Bay was familiar to the whalers for over two centuries. Along the Greenland coast they could expect open water as far north as Disko Bay. From there they would work their way north and northwest, skirting the edge of the heavy ice in Melville Bay, and arrive by the end of June in the famous "North Water" between Smith, Jones, and Lancaster Sounds. Whales could usually be expected off Pond Inlet about the second week in July and the whalers would follow them down the coast along the edge of the pack ice as the currents and summer melting cleared the route south. Except for unlucky ships that became frozen-in[1] none of the whalers remained in the Bay after late summer or early autumn. They were all convinced, however, that during the winter the Greenland coast remained open possibly

[1]Smith, Charles Edward, 'From the Deep of the Sea', 1922. An account of the experiences of the whaling ship *Diana*, which became frozen-in in Baffin Bay in 1866.



as far north as Disko Island, that the North Water was never ice-bound, and that the shelf of pack ice against the east Baffin coast was impenetrable and of considerable width. From the information available at present this appears to be a fairly accurate picture.

Ice may form at the head of the south Greenland fjords in November or December but the marine approaches along the south and west coasts remain open until the heavy east-coast ice arrives in January or February. By the end of March this stream has reached its maximum extent in Baffin Bay. In the early winter months open water may reach as far north as the Melville Bay area and Mr. A. E. Porsild[2] has recently reminded us that

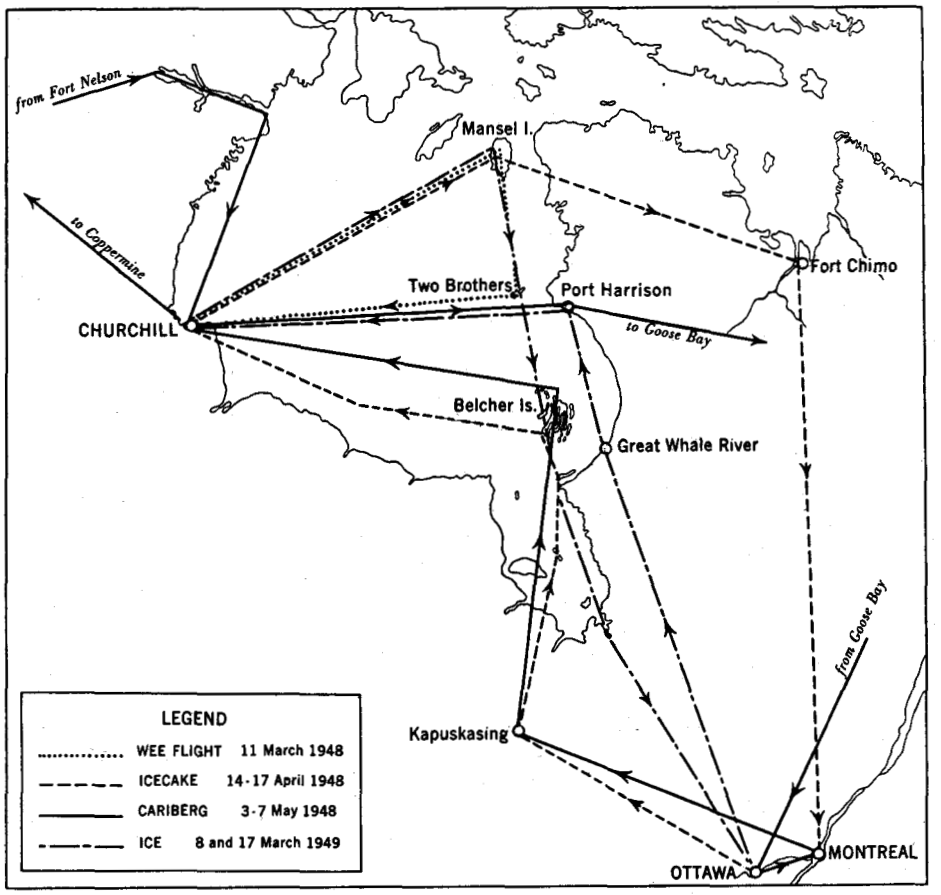


Fig. 1. Routes of ice reconnaissance flights in the winters of 1947-8 and 1948-9.

at Upernivik, nearly 73°N. latitude, cargo ships were able to unload during the Christmas week in 1942. Even when the great stream of east-coast ice moves round the tip of Greenland and up the west coast there is usually a belt of open water or loose pack between it and the heavy ice off Baffin Island.

As with other climatic phenomena there may be considerable annual variation in the amount and date of arrival of this heavy ice. During the past winter, navigation off the Greenland coast as far north as the Arctic

[2]Porsild, A. E., "The changing climate of the Arctic". *Arctic Circular* 2 (1949) p. 4.

Circle was completely ice-free even late in February. Those who were in the area are of the opinion that open water extended much farther north but that its width from the coast became rapidly narrower. This agrees very well with the *Arctic Pilot*:[3] "Between Disko bugt and Upernivik . . . the West ice is usually visible during the whole winter, and sometimes approaches the coast and freezes together with the winter ice."

