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Report of the International Ice Patrol Service in the North Atlantic Ocean

SEASON OF 1971

CG-188-26

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MAILING ADDRESS:
U.S. COAST GUARD (G-OOO-1)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE:

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FOREWORD

Forwarded herewith is Bulletin No. 57 of the International Ice Patrol describing the Patrol services, and ice observations and conditions during the 1971 season.

R. H. SCARBOROUGH
Acting Chief, Office of Operations

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PREFACE

This report is the 57th in a series of annual reports on the International Ice Patrol Service in the North Atlantic Ocean. It contains information on Ice Patrol organization, communications, and operations and on ice and environmental conditions which existed during the 1971 International Ice Patrol year.

The author of this paper, Commander Eugene A. DELANEY, USCG acknowledges ice and weather data provided by the Canadian Atmospheric Environment Service, weather and oceanographic data provided by the U. S. Naval Weather Service, and oceanographic data provided by the U. S. Coast Guard Oceanographic Unit. Acknowledgement is also made to Senior Chief Marine Science Technician P. Riley FLOWERS, Marine Science Technician First Class James A. SHAFER, and Yeoman Second Class Bruce S. COLLINS of the United States Coast Guard for their assistance in the preparation of the manuscript and illustrations for this report.

The final section of this Report is a paper by Lieutenant Commander Charles W. MORGAN, U.S. Coast Guard, the assistant Ice Patrol Officer during the early portion of this season, entitled Long Term Trends in the Iceberg Threat in the Northwest Atlantic.

INTERNATIONAL ICE PATROL 1971

The 1971 International Ice Patrol Service in the North Atlantic Ocean was conducted by the United States Coast Guard under the provisions of Title 46, United States Code, Sections 738, 738a through 738d, and the International Convention for the Safety of Life at Sea, 1960, Regulations 5 through 8. The International Ice Patrol is a service for observing and disseminating information on ice conditions in the Northwest Atlantic Ocean. During the ice season, the southeastern, southern, and southwestern limits of the regions of icebergs in the vicinity of the Grand Banks of Newfoundland are guarded for the purpose of informing passing ships of the extent of this dangerous region. The International Ice Patrol also studies ice conditions in general with emphasis on the formation, drift and deterioration of icebergs, and assists ships and personnel requiring aid within the limits of operation of the Ice Patrol forces.

The International Ice Patrol is directed from the Ice Patrol Office located at the U. S. Coast Guard Base, Governors Island, New York. The Office gathers ice and environmental data from a variety of United States and Canadian sources, maintains an ice plot, forecasts ice conditions, prepares the twice-daily Ice Bulletin, replies to requests for special ice information, and executes operational control of the Aerial Ice Reconnaissance Detachment, the Ice Patrol oceanographic ship, and any surface patrol ship assigned to Ice Patrol duties.

Rear Admiral Benjamin F. ENGEL, U. S. Coast Guard was Commander, International Ice Patrol during the entire season. Commander Eugene A. DELANEY, U. S. Coast Guard was directly responsible for the management of the Patrol.

Preseason Ice Patrol flights were made in September 1970, and in January, February, and March 1971. The Aerial Ice Reconnaissance Detachment was deployed to Canadian Forces Base, Summerside, Prince Edward Island on 9 March 1971. The Detachment returned to the United States on 29 June 1971.

The 1971 Ice Season officially commenced at 0000 GMT, 10 March, when the first Ice Bulletin was issued, and continued until the final Bulletin was issued at 1200 GMT, 29 June 1971. Twice-daily Ice Bulletins were broadcast by the International Ice Patrol Radio Station Boston/NIK, U. S. Naval Radio Station Washington/NSS, Canadian Forces Radio Station Mill Cove/CFH, and Canadian Coastal Radio Station St. John's/VON. The Ice Bulletin was also included in the U. S. Marine Information Broadcast for the High Seas of the North Atlantic, a voice broadcast originating from the U. S. Coast Guard Radio Station Boston/NMF. A facsimile ice chart was also broadcast from Radio Boston once daily.

The U. S. Coast Guard Cutter EVERGREEN, commanded by Lieutenant Commander Robert E. PHELPS, U. S. Coast Guard, conducted oceanographic cruises for the Ice Patrol during April and May. The U. S. Coast Guard Cutter ROCKAWAY, commanded by Commander William T. ADAMS, U. S. Coast Guard, joined EVERGREEN during the May survey to conduct a multi-ship survey of the Labrador Current and the surrounding oceanic area. For the twelfth consecutive year, it was unnecessary to use a surface patrol cutter.

During the 1971 Season an estimated 62 icebergs drifted south of 48°N, a relatively light season. It is also estimated that another 11 icebergs drifted south of 48°N during July 1971 only to deteriorate before reaching 47°N.

AERIAL ICE RECONNAISSANCE

During the period 1 September 1970 to 31 August 1971 a total of 56 ice observation flights were flown. Preseason flights made in September, January, February, and March accounted for 17 flights, and the remaining 39 flights were made during the Season. There was no requirement for postseason flights. The objective of the preseason flights was to study the iceberg distribution in Baffin Bay and the Labrador Sea, and to assess the iceberg potential of the coming Season. The Season flight objective was to locate the southerly limit of the region of icebergs, to assess the iceberg potential for the near term in the area immediately north of the Grand Banks, and on 2 occasions to determine the iceberg distribution along the southern part of Labrador's eastern coast. The flight statistics shown in Table 1 do not include the flight time required to make the passages between U. S. Coast Guard Air Station, Elizabeth City, North Carolina and the operating bases for the Ice Patrol reconnaissance for crew relief or aircraft maintenance.

The reconnaissance aircraft were U. S. Coast Guard HC-130-B (Lockheed Hercules) four-engine planes from the Coast Guard Air Station at Elizabeth City, North Carolina. The aircraft operated from Canadian Forces Base, Summerside, Prince Edward Island, Canada throughout the season. Since Summerside is some 500 miles from the area of icebergs, it was the usual practice to top-off fuel at St. John's, Newfoundland on the outbound leg of the flight. Occasionally, when good visibility was forecast for two or more successive days the aircraft terminated its flight at St. John's and several thousands of air-miles were saved.

The honest welcome and cooperation given by the Canadian Forces at Summerside was deeply appreciated. They were generous and professional in providing logistic and communication support to the Ice Reconnaissance Detachment.

Table 1 - Aerial Ice Reconnaissance Statistics

September 1970 to August 1971

MONTH	Preseason No. Flts.	Preseason Flt. Hrs.	Season No. Flts.	Season Flt. Hrs.	Postseason No. Flts.	Postseason Flt. Hrs.	Total No. Flts.	Total Flt. Hrs.
SEP	3	13.4					3	13.4
OCT	4	22.9					4	36.3
NOV	0	0					0	0
DEC	0	0					0	0
JAN	4	20.7					4	20.7
FEB	3	19.2					3	19.2
MAR	3	20.7	8	60.8			11	81.5
APR			9	56.8			9	56.8
MAY			11	68.0			11	68.0
JUN			11	72.2			11	72.2
JUL					0	0	0	0
AUG					0	0	0	0
GRAND TOTALS	17	96.9	39	257.8	0	0	56	354.7

COMMUNICATIONS

Ice Patrol communications included ice, meteorological, and oceanographic data, Ice Bulletins, special ice advice, a daily facsimile chart, and the administrative and operational traffic necessary to the operation of the Patrol. The Ice Bulletin was transmitted by teletype from the Ice Patrol Office in New York twice each day to over 30 addressees, including those radio stations which broadcast the Bulletin. These radio stations were the U. S. Coast Guard Radio Station Boston/NIK/NMF, U. S. Naval Radio Station Washington/NSS, Canadian Coastal Radio Station St. John's/VON, and Canadian Forces Maritime Radio Station Mill Cove/CFH.

Coast Guard Radio Station Boston transmitted the Bulletin by CW at 0018 GMT on 5320 and 6502 kHz and at 1218 GMT on 8502 and 12750 kHz. Coastal Radio St. John's made CW broadcasts at 0000 and 1330 GMT on 478 kHz, while the stations at Mill Cove and Washington made their CW broadcasts on a wide range of low and high frequencies. An abbreviated form of the normal Bulletin was included in the twice daily voice transmission of the North Atlantic High Seas Broadcast which originated from Radio Boston. A daily radio facsimile broadcast, a service which was not available in 1970, was reinstituted on 10 March. A chart depicting the locations of icebergs and sea ice was broadcast at 1600 GMT simultaneously on 8502 and 12750 kHz at a drum speed of 120 revolutions per minute.

