C. I. Stevenson

Canada

GEOGRAPHICAL PAPER No. 21

Sea Ice Conditions in the Northumberland Strait Area

C. N. Forward

GEOGRAPHICAL BRANCH
Department of Mines and
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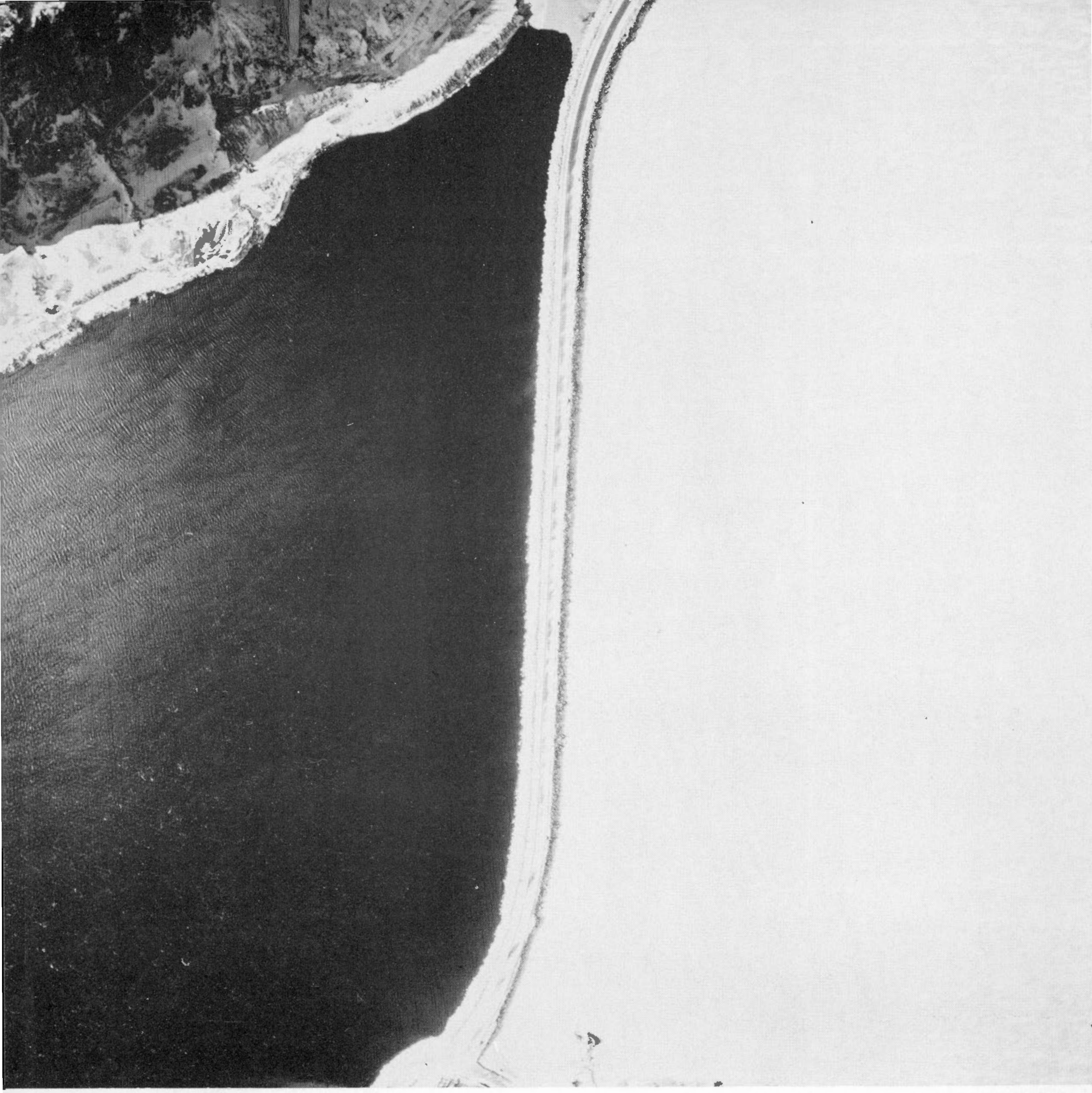

An aerial view of the Canso Causeway on February 23, 1959 showing the striking contrast between the solid ice on the northwest side and the open water on the southeast side. The snow-covered sheet of ice displays no signs of disturbance such as cracks, pools or ridges.

PREFACE

For the past nine years the Geographical Branch has been collecting data on sea ice conditions, and investigating ice distribution in Canadian waters as part of the Canadian Ice Distribution Survey.

This report is a study of the annual variability of ice conditions in Northumberland Strait. Its purpose is to assemble the relevant information on sea ice distribution, and to assess the factors that affect the accumulation and deterioration of ice in Northumberland Strait.

N. L. Nicholson,
Director,
Geographical Branch.

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SEA ICE CONDITIONS IN THE NORTHUMBERLAND STRAIT AREA

Knowledge of ice conditions in Northumberland Strait has become of increasing importance in view of recent proposals for economic development in the Maritime Provinces. A proposal has been advanced to build a causeway across Northumberland Strait, joining Prince Edward Island to the mainland. The existence of a causeway would end the present necessity of operating ice-breaking ferries on this route in winter. Before the construction of a causeway is begun, however, a careful investigation of its effects on ice conditions must be carried out. The possibility of lengthening the navigation season also depends on a detailed knowledge of ice conditions. Of special significance are the long term characteristics of ice behaviour and what might be considered average conditions.