Present information is not sufficient to allow us to determine if a belt of open water or loose ice extends northwesterly across Baffin Bay to Lancaster Sound. It is, however, generally recognized that there is always an ice-free area in the North Water off Smith and Lancaster Sounds. Even in the worst ice years, sailing ships such as the *Diana*[4] could always count on open water in this area. According to Dr. M. J. Dunbar[5] it is the opinion of the natives that Lancaster Sound never freezes over, or at least not solidly enough to be safe for travel. This was also the conclusion reached by the *Marion* Expedition in 1928.[6] That expedition reported that "Lancaster Sound is, however, occasionally frozen solidly from shore to shore, but at such times even the natives deem any attempt to cross to North Devon an extremely hazardous undertaking because a sudden shift of the winds or the currents may break the bridge. The neighbourhood of Cape Warrander on Lancaster Sound is said to have more open water than any other locality in Baffin Bay."

On Baffin Island the stretch between Lancaster Sound and Cape Dyer has been described as the most unexplored region of the east coast because of its barrier of ice, floe and pack. South of Cape Dyer tides and currents limit the seaward growth of the ice shelf, but north of this, shoals and coastal islands favour a wide ledge of shore ice. Against this land floe the thick, hard, heavy pack is piled up by the current. Even in July and August the *Marion* in 1928 was unable to penetrate closer than within 36 miles of the coast off Cape Dyer.[7] Dr. Boas[8] has estimated that between Bylot Island and Cape Dyer, notably off the Home Bay area, the width of the ice shelf in winter averages about 80 miles. This ice is in general rough and hummocked, with smooth surfaces only in the sheltered bays. Beyond this, there is an almost 100% cover of pack ice.

In February of 1949 some observations were made along the eastern border of this ice edge in the vicinity of 65° North and 57° West. The pack became increasingly heavy as the ship tried to force a passage

[3]*Arctic Pilot*, vol. III, 4th ed., 1947, pp. 160-61. cf. also 'The Marion Expedition to Davis Strait and Baffin Bay, 1928'. Scientific Results, Part III, Washington, 1931, p. 44.

[4]Smith, Charles Edward, op. cit.

[5]Personal letter from McGill University, dated 9 February 1949.

[6]'The Marion Expedition to Davis Strait and Baffin Bay, 1928'. Scientific Results, Part III, Washington, 1931, p. 44.

[7]Ibid, Scientific Results, Part I, Washington, 1932, p. 30.

[8]Boas, F., "The Central Eskimo", *Ann. Rep. Smithsonian Inst. Bur. Ethnology*, 6 (1884-5) p. 417.

westward. It was felt that a strongly built ship with icebreaker escort might on occasion be able to get through the outer fringe of this pack even when its ice cover was as much as 70% to 80%. It was considered doubtful if even an icebreaker could penetrate much farther under conditions of greater coverage.

A review of available information of winter conditions in Baffin Bay, therefore, shows open water extending along the Greenland coast, narrowing as it goes northward and reaching its minimum width about the month of March. Northwest, in the vicinity of Lancaster Sound, open water may be expected in all seasons. East Baffin as far south as Cape Dyer is blocked during the winter months by heavy ice which extends far over to the Greenland coast.

Hudson Strait

It is the unanimous opinion of those who have had experience in the area, that Hudson Strait never completely freezes over. Though the disposition and amount of ice may vary from place to place, from month to month and from year to year, there appears to be no record of the channel having been blocked solidly by ice throughout its entire length at the same time.

The outstanding explorers of this region such as A. P. Low[9] and Robert Bell[10] have stressed this point of view. At the Select Committee of the House of Commons in 1884, various Hudson's Bay Company officials pointed out that Eskimo from Baffin Island could only cross to the mainland trading posts on the south side of Hudson Strait about once in every ten years. Even then the crossings were always made at different places along the coast and never over solid ice but across floating pans. The Honourable W. J. Christie, testifying before this Committee[11] stated that in his experience along the Strait he had frequently seen sea smoke rising far out in the channel during the winter months. To natives and whites alike this sign was an indication of the presence of open water.

In 1927-28 the Dominion Government sent an expedition under N. B. McLean[12] to report on ice conditions during the whole year. Three stations were set up, one at Nottingham Island at the western entrance, one at Wakeham Bay in the centre, and one at Port Burwell at the eastern approaches. In addition to observations made from the shore, each base had R.C.A.F. air support and flew regular sorties over the channel. The report of this expedition is the most complete and extensive ice survey

[9]Low, A. P., 'The cruise of the *Neptune*', Ottawa, 1906, p. 292.

[10]Report of the Select Committee of the House of Commons (Canada) on "The question of the navigation of Hudson's Bay", Ottawa, 1884, p. 5.

[11]Ibid., p. 39.

[12]'Report of the Hudson Strait Expedition, 1927-28'. Dept. of Marine and Fisheries, Ottawa, 1929.

made in the Canadian Arctic. It also confirmed the report of an earlier Hudson Strait expedition under Wakeham in 1897 that the Strait is never completely closed.

In the fall, winter ice appears first in the western end of the Strait. It usually forms late in October or early in November. From then on until some time in the third week of April the shelf of fast ice around the islands in this area varies from between two to five miles. Along the coast of northwest Quebec, the land-fast ice rarely exceeds two miles in width except in the very sheltered bays. The extent of pack ice cover is greater near the western entrance than elsewhere in the straits and may vary from 50% to 95%. From the end of January to the end of May it usually averages at least 80% to 85%. This is, however, not a static condition and may change entirely from one day to the next as the ice is driven by the wind or as leads open up stretches of ice-free water. These leads may be long or short and vary from half a mile to 10 miles in width.