In a conscious effort to shorten the Bulletin's transmission time, the sentence, which requested ships between latitudes 40°N and 50°N and between longitudes 42°W and 60°W to report their position, course, speed, visibility, air temperature, sea surface temperature, and wind every six hours, was eliminated from the twice-daily Bulletin. Perhaps as a result, the number of these reports received from shipping fell to 159 from the total of 1014 received in 1970. During the Season 162 ice reports were received from shipping. There were 4 requests for special ice information.

ICE CONDITIONS, 1971 SEASON

September-December

During this period icebergs continued to drift south along the Labrador Coast. Icebergs were frequently reported along the Great Circle track to the Strait of Belle Isle from the coast eastward to 50-30W. Several grounded bergs were reported along the Newfoundland Coast from Cape Bauld to Cape Freels. The southernmost drifting iceberg was reported in early September at 50-55N 47-21W. Aircraft and ships reported icebergs south of Greenland to as far south as 56-06N, which is not unusual. New sea ice began to form along the entire Labrador Coast in December.

A preseason flight was flown between 27 September and 5 October over Baffin Bay and along the Canadian Coast from Cape Dyer to the Strait of Belle Isle. Figure 1 shows the distribution per one degree rectangle. Icebergs in bays and fiords were not counted.

Routine surveys of this nature are not planned in the future, nor does the International Ice Patrol plan to conduct preseason flights in December of each year as has been done since 1963 over the waters offshore from the Strait of Belle Isle to Cape Christian on northern Baffin Island. While these flights provided a valuable insight into the movement of icebergs in Baffin Bay and along the Canadian Coast, they have been of little value in the development of a capability to forecast the beginning and extent of the iceberg season on the Grand Banks.

January

No icebergs were reported from outside sources in January. On 13 and 14 January flights were made over the waters along the Canadian Coast from Hamilton Inlet to Cape Dyer. The result of these flights is shown in Figure 2, while Figure 3 depicts the anomalous count compared to the 1963-1970 average. At this time the sea ice extended south to the vicinity of Cape Freels, Newfoundland.

February

During the latter half of February icebergs were reported from 48-34N to 51-30N from the coast out to 47-15W. The southernmost iceberg was reported at 48-34N 47-15W on 25 February in open water. A growler was reported at 46-41N 47-16W on 24 February by the Coast Guard Cutter CHASE.

The February preseason flight was flown on 27 - 28 February and 4 March from 50-00N to Cape Chidley, Labrador. Flight results are contained in Figure 4 and they are compared with the 1963 - 1970 average in Figure 5. The iceberg count south of Hamilton Inlet was 181, which is considerably above the average of 63 icebergs. From Hamilton Inlet to Cape Chidley 335 icebergs were sighted; a number quite close to the average of 300 icebergs. At the end of the month the sea ice reached its maximum southern extent for the year as the southern ice edge lay from 47-10N 52-00W to 49-00N 49-00W.

March

The results of ice reconnaissance flights flown on 6, 7, and 9 March are depicted in Figure 6. During this period there was generally good visibility above 47-00N, while the visibility was quite poor to the south. The icebergs appeared to be in excellent position to move around the Grand Banks in the Labrador Current. However, subsequent March flights, which were conducted under poor conditions of visibility, sighted no icebergs south of 46-00N. Figure 7 displays ice reports received during the period 22 - 26 March. The southernmost iceberg of the month was sighted on 30 March at 46-15N 48-05W. Icebergs were also located well to the east of the core of the Labrador Current during the latter part of the month. Visual sightings and radar placed approximately six icebergs in the vicinity of Flemish Cap between 20 and 30 March. The easternmost berg was reported at 47-40N 43-47W on 27 March. During this period the sea surface temperature in the vicinity of Flemish Cap was 42°F (5.°C). It is estimated that 31 icebergs drifted south of 48-00N during the month. By the end of the month the sea ice had retreated to north of 50-00N.

The use of anomalous pressure patterns to predict or explain anomalous iceberg movement was discussed by Kelly and Morgan (1970). Using the same techniques of determining pressure gradients along lines which are parallel or perpendicular to the normal iceberg route, it is observed that the conditions during March were very unfavorable for southward iceberg drift and favorable for eastward drift. In this connection and noting the early appearance of icebergs and growlers south of 49-00N in February, it should be explained that the mean wind conditions during February were favorable for southward drift and slightly favorable for eastward movement.

April

The reconnaissance aircraft was unable to obtain a good series of flights along the eastern and southern edges of the Grand Banks during April due to frequent frontal passages and associated rain and fog. On only three flights was the visibility sufficient to obtain 75% coverage of the planned search area and two of these were over the area north of the Grand Banks. Visual effectiveness was approximately 20% on the remaining six flights. A flight on 7 April located 44 icebergs north of the Grand Banks with the greatest concentration lying from 49-30N to 50-00N between 47-30W and 51-00W. It is estimated that four icebergs drifted south of 48-00N during the month. The southernmost iceberg for the month was reported at 45-35N 48-45W on 15 April. The easternmost iceberg was sighted on 18 April at 48-35N 44-25W. It is estimated that one iceberg drifted east to 47-11N 41-32W on 4 April after being sighted on 21 March at 46-55N 45-25W. At the end of the month the majority of the icebergs were located north of 48-00N between 45-00W and 49-00W and the sea ice had retreated farther north to 51-00N. Figure 8 is a chartlet showing ice reports received and the results of aerial reconnaissance during the period 7 - 12 April.

May

Only once during May, on the 9th, was the Patrol able to obtain good aerial reconnaissance south of 47-30N. This flight observed no icebergs north or east of the 50-fathom contour of the Grand Banks. Flights to the north located a concentration of 47 bergs between 49-00N and 50-00N which extended from 51-00W to 52-00W on the 3rd. This group was relocated on the 11th in a less compact arrangement which extended from 48-30N to 50-00N and westward from 49-00N to the Newfoundland Coast. This large group was never resighted, but the drift computations and aircraft and ship radar reports indicate that the bergs in the eastern portion of this group drifted southeasterly until their remains were scattered within a 100-mile radius of Flemish Cap by the 26th. An estimated 20 bergs drifted south of 48-00N during the month. The southernmost sighting occurred on 31 May when a ship reported two icebergs at 46-17N 48-25W. The month's easternmost sighting was reported on 11 May at 48-20N 45-15W. It is estimated that this iceberg drifted east to 49-14N 42-09W before melting. The iceberg drift plot carried the month's southernmost berg to an estimated position of 45-50N 47-45W on 8 May. Winds during the month were unfavorable for southerly drift over the Grand Banks and Flemish Cap area.

Figures 10 and 12 describe the results of aerial reconnaissance and ship reports during the period 6 - 14 and 24 - 31 May, respectively. Figures 9 and 11 show the estimated ice situations on 1 and 15 May, respectively.

June

The month of June began with the two bergs reported on 31 May as the only known ice south of 48-00N. This situation continued until 21 June when 3 icebergs and a large number of radar targets were reported by a ship near 47-05N 51-30W. These bergs were not sighted by our aircraft while flying over this area on 19 June nor were they relocated by aerial reconnaissance over this area on 24 and 26 June and they were presumed melted on the 27th. By 29 June, when Ice Patrol services for the season were terminated, the estimated limit of all known ice had retreated to the northwest. The limits in the final Bulletin were reported as extending from the Newfoundland Coast at 48-10N to 48-10N 46-30W to 48-30N 46-30W and then northwestward. It is estimated that only seven icebergs drifted south of 48-00N during June. Figure 13 depicts the results of reconnaissance and ship sightings during the period 14 - 21 June.

July

A drift plot of all the icebergs which were on plot when the 1971 Season ended was continued through 16 July when all were judged to have melted. It is estimated that 11 bergs drifted south of 48-00N during the month only to melt before crossing 47-00N. Several icebergs were sighted along the 48th parallel in early July. Throughout the month icebergs were reported in the eastern approaches to the Strait of Belle Isle from the coast eastward to the 100-fathom contour.

August

During August ships continued to report icebergs in the eastern approaches to the Strait of Belle Isle. The majority of these reports were west of the 1000-fathom contour and the frequency of reports tapered off rapidly after the 12th. The easternmost berg of the month was reported in position 54-27N 47-42W on the 9th. The southernmost reported berg was sighted in the vicinity of Funk Island. It is estimated that no icebergs drifted south of 48-00N during August 1971.