It is the aim of this study to analyse and interpret the available data in order to present an integrated picture of ice conditions in the area, which extends from Miramichi Bay to the west coast of Cape Breton, including the Strait of Canso. An attempt will be made to determine the variability of ice conditions from year to year and to define average conditions. Regional differences in ice conditions within the area will be investigated also.

The basic sources of information are the various aerial ice survey reports produced during recent years. Spring ice surveys have been conducted regularly since 1940 by the Marine Services Branch of the Department of Transport. The interpretation of these reports and the plotting of the ice data were carried out by the author *. Ice observation flights were carried out two or three times a week during late March and

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* Forward, C.N. "Ice Distribution in the Gulf of St. Lawrence During the Break-up Season". Geographical Bulletin, No. 6, 1954, pp. 45-84.

Forward, C.N. Ice Conditions in the Gulf of St. Lawrence During the Spring Seasons 1953-1957, Geographical Paper, No. 16, 1958.

April in each of the 19 years. The ice information, expressed in general terms only, was intended for use by mariners, and summaries were broadcast over the Maritimes radio network. More detailed ice observations were begun in 1956 under the sponsorship of the Defence Research Board*. Flights began in early February and continued until the spring survey was well under way in late March. This winter survey was continued in 1957 and 1958, giving a three-year record of winter ice conditions**. To extend the data obtained from aerial surveys the captains of the Northumberland Strait ferries, several lighthouse keepers and a number of fishermen were interviewed during the summer of 1958.

ANNUAL VARIABILITY OF ICE CONDITIONS

There is a great variability in ice conditions from year to year, as the Gulf of St. Lawrence lies on the borderline between the Northern Hemisphere's winter ice-covered waters and ice-free waters. Changes in water temperature of a few degrees higher or lower than normal may result in the virtual absence of ice or its formation on a large scale. The air temperature records of the last two decades indicate that above normal temperatures have prevailed in more than half of the ice seasons (Table 1). On the basis of the air temperature factor alone, normal ice conditions would be expected in 5 of the 19 years, less abundant ice would be expected in 10 years of the total and more abundant ice in the remaining 4 years. Essentially, this was the case in the

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* Black, W.A. and Forward, C.N., Gulf of St. Lawrence Ice Survey, Winter 1956, Geographical Paper, No. 12, 1957.

** Black, W.A. Gulf of St. Lawrence Ice Survey, Winter 1957, Geographical Paper, No. 14, 1957.

Black, W.A. "Ice Conditions: Gulf of St. Lawrence, 1956", Geographical Bulletin, No. 10, 1957, pp. 77-83.

Black, W.A. Gulf of St. Lawrence Ice Survey, Winter 1958, Geographical Paper, No. 19, 1958.

Gulf of St. Lawrence as a whole, but other factors, such as winds and water movements, caused accumulation of ice locally within the gulf.

TABLE I

TEMPERATURE CHARACTERISTICS OF THE ICE SEASONS IN THE SOUTHERN GULF OF ST. LAWRENCE 1940 TO 1958

	Years with below-normal temperatures	Years with approx. normal temperatures	Years with above-normal temperatures	
Ice Seasons (November to May)	1943 1944 1948 1957	1941 1946 1947 1950 1956	1940 1942 1945 1949 1951	1952 1953 1954 1955 1958
Total	4	5	10	

The Northumberland Strait area is especially vulnerable to ice accumulation because the general movement of ice is from northwest to southeast. This southern embayment of the gulf acts as a trap from which ice can escape only by moving north-eastward to Cabot Strait. Westerly winds, normally prevailing during the ice season, are chiefly responsible for the ice drift. It has been suggested, also, that there is a weak flow of water from west to east, culminating in the well-defined current off Cape North in Cabot Strait. In Northumberland Strait, however, the currents are tidal in nature and no permanent current has been defined. Tremendous quantities of ice may be redistributed by strong gales blowing from the same general direction for several days. Thus, a normal distribution of ice under the influence of westerly winds may be greatly changed by sustained winds from an easterly quarter. It is quite possible in the

Northumberland Strait area to have an abundance of ice during a season characterized by above normal air temperatures, depending on the direction and strength of prevailing winds. This occurred in 1952 under the influence of northerly winds. In spite of the fact that great variations in ice conditions from year to year do occur, it is possible to outline, within broad limits, the stages of ice behaviour throughout the season.

WINTER ICE CONDITIONS

Ice begins to form along the shores in late December and by the end of the first week in January there may be inshore ice a few inches thick, permitting a man to walk on it. This landfast strip grows seaward during January and February, attaining a thickness of 20 to 30 inches. It varies in width from a few hundred yards on exposed headlands to several miles in shallow bays and harbours (Figure 1). The landfast ice may rise and fall with the tide, but is seldom pushed up onto the shore to cause damage or increase erosion. Although the landfast ice formed behind bars or in enclosed bays generally remains throughout the winter, that formed in more exposed places may be detached and broken up by storms during the winter. In such cases new ice usually forms to take its place.