In the central area of the Strait off Wakeham Bay, ice forms along the coast by early November and may grow to a thickness of nearly four feet during the winter.[13] Ice in mid channel appears late in November or early December. Although periodically the area may be almost entirely covered with heavy pack, the total ice cover during any season is less complete here than at the western end. As a rule the period of closest pack occurs between the end of January and the middle of March. The ice by that time has become heavily rafted through the action of wind and tide.

Around Port Burwell ice forms along the coast in November but is liable to be constantly broken up by wind and tide and may not become solid until late in that month or even in December. When it does, it quickly grows to a depth of 20 inches or more. Thick fields of floe ice from Baffin Bay may block the channel for several days and then clear away leaving less than a 50% cover in the area. Along the eastern edge of Ungava Bay where the water is shallow, a shelf of fast ice extends out for about 8 miles. Beyond this, however, the ice never appears to consolidate and usually varies between a 60% and 80% cover. From January onwards the amount of ice in the entrance of the Strait may range from nothing to 95% or 100% depending on whether or not thick fields of Baffin Bay ice are in the vicinity.

Deep channels, such as Gray Strait north of Port Burwell and the area south of Digges Islands at the western end of Hudson Strait, are practically never covered even with loose pack during the winter months as their strong currents keep them clear. In the spring, when the ice

[13]'Report of the Expedition to Hudson's Bay and Cumberland Gulf', under the command of William Wakeham in 1897. Dept. of Marine and Fisheries, Ottawa, 1898.

begins to run freely from Foxe Basin, these channels are usually choked while the surrounding areas gradually become ice-free.

The observations of the 1927-28 expedition confirmed earlier reports of winter ice conditions in Hudson Strait.[14] The ice forms first in the west, becomes closely packed there and for months at a time is so jammed that no open water is visible from Southampton Island to beyond Nottingham Island. Elsewhere in the Strait the amount and extent of ice cover shows great variation with place and time. In general however, during the winter months it tends to decrease as one goes eastward. North of Port Burwell conditions are greatly dependent on the flow of ice from Baffin Bay.

Hudson Bay

Until recently it was generally accepted that the central part of Hudson Bay never freezes over. This opinion has persisted for many years even among explorers and scientists familiar with the region.[15] A. P. Low in his report of 'The cruise of the *Neptune*', (1906, p. 292) states that "The main body of Hudson bay does not freeze solid, and the same may be said of Hudson strait." He adds that "Although this is the case, these waters are quite unnavigable for ordinary ships during the winter and spring months owing to the great sheets of heavy ice borne backwards and forwards by the tides and currents". . . . Similarly the *Arctic Pilot*[16] states "In general the ice is about 3 to 4 feet . . . in thickness, and extends off the east shore for 60 or 70 miles to include the islands" while "in the remainder of the bay [it extends only] from one to 5 miles. During the winter this shore ice is broken up from time to time by gales into large floes." Such opinions were constantly repeated by those who gave evidence to the House of Commons Committee on "The question of the navigation of Hudson's Bay" in 1884.[17]

Recent R.C.A.F. reconnaissance flights during the winter months of 1948 and 1949 have shown a very different picture. Around the edge of the Bay is a shelf of land-fast ice which varies in width according to the depth of water, the outline of the coast, and the general configuration of the bottom. Beyond this fast ice usually lies the open water of the shore lead or a stretch of brash ice. According to the direction of the wind this area varies in width anywhere from about a mile or a mile and a half to 30 or 40 nautical miles across. Beyond this, the centre of the Bay is frozen solid.

[14]'Report of the second Hudson's Bay Expedition', under the command of Lieut. A. R. Gordon, 1885. Dept. of Marine and Fisheries, Ottawa, 1898.

[15]Although it became known during the war, as a result of air activity in the winter, that large parts of Hudson Bay were frozen over, no systematic work had been done to determine the extent or date of this cover.

[16]*Arctic Pilot*, vol. III, 4th ed., 1947, p. 54.

[17]Report of the Select Committee of the House of Commons, op. cit.

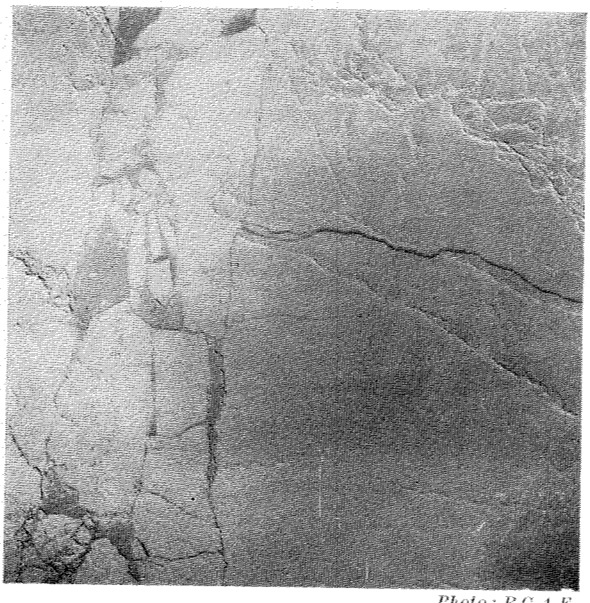


Photo: R.C.A.F.