Table 2 - Estimated Number of Icebergs South of Latitude 48°N, Season of 1971

Season	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1971	0	0	0	0	0	0	31	4	20	7	11	0	73
Average 1900-1945	5	2	2	2	3	10	46	105	154	76	26	8	440
Total 1946-1971	5	2	4	5	10	87	576	1850	1539	1068	246	12	5404
Average 1946-1971	0	0	0	0	0	3	22	71	59	41	9	0	208
Total 1900-1971	251	109	110	85	130	538	2678	6695	8622	4586	1442	401	25647
Average 1900-1971	3	2	2	1	2	7	37	93	120	64	20	6	356

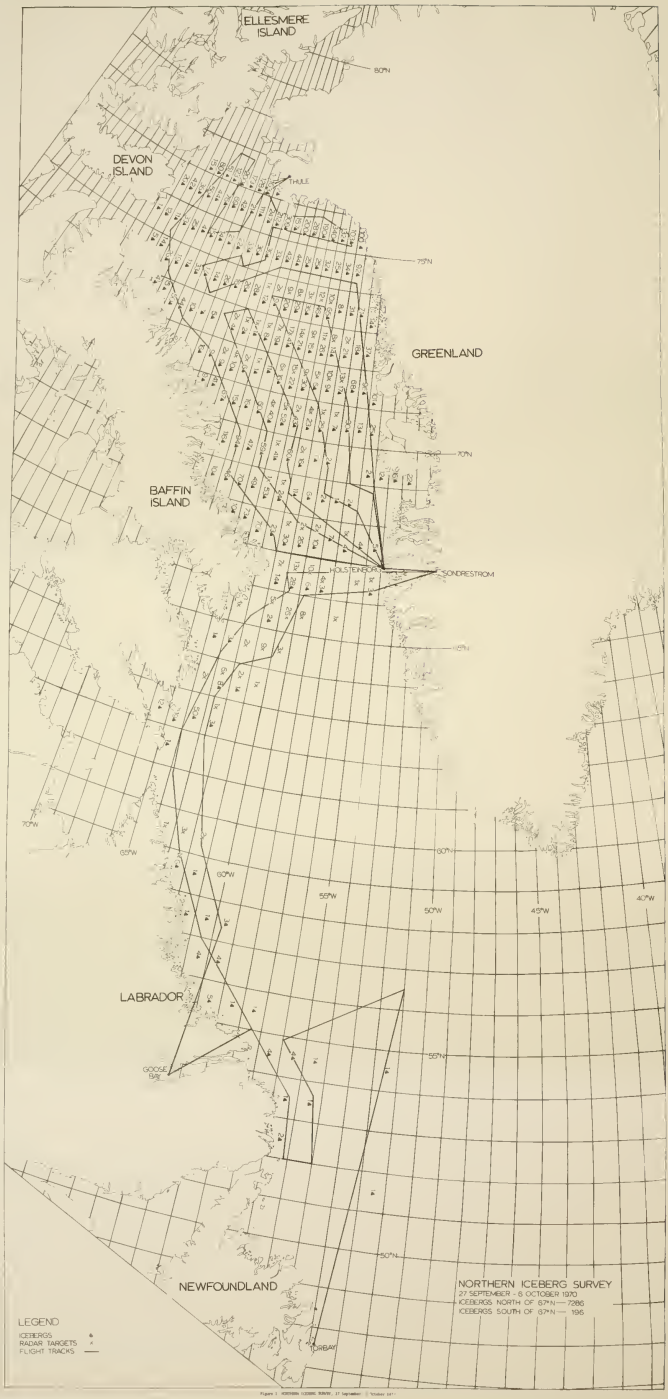


Figure 1. NORTHERN ICEBERG SURVEY, 27 September - 8 October 1970

Long Term Trends in the Iceberg Threat in the Northwest Atlantic

Abstract

Analysis of records on icebergs drifting past Newfoundland since 1880 reveals that the seasonal count of icebergs has fallen by 55% in the last three decades. An analysis of available environmental data for the same period shows that the decrease is associated with a decrease in the strength of winter northwesterly winds off southern Labrador and with an increase in winter air temperatures at Torbay, Newfoundland.

Introduction

Each year in the spring icebergs drift south in the Labrador Current along the Labrador coast. Many pass Newfoundland and are carried along the eastern slopes of the Grand Banks where they become serious hazards to ships (Figure 1). Smith (1931), drawing on his own observations and the earlier work of Schott (1904), Mecking (1907), and others, gives an excellent account of the origin, drift, distribution, and eventual disintegration of icebergs.

The number of icebergs which drift south of Newfoundland each year is highly variable, ranging from one or two to over a thousand. Mecking (1907) compiled a record of iceberg counts for the period 1880-1899. Smith (1931) extended this compilation to 1929. Since 1929 the annual Report of the International Ice Patrol Service in the North Atlantic has contained iceberg statistics. This record stretching back in time for 90 years is of interest because it reflects meteorological, oceanographic, and glaciological conditions since the 1880's. However, its validity should be tested by comparison with the record of another environmental parameter which is related to the iceberg count to see if the iceberg record appears consistent.

Internal Consistency of the Iceberg Record

Traditionally the intensity of the iceberg season is measured by the number of icebergs drifting south of 48°N. This is because 48°N represents the approximate northern boundary of trans-Atlantic shipping routes passing south of Newfoundland. Although icebergs can be found south of 48°N in all months of the year, an average of 93% are found during March-July, and these months are considered the iceberg season.

In analyzing the internal consistency of the iceberg record, it is of interest to understand how the various sections of the record were collected. The original compilation made by Mecking for 1880-1899 was of iceberg sighting reports. Because of duplicate sightings Mecking's counts commonly show several thousand iceberg sightings each year. Smith, in contrast, tried to eliminate duplicate reports, and his counts for the years 1900-1929 represent the actual number of icebergs which drifted past 48°N. Smith, through comparison of the two compilations with associated winter surface atmospheric pressure patterns, was able to establish a correspondence between the two different compilations, and published a summary table of iceberg intensity on a scale of 0-10 for the period 1880-1929 (Smith, Unpublished notes)(Smith, 1931). After 1929, although the data were collected and analyzed by different persons, it probably was done rather uniformly until 1942. During 1943-1945 the International Ice Patrol was suspended, and iceberg counts were based on the reports of convoys and military air patrols. It is believed that the counts for these years are too high (Schell, 1962). When the International Ice Patrol recommenced after the war, regular aerial ice patrols replaced ship reports as the primary means of collecting ice information. Because of the relative regularity and more systematic coverage of aerial reconnaissance, the data collected since 1946 is undoubtedly the most accurate.

The iceberg counts used in this paper are given in Table 1, and were based on data presented by Smith (1931), Murray (1969), and Kelly and Morgan (1970).

The environmental parameter used in evaluating the internal consistency of the iceberg record is the December-March atmospheric pressure difference between Belle Isle, Newfoundland and Ivigtut, Greenland. This pressure difference is an indicator of the strength of northwesterly winds along the southern Labrador coast since the pressure gradient it measures is approximately normal to the Labrador coast in a northeasterly direction. Many authors (Mecking, 1907; Smith, 1931; Soule and Challender, 1949; Schell, 1962) emphasize the relationship between the strength of northwesterly winter winds and the drift of icebergs south toward the Grand Banks. Smith (1931) and Schell (1952,1962) made use of Newfoundland/Greenland pressure differences in deriving iceberg prediction formulas. Assuming then that a relationship exists between iceberg intensity and the Belle Isle/Ivigtut pressure difference, if the iceberg data have been collected with relatively uniform accuracy there should be no substantial difference in the iceberg/pressure difference relationship when it is derived for various periods between 1880 and 1969. Such a derivation is made for the periods 1880-1903, 1919-1942, and 1946-1969. These three periods more or less cover the periods of Mecking's data, Smith and pre-aerial patrol data, and aerial patrol data.