Offshore, shifting pack ice of local origin generally appears in early January and becomes abundant in February. This ice attains a normal thickness of about 3 feet, but individual floes may be thickened by rafting and ridging to as much as 15 feet. It has been reported that ice floes ground on the Jourimain Shoals which lie 8 to 12 feet below low water. The floes vary greatly in size from small pieces a few feet in diameter to large floes of several miles in diameter. Floes of 500 feet in diameter are quite common and floes of about 3 miles in diameter are encountered occasionally. The concentration of ice is usually 8/10 to 10/10 over wide areas beyond the landfast strip during February and March, although pools and leads appear frequently.

ICE CONDITIONS IN THE NORTHUMBERLAND STRAIT AREA

The ice is constantly in motion under the influence of tides and winds. The incoming tide tends to pack the ice in the strait, while the outgoing tide tends to loosen it. West and northwest winds, which usually prevail in winter and spring months, effectively drive the ice eastward, relieving compaction in central areas of the strait. Easterly winds, on the other hand, generally tighten the pack and retard the eastward movement of ice. During late February and March ice from the central part of the gulf frequently enters Northumberland Strait. It is relatively thick winter ice that has been positively identified as originating in the gulf. On several occasions in recent years piles of sealskins have been sighted near Cape Tormentine on floes that must have drifted from the central gulf.

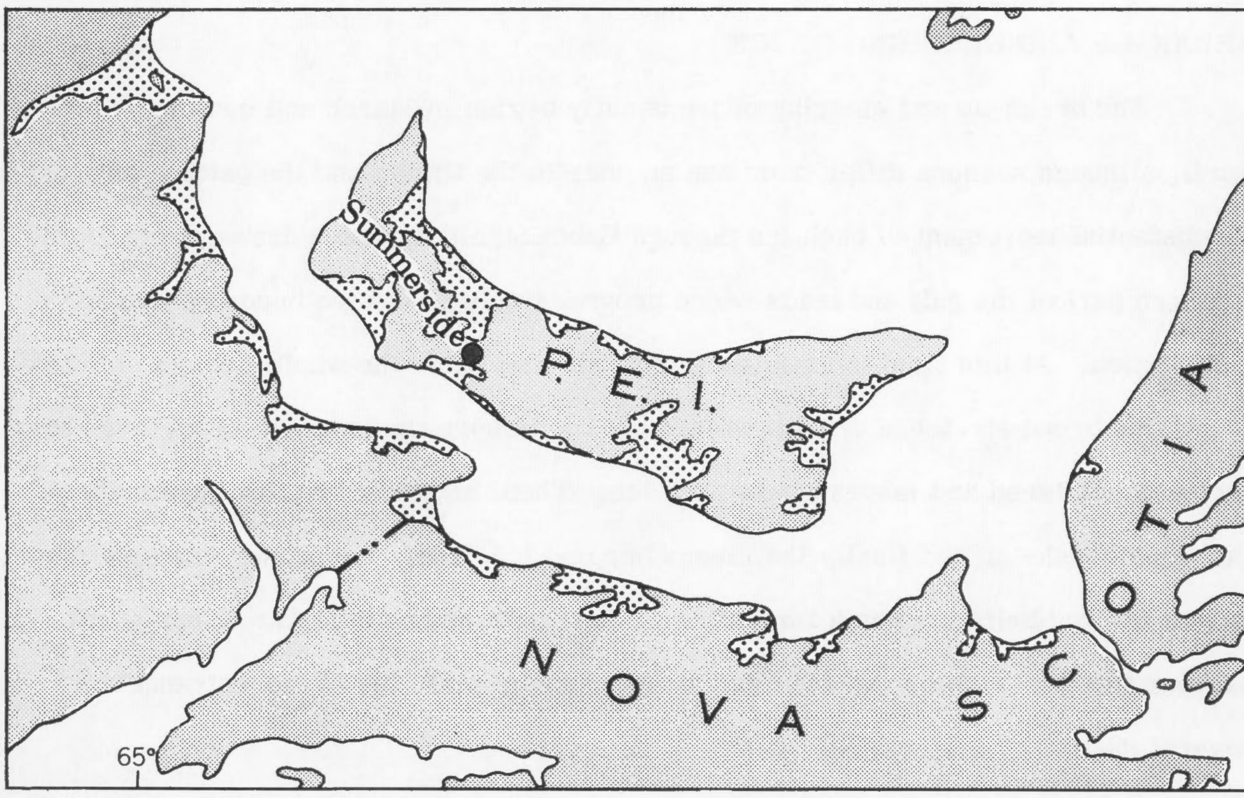

Figure 1. Main areas of landfast ice.

The Canadian National Railways ferry service across Northumberland Strait between Cape Tormentine, N.B. and Borden, P.E.I., a distance of 8.6 miles, is

maintained throughout the winter with the icebreaker M.V. "Abegweit". In open water the vessel normally completes a crossing in less than an hour. From January to April the "Abegweit" is impeded by ice and crossing time is lengthened, as indicated on the accompanying graph covering the years since the ship was placed in service (Figure 2). It may be observed that both 1948 and 1957 operations show lengthy average crossings in each of the four months. Below average air temperatures were experienced during both of these seasons. Crossing times in 1952 were long also, especially in March, owing chiefly to the packing of ice in Northumberland Strait by strong northerly winds. In fact, the longest crossing recorded during the 10-year period occurred in March, 1952: almost 9 hours compared with the 1-hour run in open water.