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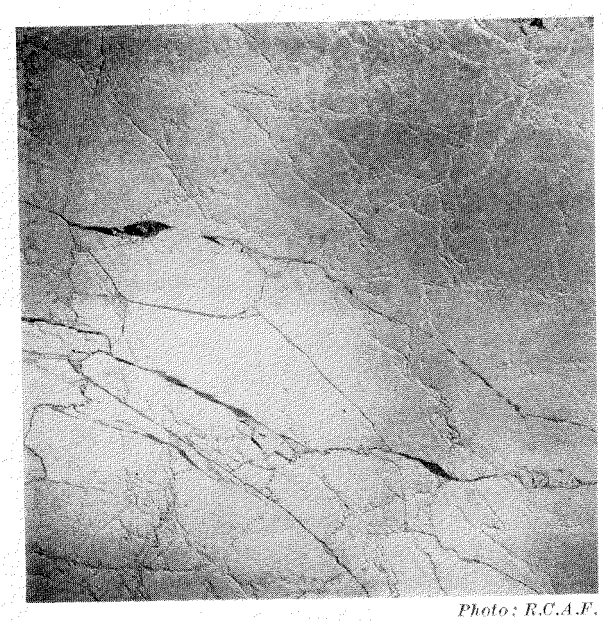
Vertical photographs taken at 20-minute intervals across Hudson Bay between Port Harrison and Churchill on 8 March 1949.



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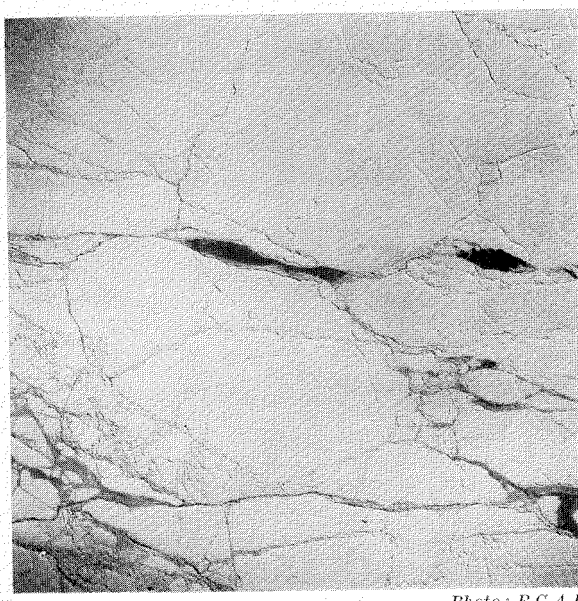

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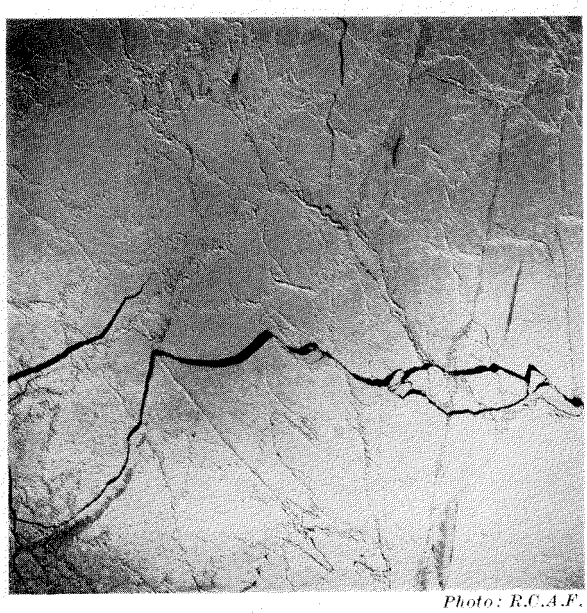

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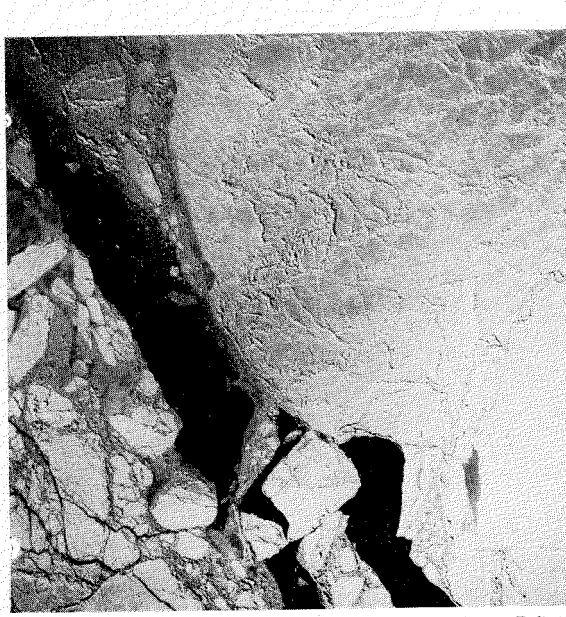

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Vertical photographs taken at 20-minute intervals across Hudson Bay between Port Harrison and Churchill on 8 March 1949.