Figure 2-January 1971 Iceberg Concentration

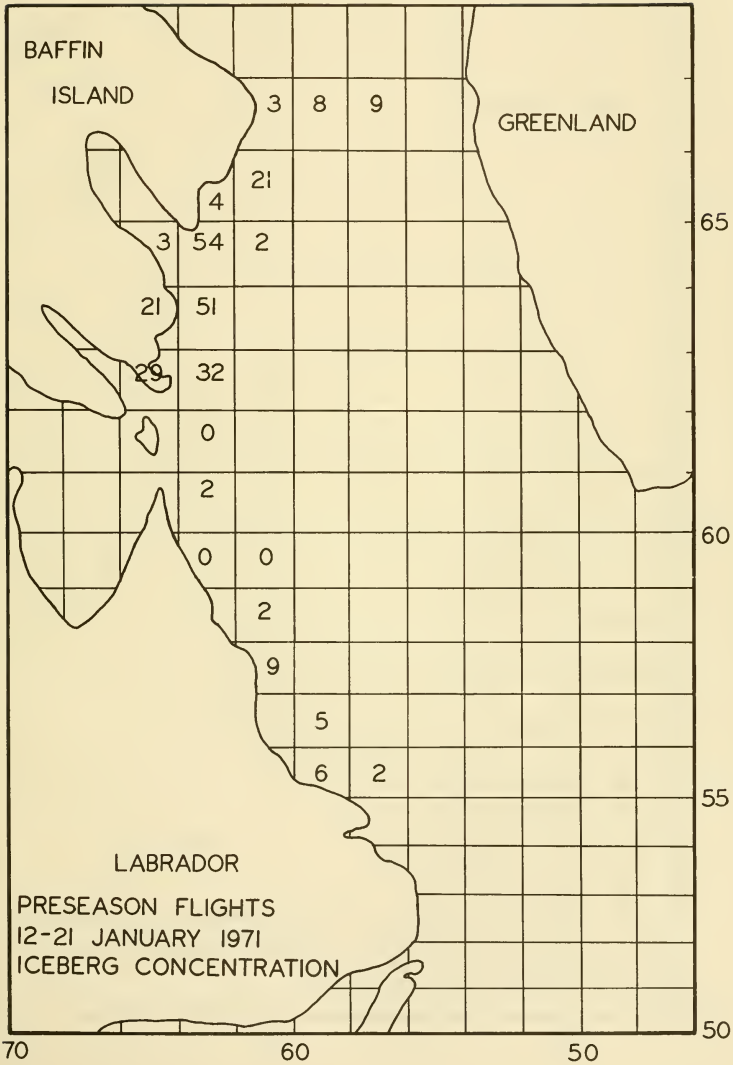


Figure 3-January 1971 Anomoly

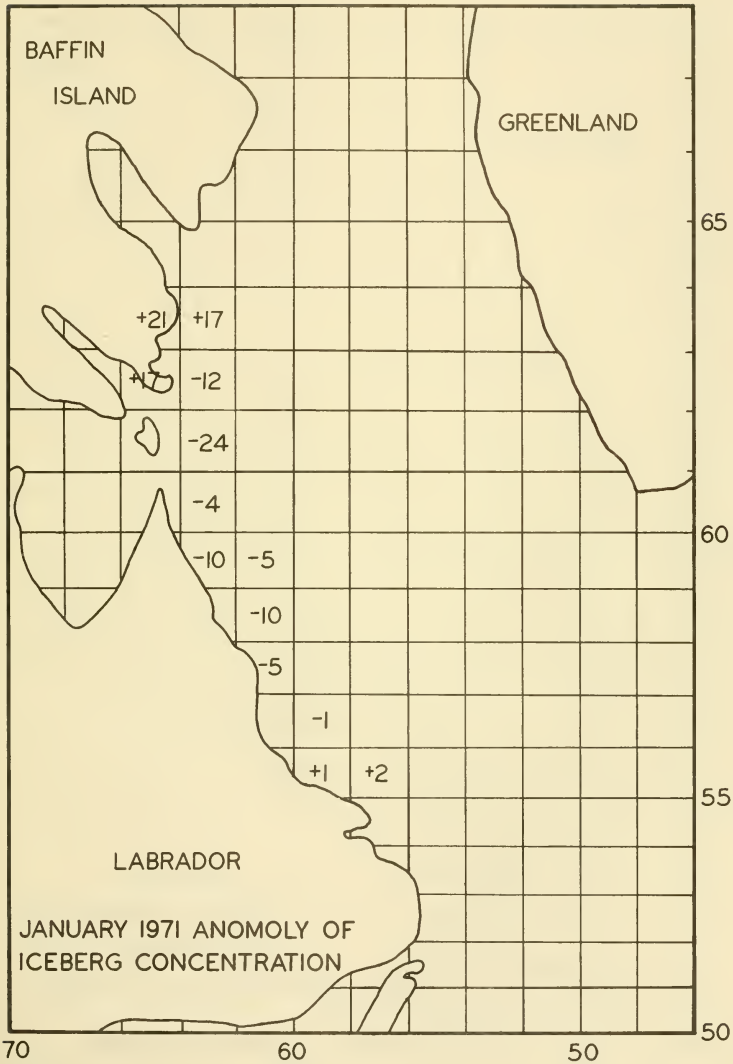


Figure 4-February 1971 Iceberg Concentration

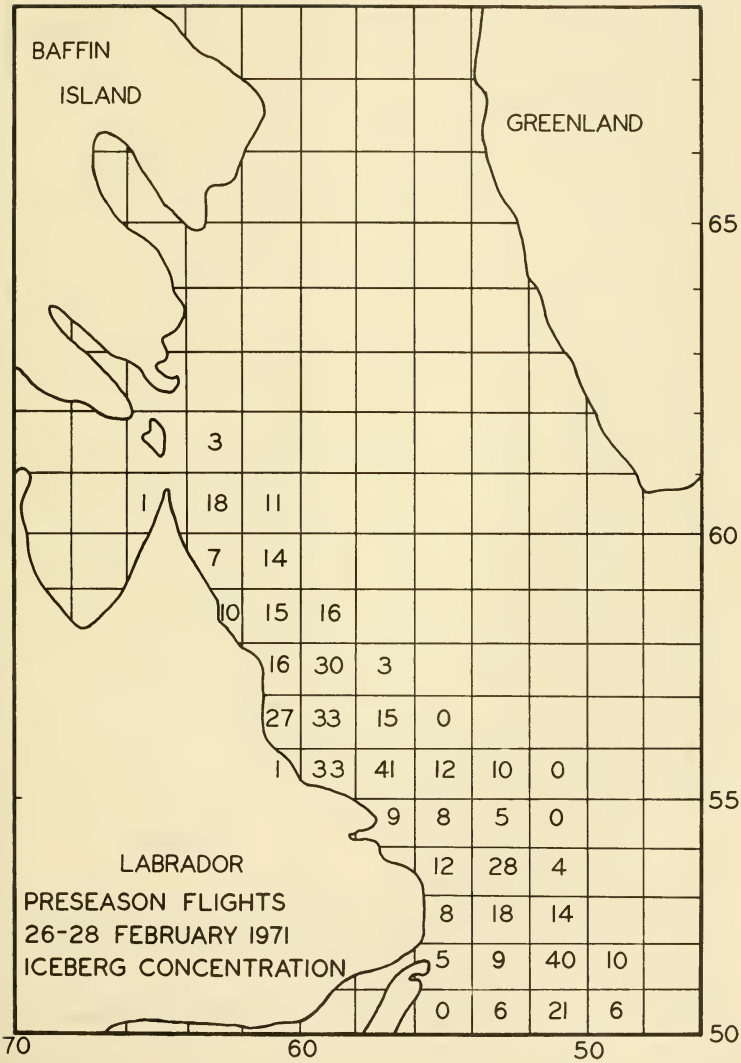
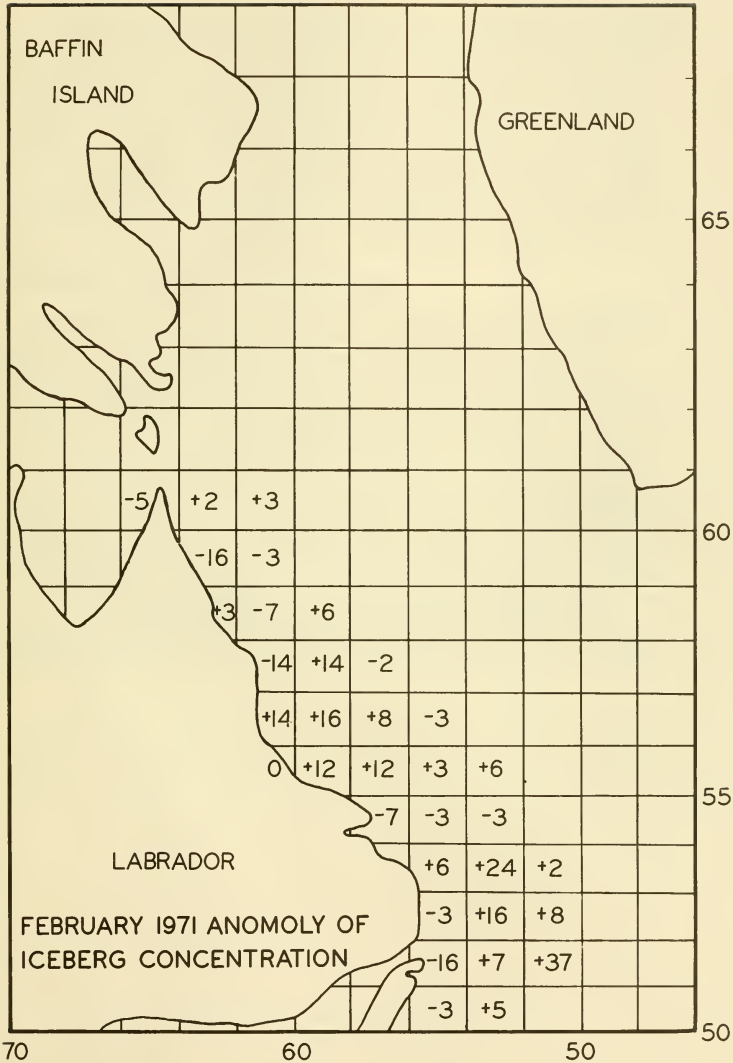