BREAK-UP AND CLEARING OF ICE

The break-up and clearing of ice usually begins in March and continues through April, although seasons differ from one another in the timing and the pattern of break-up. A substantial movement of pack ice through Cabot Strait in March draws ice from the southern part of the gulf and leads widen progressively as the ice becomes looser in distribution. At this time the influence of winds may alter the whole pattern of break-up. After broad stretches of open water appear offshore the landfast ice in large bays becomes shattered and moves off as pack ice. Then the ice in smaller bays and harbours breaks up and finally the rivers become ice-free. Ice often remains offshore in patches and belts for some time after the landfast ice has broken. Consequently, a harbour that has become ice-free may be blocked by pack ice at the entrance for several days.

There are several distinct patterns of break-up which appear to be associated with certain wind combinations. The nineteen ice seasons examined fall into four main types according to their break-up patterns. These are indicated on the accompanying maps. The lines mark the limits of main ice areas at specific dates and exclude regions of widely scattered strings and patches of ice.

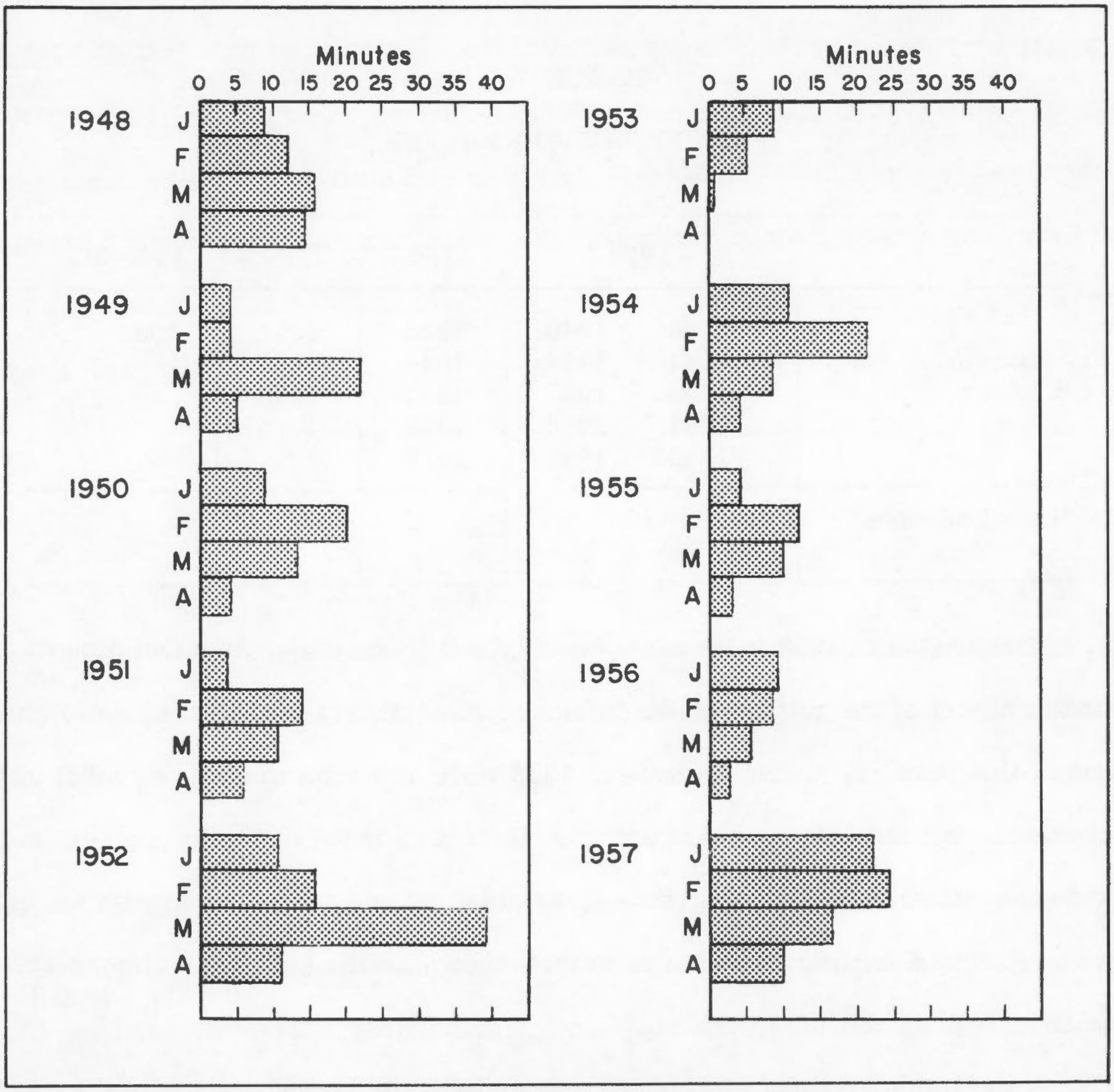

Figure 2. Average additional crossing time of M.V. "Abegweit" during the ice-breaking season, normal crossing time in open water being 52 minutes.