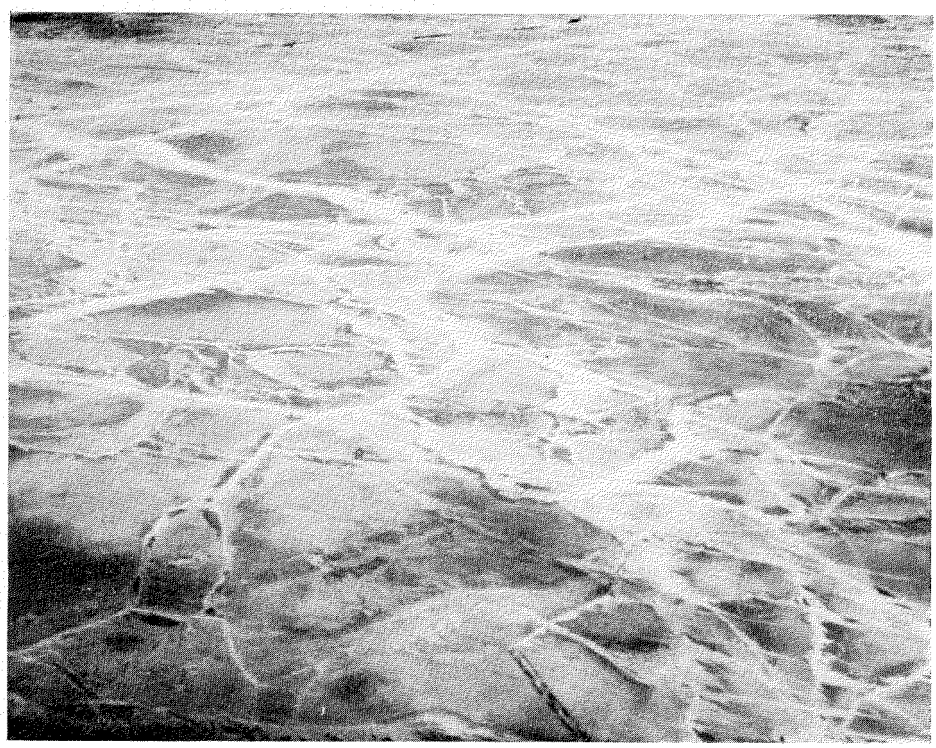

Photo: R.C.A.F.
Windswept surface of close pack ice towards the centre of Hudson Bay, 6 May 1948.

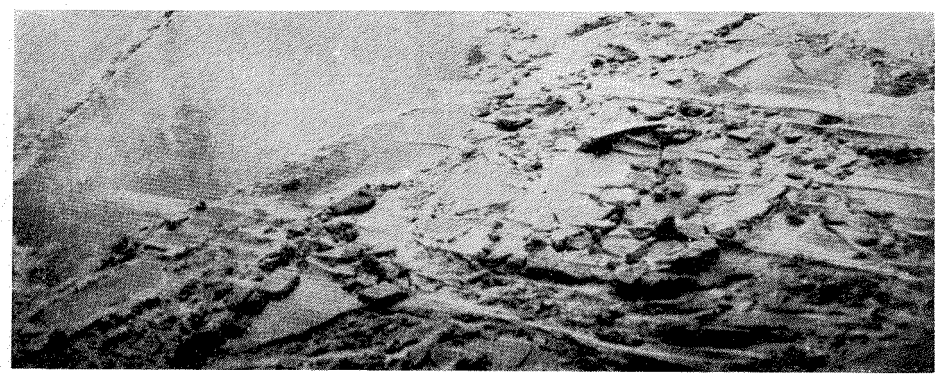

Photo: R.C.A.F.
Detail of rafted ice in central area of Hudson Bay, 6 May 1948.

Photographs taken in the early spring months of 1948[18] when the snow cover was disappearing along the floe edge show that this solid ice sheet over the centre of the Bay is formed originally of large and small pans which may have broken-up many times in the course of the winter. These become rafted together, refrozen into a single sheet and covered over during the winter by a heavy layer of packed and driven snow. Pressure ridges containing ice blocks 5 or 10 feet thick criss-cross the surface in all directions and may rise to heights of 15 or 30 feet. Leads

[18]The "Cariberg" flight, 3-7 May 1948,—R.C.A.F.

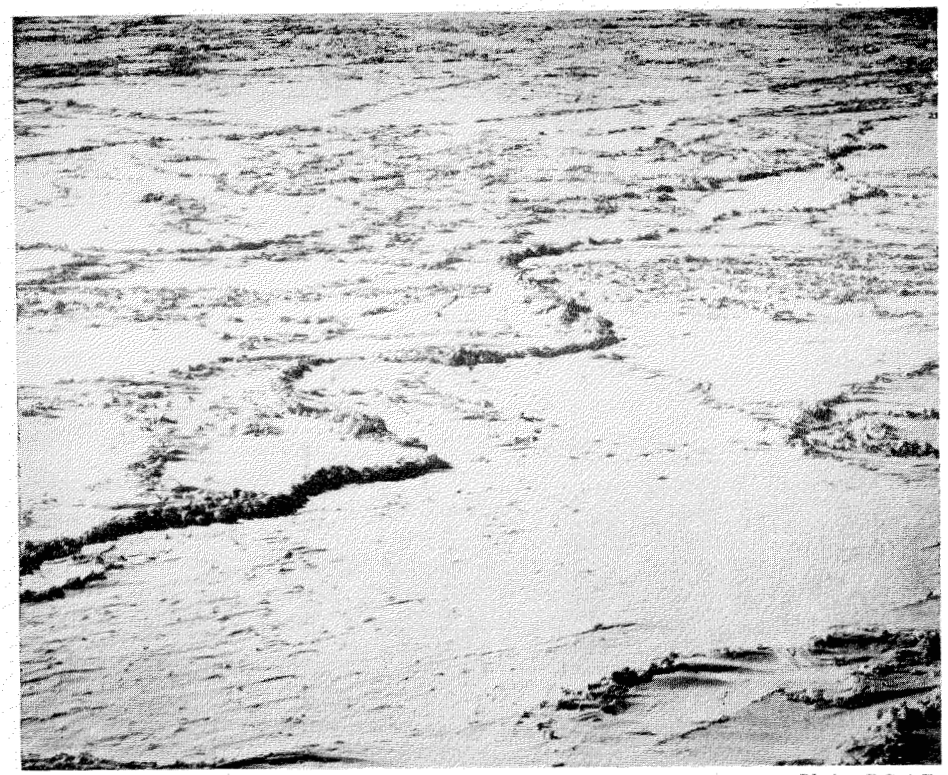

Photo: R.C.A.F.