Figure 5-February 1971 Anomoly



The regression line relating iceberg count as dependent variable to December-March Belle Isle/Ivigtut pressure difference as independent variable is shown in Figure 2 for the three periods selected. There is no substantial difference in the slope of the regression line for the three periods, however it is observed that Smith in recompiling Mecking's data possibly introduced bias through considering the December-March Belle Isle/Ivigtut pressure difference to some extent which cannot now be exactly reconstructed. Assuming that the 1946-1969 data are most correct, then the 1880-1903 relationship is high by about 66 icebergs or 19%, and the 1919-1942 relationship is high by about 42 icebergs or 11%. It is concluded that, in terms of average values over about twenty years, differences in iceberg count of more than those shown in Table 2 are probably significant.

Frequency Distribution of Iceberg Counts

Smith (1931) states that iceberg count data fail to follow the requirement that a normally distributed variable show the greatest number of deviations proportionately near the mean. In order to correct this he arranged the data in conformity with the shape of a normal probability curve, and from this constructed a transform curve to convert from actual iceberg counts to normally distributed counts on a scale of 0-10. Smith (1931) and Schell (1952, 1962) made use of normally distributed iceberg data on a scale of 0-10 in deriving their iceberg prediction formulas. Figure 3 shows the frequency distribution of iceberg count data. The distribution is clearly not normal. Low count data are most frequent, with frequency falling off rapidly with increasing count. There are indications of a second frequency mode at 200-400. About 30% of the years since 1880 have seen less than 100 icebergs even though the average count since 1880 is 337 icebergs. In about 50% of the years since 1946 the count has been less than 100 even though the average since then is 222. Thus a normal distribution centered on the average fails to emphasize the fact that iceberg intensity is most commonly very light.

Long Term Trends in the Iceberg Threat to the Northwest Atlantic

In order to analyze the long term trend of the iceberg threat, nineteen year running average iceberg counts were computed for the years 1889-1960. The effect of the nineteen year running average is to remove short term variations in the iceberg record. The choice of 19 years for the period of the running averages was arbitrary; it being desired to show trends which were only significant over periods of about twenty years since that was the approximate periods of the data series in Table 2. The nineteen year running average of iceberg counts is shown in Figure 4. There appear to be three phases in the data. The first phase, extending from 1889 to the early 1920's, was a more or less stable period with average counts running between 325 and 440. The second phase, from the early 1920's to about 1937, was a period when the average number of icebergs was rising to almost 500. During the third phase subsequent to about 1937 the average iceberg count has fallen sharply and almost continously to reach a low of about 200 as of 1960. Comparison of the stable, rising, and declining phases with the criteria in Table 2 indicates that the differences in the three phases are probably significant. Assuming that the trends in Figure 4 are significant, then the average iceberg danger at present is about half of what it was at the time of the sinking of the Titanic in 1912, and is about 45% of what it was in 1937.

Factors Associated with Iceberg Trends

The purpose of this paper is simply to present the long term trend of iceberg statistics. The purpose is not, at this time, to explain the causes of these trends. Presented below is information on long term trends of environmental data that might be expected to be associated with long term iceberg trends. The fact that the data correlates is merely to be interpreted that the iceberg statistics are probably valid. The choice of environmental data is severely limited to that which is available back to 1880.

Soule, et al (1950) indicate that the three most important factors affecting the iceberg threat are 1) the supply of icebergs available, 2) the efficiency of iceberg transport to the northwest Atlantic, and 3) iceberg mortality during the drift south. The complexity of these factors is increased because they are interrelated and act over a path of about 1800 miles and possibly several years duration.

In the case of the iceberg supply factor it is difficult to find environmental data that is both intuitively reasonable and available. Direct iceberg counts in Baffin Bay have been made only a few times since 1880, and are thus not available. Smith (1931) suggested a relationship between summer air temperatures at Upernavik, Greenland and iceberg supply. It is not unreasonable to suspect that increased air temperatures at Upernavik might be related to a decrease in iceberg supply through melting.

In the case of efficiency of iceberg transport, the Belle Isle/Ivigtut pressure difference as a measure of the strength of northwesterly winds has already been described. This pressure difference is probably also associated with the strength of the Labrador Current.

In the case of iceberg mortality during the drift south, Groissmayr (1939) found that the December-February air temperature at St. Johns, Newfoundland correlated with iceberg intensity. It is reasonable to infer that this correlation was related to increased melting caused by either the higher air temperatures or higher water temperatures associated with the higher air temperatures. It should be mentioned that to some degree this correlation must also be attributed to the fact that warmer air temperatures are related to a decrease in northwesterly winds which carry icebergs south.

To investigate the possible iceberg supply, efficiency of transport, and mortality since 1880, the 19 year running average for each of the following was computed and is shown in Figure 4: June-September Upernavik air temperature, December-March Belle Isle/Ivigtut pressure difference, and December-March Torbay, Newfoundland air temperature. The record at Torbay is actually a combination of Torbay and nearby St. Johns. The record at Torbay began in 1946, and the record at St. Johns ended in 1956. A correction which was constant within ±0.1°C in 75% of the cases during the period of overlapping record was applied to the St. Johns data to convert it to Torbay data.

Considering the overall trend of the 19 year running average of temperatures at Upernavik, the temperature in the 1950's is about 0.7°C warmer than in the 1890's, however the details of the Upernavik record are difficult to relate to the iceberg record; there are warming peaks soon after the turn of the century and in the mid-1930's which appear to positively correlate about 7 years later with increasing iceberg intensity on the Grand Banks. Although the Upernavik temperature record does not seem to support the validity of the iceberg statistics, it is of interest that if the iceberg record lags the Upernavik temperature record by about 2 decades, they do seem to correlate inversely as postulated.

The trend of the 19 year running average Belle Isle/Ivigtut pressure difference is in general agreement with the trend of average iceberg counts, thus indicating that the iceberg record is valid. There is an initial period of moderate pressure differences followed by a rise in the 1920's which reached a peak of 9 millibars in the late 1920's, about 6 or 7 years before the iceberg intensity peak. The decline in the average pressure difference since 1929 has been almost uninterrupted.

The 19 year running average air temperature at Torbay has, as expected, varied more or less inversely with the iceberg count. After a low of about -5°C in the early 1920's, about 18 years before the iceberg maximum, the average has climbed steadily, reaching about -2.7°C by the late 1950's. The air temperatures at Torbay also correlate inversely with the Belle Isle/Ivigtut pressure difference, as expected.

Conclusions

The evidence indicates that there has been a significant decrease in the severity of the iceberg threat to the northwest Atlantic since the 1880's. This decrease is apparently substantiated by a trend toward winds less favorable for the drift of icebergs along the Labrador and Newfoundland coasts, and by an increase in air temperature along the Newfoundland coast.