Type 1 is exemplified by the season of 1956 when the ice withdrew from west to east (Figure 3). This pattern is associated with strong westerly winds which drive the ice eastward toward Cape Breton and Cabot Strait. The western part of Northumberland Strait and the small area off the eastern end of Prince Edward Island clear first, then the eastern part of the strait and George Bay, and finally, the west coast of Cape Breton. This pattern of break-up occurred in ten ice seasons (Table II).

TABLE II

PATTERNS OF BREAK-UP

	Type 1		Type 2	Type 3	Type 4
Ice Seasons	1940 1941 1945 1947 1948	1949 1954 1955 1956 1957	1942 1944 1946 1950 1952	1951 1953 1958	1943
No. of Seasons	10		5	3	1

The season of 1952 is an example of type 2 (Figure 4). Accumulation of ice in the southern part of the gulf under the influence of northerly winds is the chief characteristic of this pattern. Temperatures in 1952 were above normal during most of the winter and spring and ice was not abundant. However, much of the ice present in the gulf moved southward, encasing Prince Edward Island and Cape Breton with ice until early May. A total of five ice seasons experienced a similar pattern of break-up (Table II).

A west side accumulation of ice associated with easterly winds is the type 3 pattern exemplified by the season of 1953 (Figure 5). Again, temperatures were high and little ice was present. Nevertheless ice was driven westward and remained in the western end of Northumberland Strait until late April. If strong westerly winds had prevailed, the strait likely would have been clear at least a week or two earlier. A similar accumulation of ice with easterly winds occurred in 1951 and 1958.

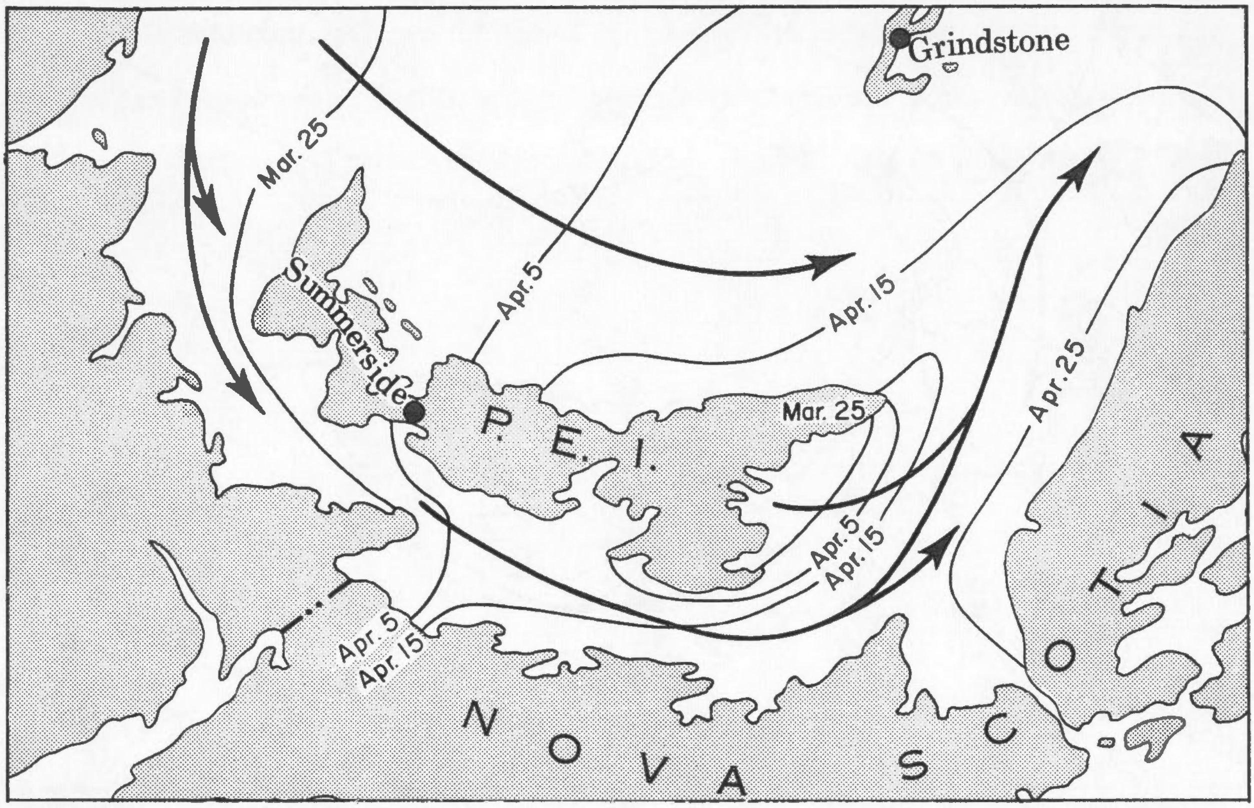

Figure 3. Limits of main ice areas, season of 1956. Type 1 pattern of break-up.