Pressure ridges west of Port Harrison from an altitude of about 150 ft., 8 March 1949.

from several feet to several miles in width are constantly opening up under the pressure of the ice and refreezing or closing again when the direction of pressure changes. Whether or not there is any consistent direction to these leads and pressure ridges has not yet been determined.

From the observations to date, it would seem that there is a tendency for the leads and ridges near the edge of the Bay to parallel the direction of the shore lead. Farther out the direction seems to change with the changing stresses of wind and tide. It is quite easy from an aircraft to trace the lines of old refrozen leads, often running at an angle to the present open lanes. The same is true for the network of pressure ridges although these ridges may at times be practically absent in the area immediately beyond the shore lead. A preliminary report on operation "Ice-Cake"[19], April 1948, notes that "there were very few pressure ridges for about 80 miles out of Churchill. They started as a very fine open lacy pattern and increased moderately in size and number". The maximum was reached about two-thirds of the way to Mansel Island, but at no time were the ridges as large or as numerous as those seen opposite the Nelson River.

[19]Leggett, R. F., and Nazzer, D. B., "Snow and ice conditions in Northern Canada, spring, 1948". Nat. Res. Council, Ass. Comm. on Soil and Snow Mechanics, Tech. Mem. 12, Ottawa.

The shore lead, which seems to have caused so much confusion in estimating the ice cover of Hudson Bay, may at times be entirely absent. Along the east coast from Great Whale River to Port Harrison the "Ice" reconnaissance of 8 March 1949 found no suggestion of open water. There were traces of old refrozen leads but none of them as large or as continuous as the one found along this same coast by the "Cariberg" reconnaissance of 6 May 1948. At that time the lane of open water off Port Harrison was 25 to 30 miles wide and seemed to stretch north and south along the coast as far as could be seen. It should be noted that this wide shore lead resulted after several days of NE winds which had effectively driven the ice offshore. A month previously when the "Ice-Cake" flight had covered this same area there had been a westerly wind for several days and at that time there was no sign of open water along the east coast. Open water was however seen around Mansel Island—possibly the result of wind, tide and strong current.

It would be of interest to know whether any open water exists to the west of the Belcher Islands at times when there is no lead along the Quebec coast. If there is, it would suggest that under certain conditions the "shore lead" merely moves west beyond the protecting fringe of islands and out towards deeper water. This possibility is further strengthened by the observation of R. J. Flaherty[20] (quoted in the *Arctic Pilot*) that "The climate of the islands differs widely from that of the opposite mainland. Compared with weather reports from Great Whale River for the same period . . . [the islands had] a far greater proportion of overcast skies and fogs, stronger and more constant winds, but higher and more equable temperatures."

On the west and northwest coast where most observations of ice conditions have been made, the shore lead is more persistent than on the east coast. The explanation of this would appear to be the predominance of west and northwest winds in this area. Each time an ice reconnaissance has been made there has always been some indication of open water along this edge of the Bay.

There have as yet been no aerial reconnaissances in the late fall and early winter to observe the time of freeze-up. It is therefore possible only to repeat what has already been said by travellers and explorers in the region. There seems to be general agreement that along the coast the ice may form in the shallow bays early in November and in the mouths of rivers by the end of the month. In his journey to the Nastapoka Islands in 1910 R. J. Flaherty[21] records that he was forced to wait at Fort George on the mainland until December before the Bay ice was solid

[20]Flaherty, R. J., "The Belcher Islands of Hudson Bay: their discovery and exploration". *Geogr. Rev.* 5 (1918) p. 453.

[21]Ibid., p. 436.