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Table 1

Number of Icebergs Drifting South of 48°N, March-July

Year	Count	Year	Count	Year	Count	Year	Count	Year	Count
1880	367	1898	414	1916	54	1934	574	1952	14
81	33	99	451	17	38	35	869	53	56
82	549	1900	76	18	125	36	22	54	295
83	367	01	68	19	187	37	397	55	61
84	600	02	36	20	340	38	659	56	80
85	772	03	792	21	679	39	844	57	879
86	237	04	260	22	455	40	1	58	1
87	405	05	800	23	228	41	2	59	689
88	302	06	364	24	8	42	30	60	250
89	149	07	623	25	106	43	833	61	107
90	959	08	181	26	330	44	699	62	120
91	93	09	904	27	372	45	1062	63	25
92	237	10	50	28	502	46	428	64	365
93	321	11	323	29	1320	47	59	65	75
94	549	12	996	30	342	48	523	66	0
95	79	13	523	31	13	49	47	67	441
96	195	14	571	32	513	50	444	68	222
97	549	15	359	33	214	51	2	69	53

Table 2

Significant Differences in Iceberg Data

Periods from which Data is being Compared	Difference is probably Significant if more than (over a twenty year average)
1880-1903 and 1946-1969	66 icebergs
1880-1903 and 1919-1942	24 icebergs
1919-1942 and 1946-1969	42 icebergs

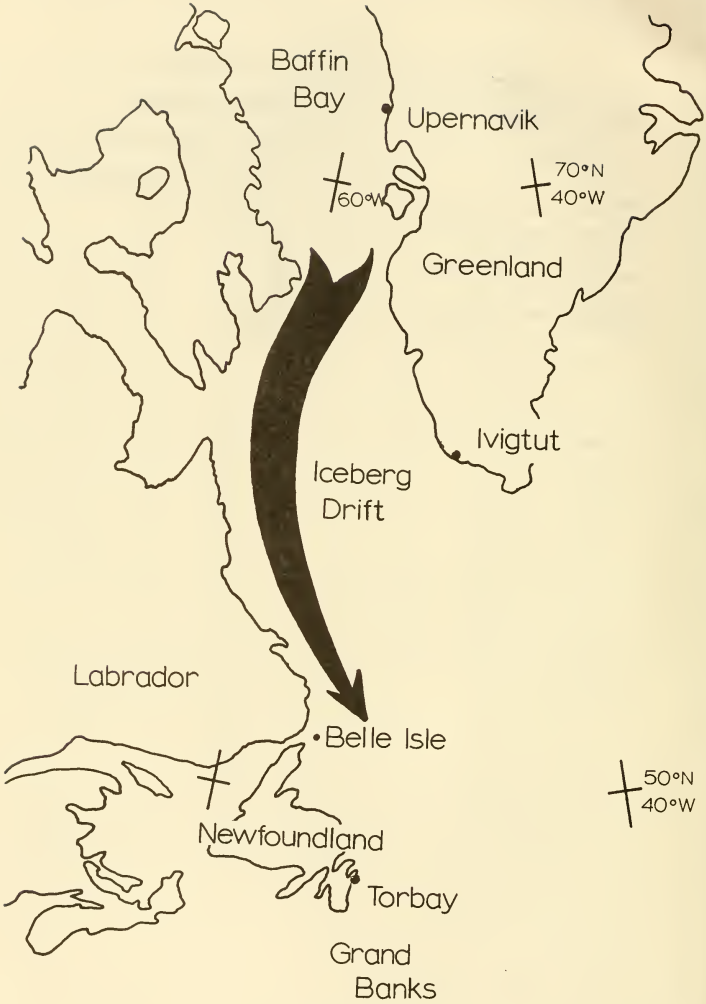
Baffin
Bay
Upernavik
60°W
70°N
40°W
Greenland
Ivigtut
Iceberg
Drift
Labrador
Belle Isle
50°N
40°W
Newfoundland
Torbay
Grand
Banks