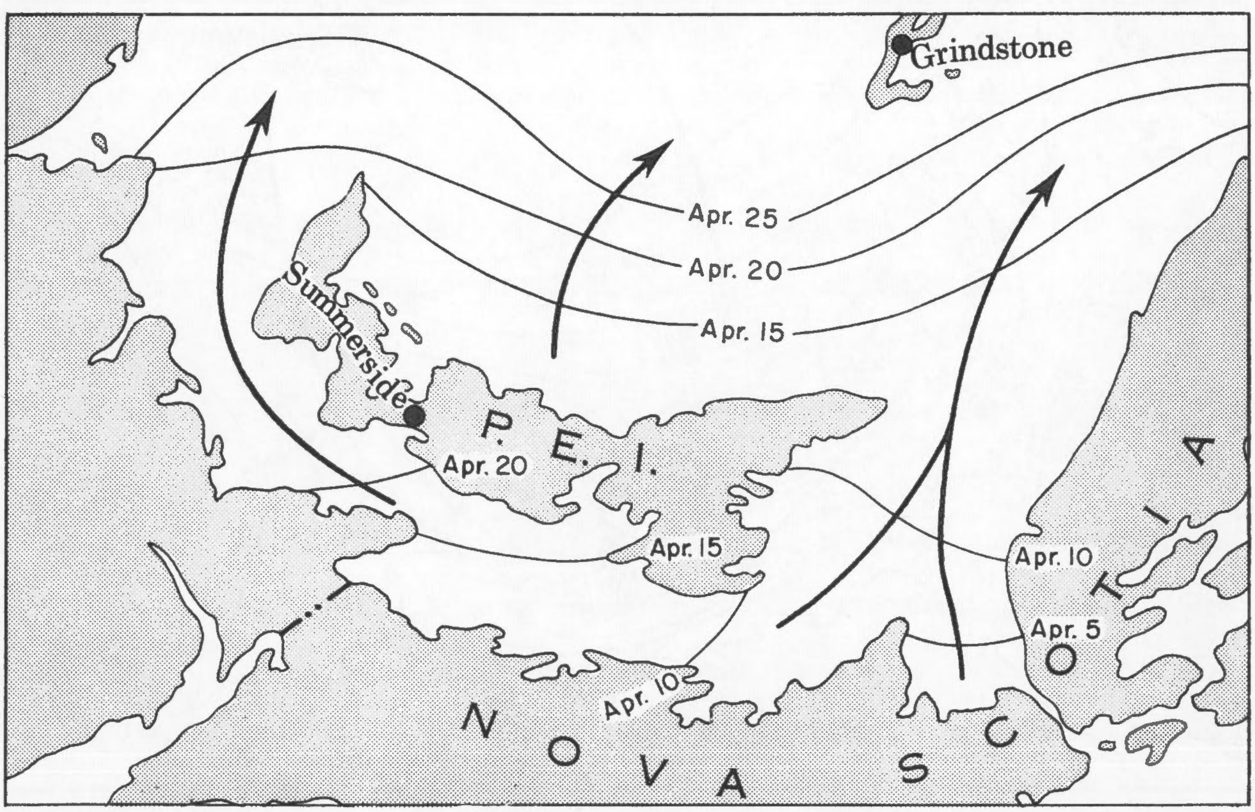

Figure 4. Limits of main ice areas, season of 1952. Type 2 pattern of break-up.