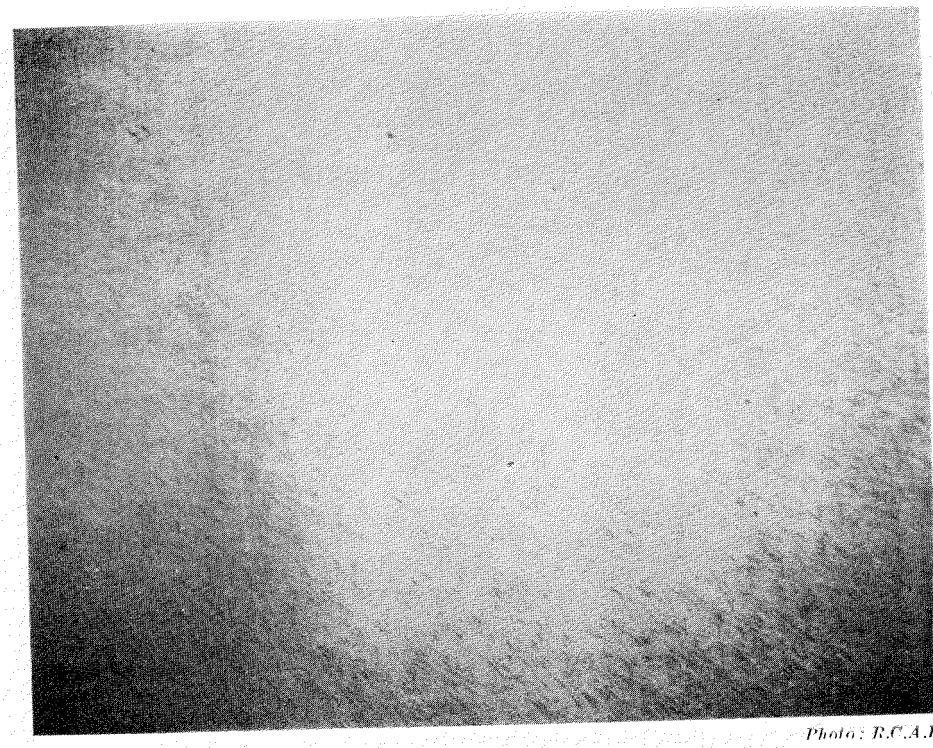

Photo: R.C.A.F.

Smooth ice, approximately 10 miles south of Churchill, 17 March 1949.

Photo: R.C.A.F.

Shore ice, shore lead, with floating pans along edge of Bay ice and streak of brash ice in foreground, west coast Hudson Bay near Eskimo Point, 6 May 1948.

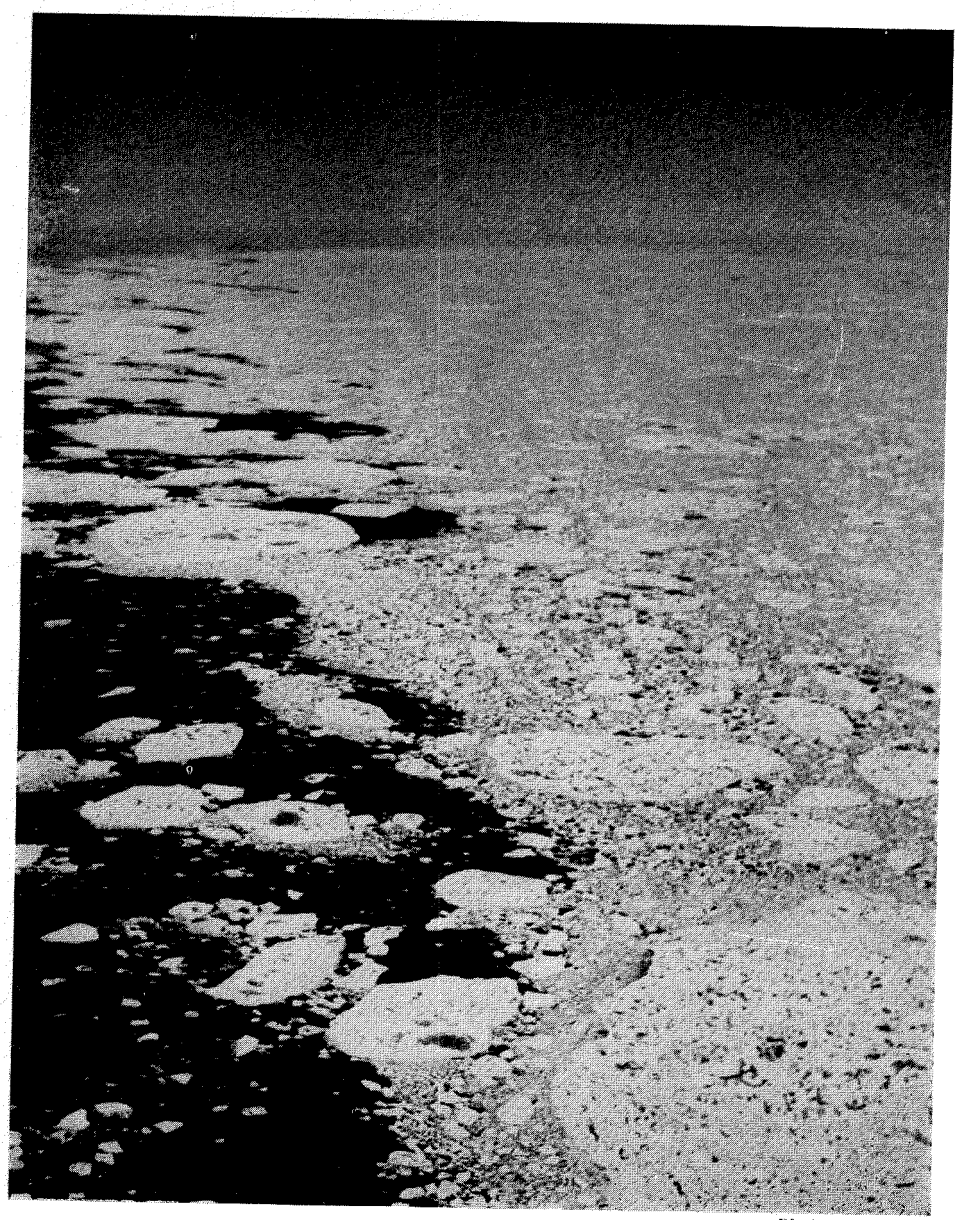

Photo: F. K. Hare

Brash ice along edge of James Bay, 5 May 1948.

enough for safe travel. He also found that February to March was the best time for a crossing from the mainland to the Belcher Islands.[22] In the far northern part the small bays freeze over early in October[23] or early in November.[24] As the centre of the Bay would freeze somewhat later than

[22]Flaherty, R. J., op. cit., p. 441.