Figure 1

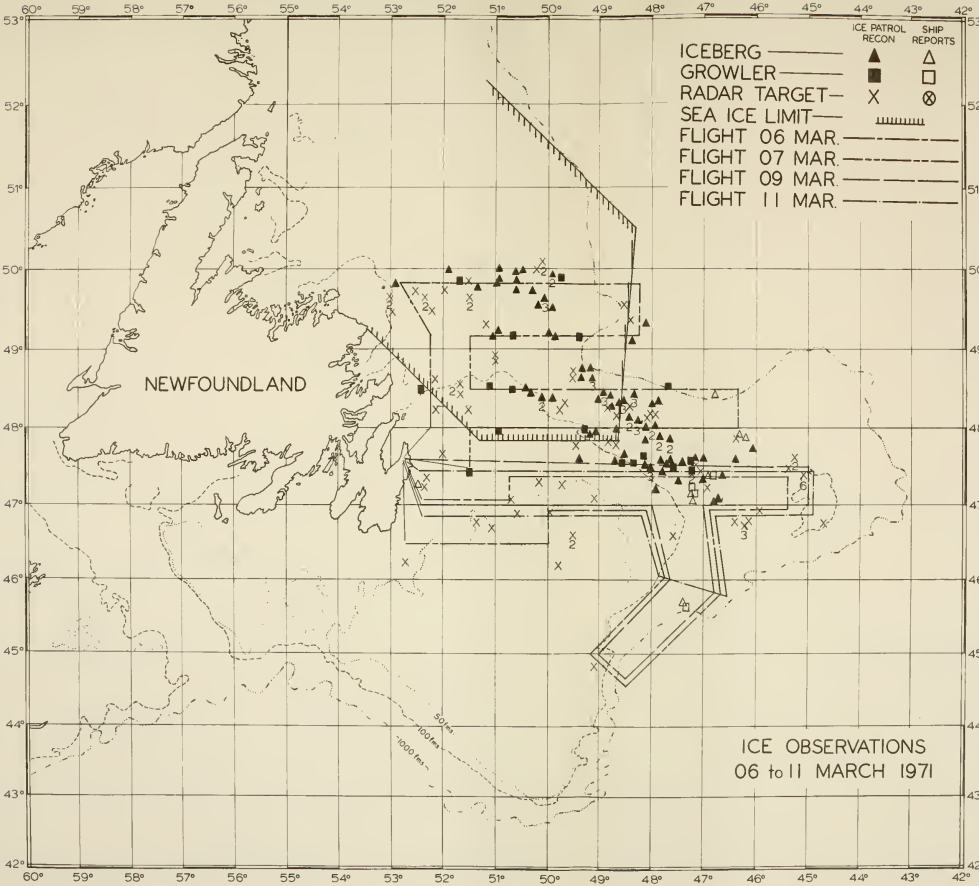

Figure 5-Ice Observations, 6-11 March 1971

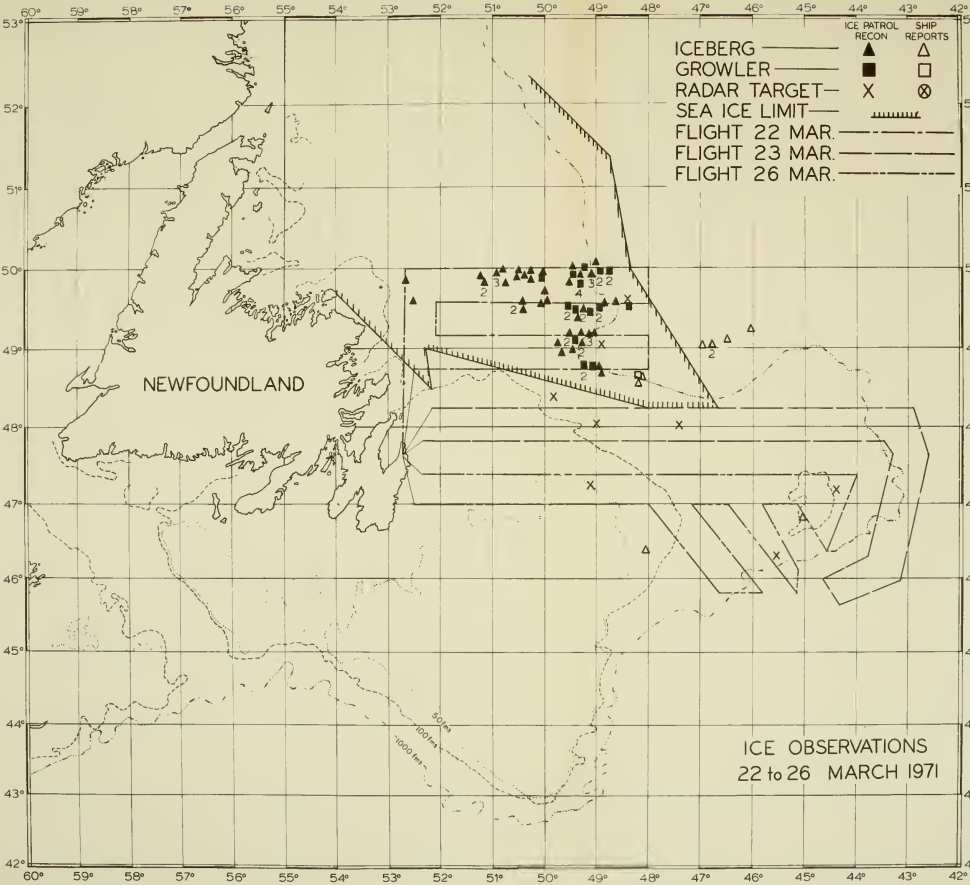

Figure 7-Ice Observations, 22-26 March 1971

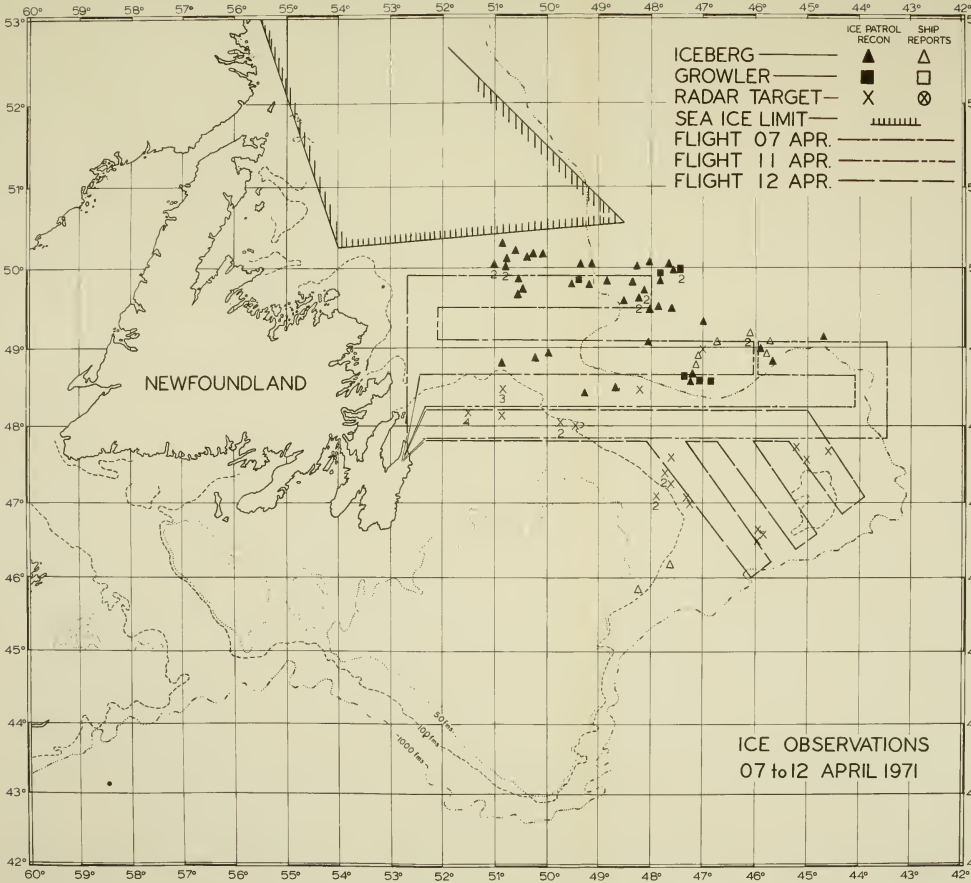

Figure 5-Ice Observations, 7-12 April 1971

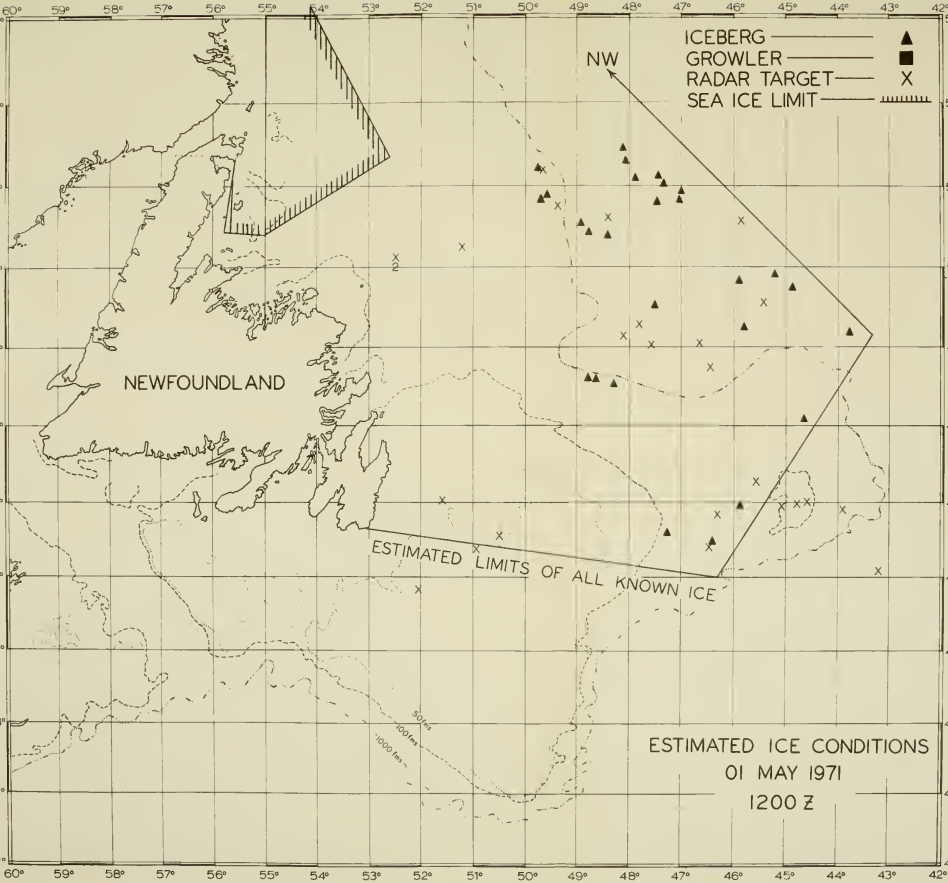

Figure 9-Estimated Ice Conditions, 1 May 1971