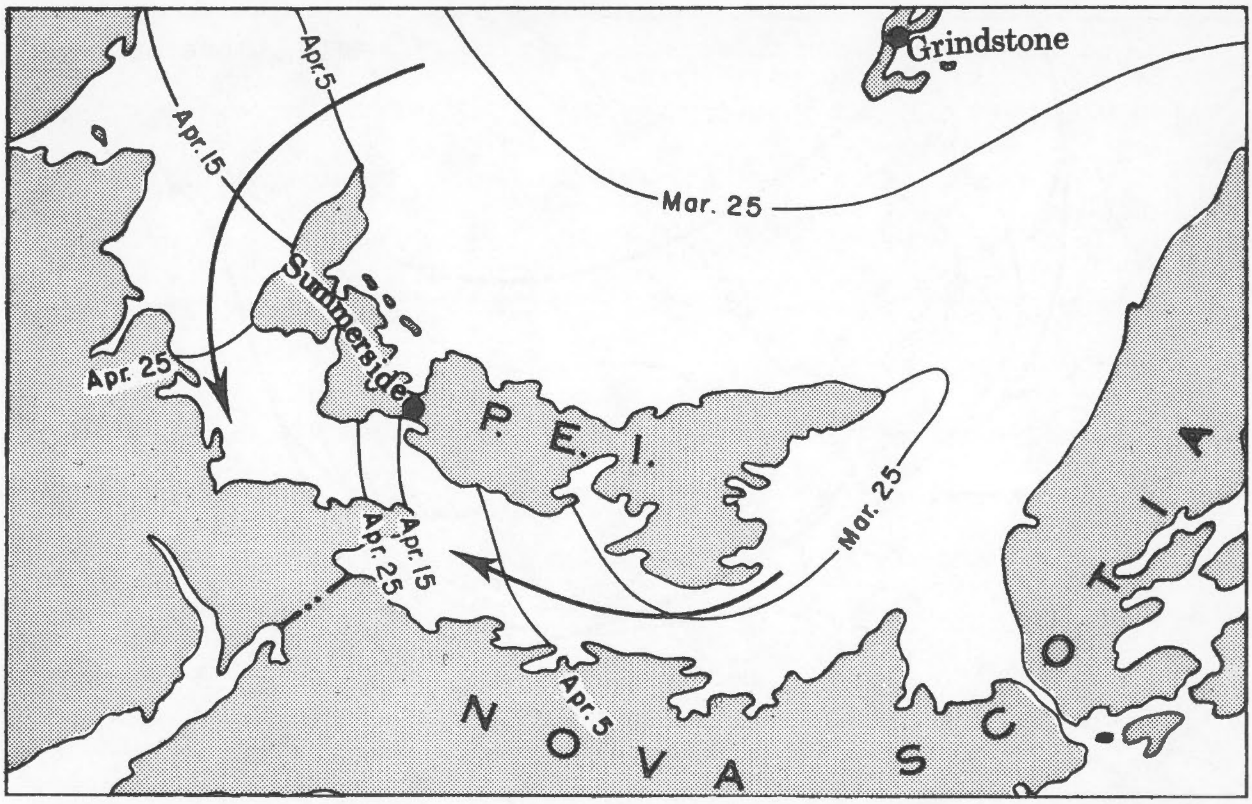

Figure 5. Limits of main ice areas, season of 1953. Type 3 pattern of break-up.

Figure 6. Limits of main ice areas, season of 1943. Type 4 pattern of break-up.

Type 4 is represented by the season of 1943 only (Figure 6). Frequent southerly winds assisted the withdrawal of ice from south to north. On the whole, temperatures were below normal during the winter and ice was abundant, but the clearing was rapid, especially in the southern embayment of the gulf. The particular combination of factors producing this pattern of break-up must occur very seldom, as no other season among the nineteen was similar in pattern.

The frequency of occurrence of each type, on the basis of the 19-year period, suggests a future probability with regard to pattern of break-up. Thus, the approximate percentage frequency of type 1 is 53 per cent, of type 2 is 26 per cent, and of type 3 is 16 per cent.

TIME OF FINAL CLEARING

All ice reports were examined to determine the dates of final clearing in each of ten sectors of the Northumberland Strait area (Figure 7). The date when the last ice had disappeared was ascertained for each of the nineteen years and an average calculated. These data are summarized in graphic form (Figure 7).

It appears that the western end of the strait becomes clear first, along with the area off the eastern coast of Prince Edward Island. Then the central portion of the strait clears progressively from west to east. Finally, George Bay and the eastern end of the strait become clear of ice. The average dates of final clearing in each sector suggest a type 1 pattern of break-up. This is to be expected because half of the ice seasons fall in type 1. The period of time between the earliest date of clearing is much longer in the four eastern sectors than in the rest of the area. Consequently, ice in these sectors may be expected to clear especially early in some years and remain very late in others. The three central sectors, D, E and F, were never clear before early April, while other sectors were clear in March in at least one season. All