[23]Low, A. P., op. cit., p. 292.

[24]Birket-Smith, Kaj, "Geographical Notes on The Barren Grounds". Rep. Fifth Thule Exped., 1921-24. Copenhagen, 1933. Vol. I, No. 4, p. 74.

the coastal regions, these dates seem to fit very closely with the time suggested by the temperature charts for the consolidation of ice cover over the whole area. It is hoped that the ice observations planned for the fall and winter of 1949-50 will give further evidence justifying this conclusion.

Most existing reports assume that James Bay is frozen from shore to shore all winter. On all flights of this series, however, it was found to have a high percentage of open water which at times extended as far north as the Belcher Islands. Apart from the shelf of shore ice and ice bridges between the islands in the southern part, the greatest amount of ice seen in this area was in the form of loose, floating pans.

The findings of the aerial reconnaissance flights agree very closely with the conclusions already drawn from a study of the temperature charts (see Part I of this paper). The question not unnaturally arises: Why then were the earlier explorers so convinced that the central part of Hudson Bay remains largely ice-free? A possible explanation may lie in the fact that there is no record of anyone having attempted to cross the Bay in winter. Travellers in the area always tried to make for harbour by the end of September or beginning of October. There they became frozen-in and were separated from the shore lead by some miles of fast ice. Sea smoke from the lead would suggest open water out towards the centre of the Bay and this belief would seem all the more likely at times when the lead was several miles wide. In fact the Honourable W. J. Christie of the North-West Council in his evidence before the Parliamentary Committee, 1884,[25] gave this very reason as the basis for his opinion. He stated, "I do not think . . . Hudson's Bay is frozen over, except a certain distance out from the shore, as vapor and fog is seen rising from the open water beyond the frozen shore ice, both at York and Churchill."

Furthermore the shore lead can be very wide. The one off Port Harrison in May 1948 was more than 28 miles across and pilots flying out from Churchill report that leads 10 miles wide are not uncommon on the western side of the Bay. From the low elevations of the coast such a stretch of water beyond the land floe would certainly give grounds for believing there was no ice further out. Pilots flying from Churchill to Chesterfield Inlet have had the experience of seeing open water to the horizon at Churchill, only to discover when they are in the air that it was merely the wide shore lead and that there was solid ice beyond.

A further reason is that those who wintered in the Bay usually did so in the northern parts. Low wintered at Fullerton Bay and put into harbour on September 23. The New Bedford[26] whalers were unanimous that "Hudson's Bay is open all winter, and what little ice makes on the shore

[25]Report of the Select Committee of the House of Commons, op. cit., p. 33.
[26]Ibid., p. 25.

breaks up with every gale of wind." But they never attempted to cross the Bay during the winter and always put into Marble Island early in the fall. This northern section has perhaps a higher percentage of open water than any other part of the Bay because of the strong currents from Foxe Basin and the upwelling along the coast. Kaj Birket-Smith[27] in the 'Report of the Fifth Thule Expedition' says "Even in the rather narrow Roe's Welcome, however, it is only exceptionally that the ice lies firm over to Southampton Island. . . . In Wager Bay there are two places where, owing to the current, it never freezes over, one at the mouth, the other a little way in at the Narrows. In Chesterfield Inlet, too, there is unsafe ice or current openings, and at the outlet of Baker Lake lies the great current opening called Morjunitjuaq, which, when we were in the country, had only been covered over once in the memory of man, viz. in 1918." Therkel Mathiassen[28] adds to this list of open water areas by including Frozen and Comer Straits around Southampton Island.

With so much open water in the vicinity it is hardly surprising that those who wintered in this northern area were convinced that the Bay remained open. It is worth noting, too, that most of our information about winter conditions over the Bay came from the explorers and whalers who had remained on the west and northern coast from fall until spring.

General Conclusion

As shown in Part I of this paper, open water surfaces in the Arctic reveal themselves by their modifying effect on surrounding temperatures. The absence of such modification during the winter may therefore be taken as an indication that the neighbouring water surfaces are frozen-over. Part II has shown that this hypothesis is supported by the existing scanty records for the Baffin Bay and Hudson Strait areas, but until more complete photographic records are available, further correlation is not possible.

In Hudson Bay the ice conditions inferred from the meteorological evidence and observed on reconnaissance flights contradict previous reports. The authors feel that these reports based on shore observations only are in error. Aerial photographs show that the Bay was completely ice-covered in the winters of 1947-8 and 1948-9, and although two winters alone cannot establish that this is always the case it should be stressed that temperatures throughout these particular winters as a whole are recorded as being normal. Extensive reconnaissance over a period of years will be necessary in order to establish beyond dispute the details of ice conditions in the area. Plans for such observations have already been completed for the winter of 1949-50.

[27]Birket-Smith, Kaj., op. cit., pp. 74-5 (cf. also Boas, F., op. cit., p. 418).

[28]Mathiassen, Therkel, "Contributions to the physiography of Southampton Island". Rep. Fifth Thule Exped., 1921-24. Copenhagen, 1931. Vol. 1, No. 1, p. 22.