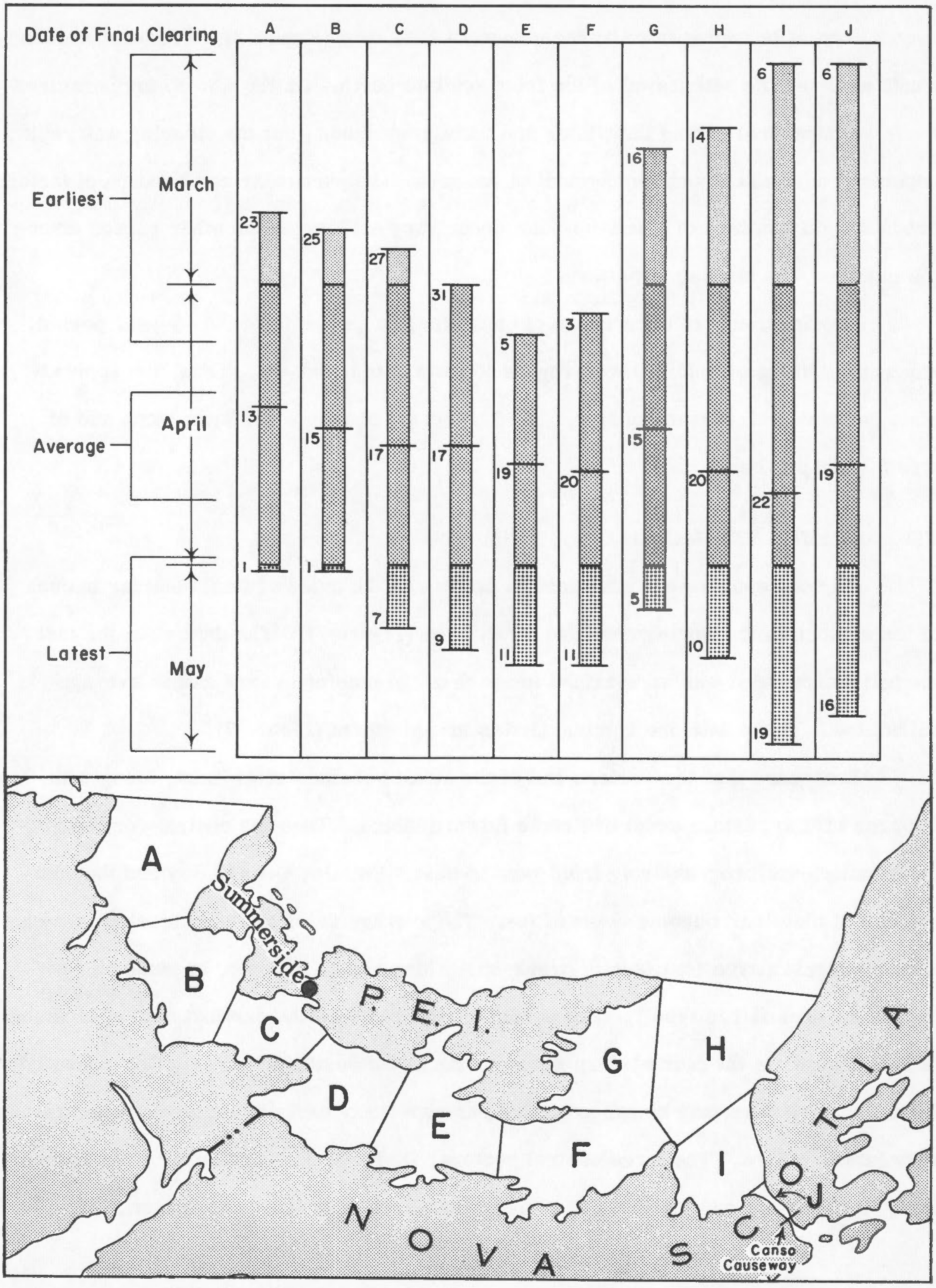

Figure 7. Dates of final clearing in ten sectors of the Northumberland Strait area.

sectors had at least one late ice season, when the date of final clearing occurred in May.

STRAIT OF CANSO

Before the causeway was built in 1955 most of the Strait of Canso became covered with drift ice repeatedly during the season and a narrow strip of landfast ice became established in the northern part. As the currents were tidal only, the strait did not act as a channel funnelling large quantities of ice from the gulf into the open Atlantic. Ice seldom extended southward into Chedabucto Bay. During the break-up some floes moved southward, but most of the ice found its way northward into George Bay in early April. The season of 1952 was an exception when northerly winds drove the ice southward and the strait was ice-covered until late April.

The construction of the causeway at Port Hastings prevented ice from passing through the strait. Consequently, the southern half of the strait was virtually ice-free, except for a brief period in 1957. The water temperatures in winter are considerably higher south of the causeway than north of it. As a result, landfast ice forms more readily on the north side, becoming about 1/4 mile wide along the causeway itself. It generally forms in late December and reaches a thickness of almost 3 feet. Outside the landfast ice, the northern half of the strait fills with pack ice in January and does not clear until April. South of the causeway some landfast ice normally forms in small bays, but is not extensive. However, a long period of calm, sub-zero weather in January, 1957 led to the formation of ice completely across the strait about 6 inches thick. Men were able to walk on the ice from Port Hawkesbury to Mulgrave for the first time in living memory. The ice was easily broken by a fishing vessel a short time later.

SUMMARY

It has been established that ice conditions in Northumberland Strait vary from season to season in accordance with variable winter climatic conditions. However, the sparsely distributed ice in the central gulf may be driven into Northumberland Strait by strong winds, greatly retarding the break-up in this vicinity.

Landfast ice begins to form in late December and floes appear offshore in January. The concentration of ice reaches a peak in February and March, being 8/10 to 10/10 over wide areas. Under the influence of winds and tides the ice moves constantly and leads open up frequently.

The break-up and clearing of ice begins in March and continues through April. The pack ice generally clears before the landfast ice breaks up and moves offshore. There are four distinct patterns of break-up, each associated with a different wind combination. A west to east withdrawal of ice is the most common pattern. An analysis of dates of final clearing indicates that the western end of the strait usually clears first, then the central portion and finally the eastern section. North of the causeway the Strait of Canso is ice-covered in winter and does not clear until mid-April, but south of it the strait is usually ice-free.

GEOGRAPHICAL PAPERS

Papers Nos. 1 to 6 are out of print.

No. 7. Extracts relating to the Navigability of Canadian Inland Waterways. By W. A. Black, Ottawa, 1956. 55 p., offset. *Price 50 cents.*

No. 8. Notes on Potential Building Sites in the Bathurst Inlet Area, N.W.T. By J. B. Bird and M. B. Bird, Ottawa, 1956. 15 p., map, offset. *Price 25 cents.*

No. 9. A Report on Sea Ice Conditions in the Eastern Arctic, Summer 1956. By W. A. Black, Ottawa, 1956. 32 p., maps, illus., offset. *Price 50 cents.*

No. 10. A Preliminary Report on Ice Conditions at Cacouna Island, Quebec. (Bilingual). By B. Robitaille, Ottawa, 1957. 24 p., maps, illus., offset. *Price 50 cents.*

No. 11. An Illustrated Glossary of Ice Types in the Gulf of St. Lawrence. By W. A. Black, Ottawa, 1957. 50 p., illus., offset. *Price 75 cents.*

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