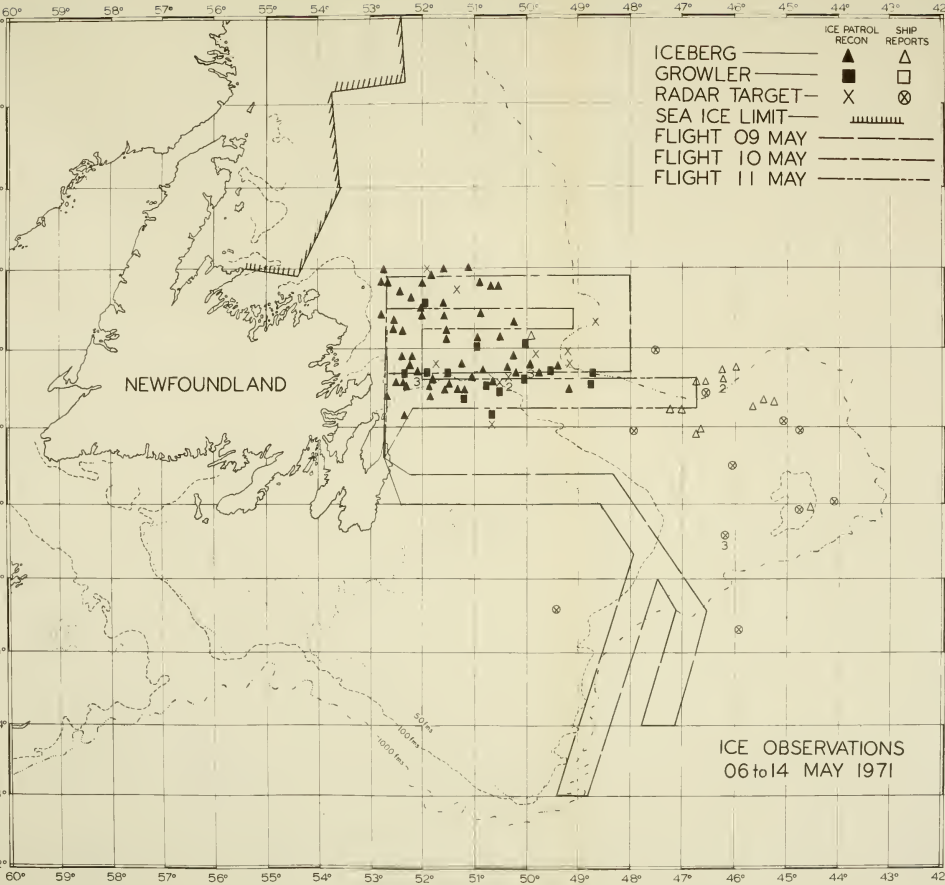

Figure10-Ice Observations, 6-14 May 1971

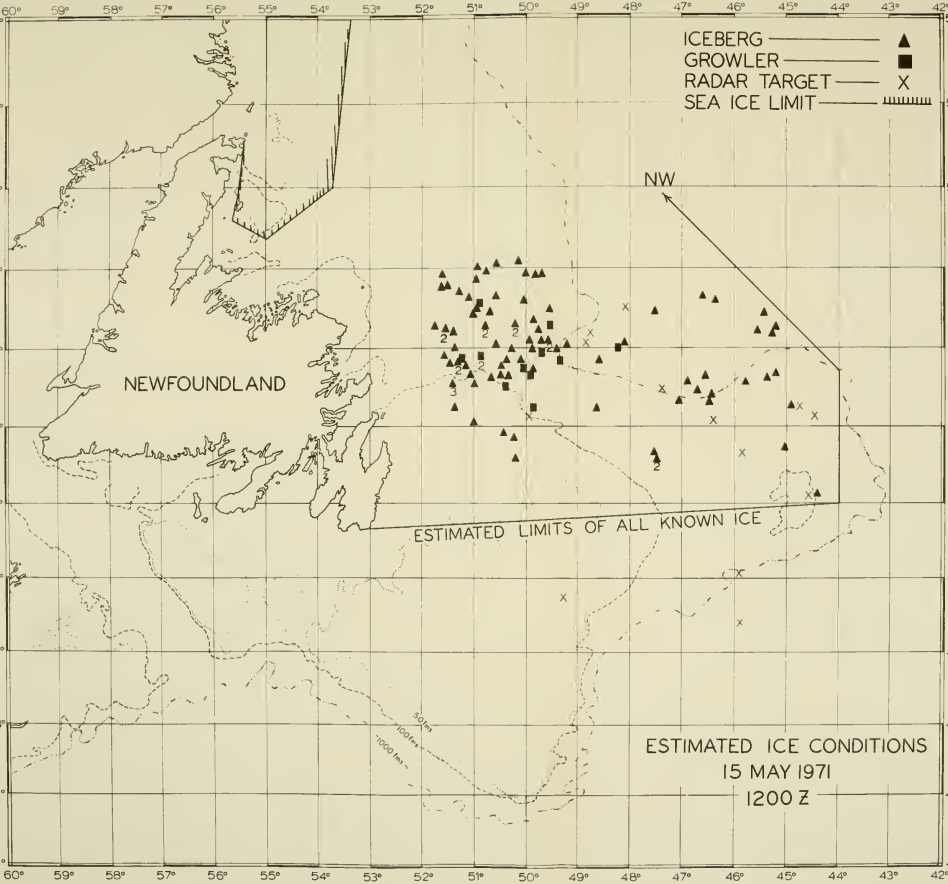

Figure 11-Estimated Ice Conditions, 15 May 1971

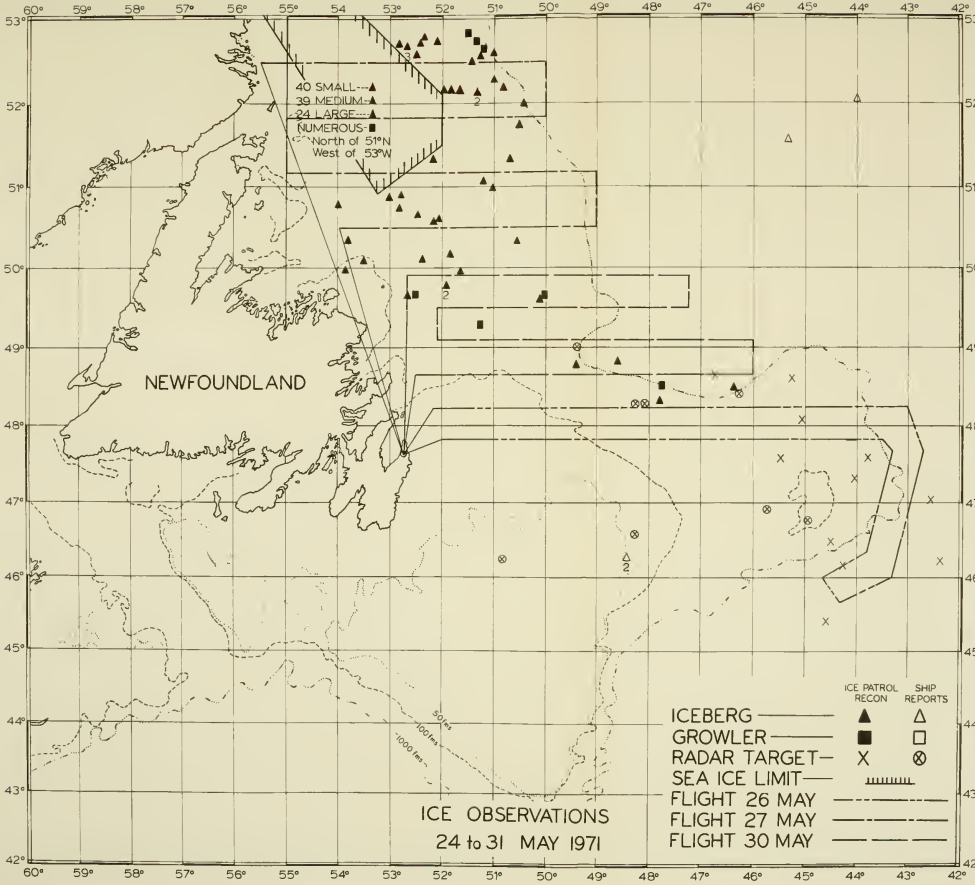

Figure 13-Ice Observations, 24-31 May 1971

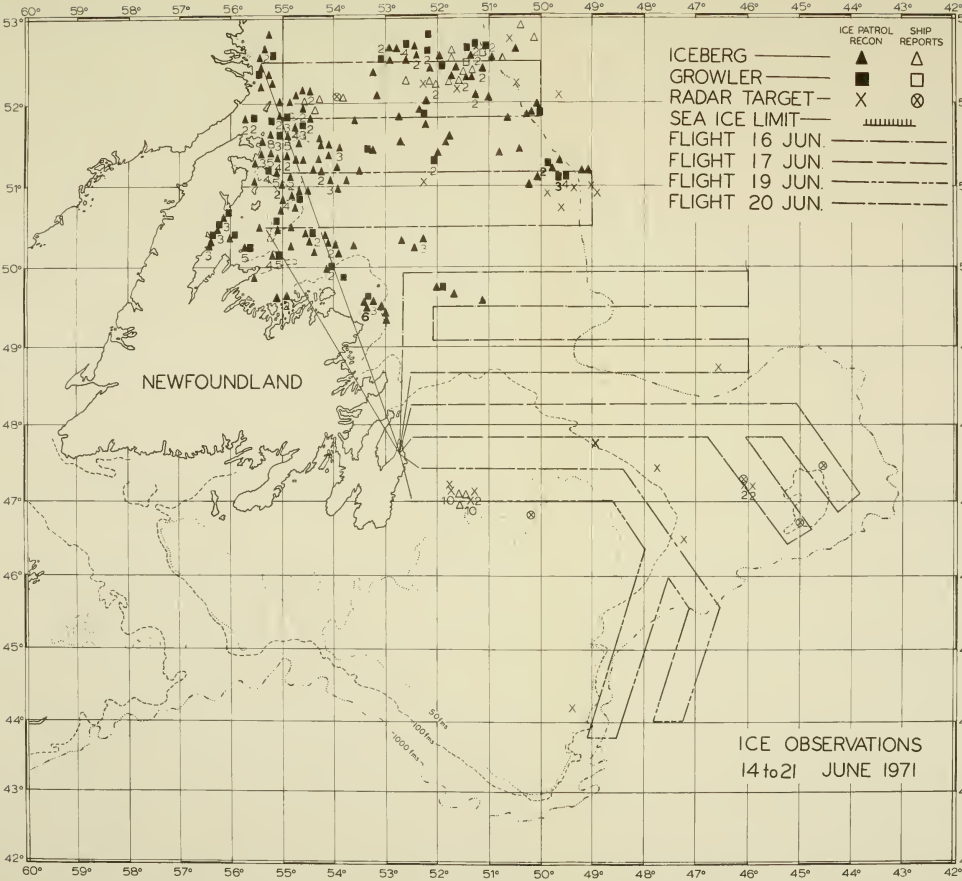

Figure 13-Ice Observations, 14-21 June 1971

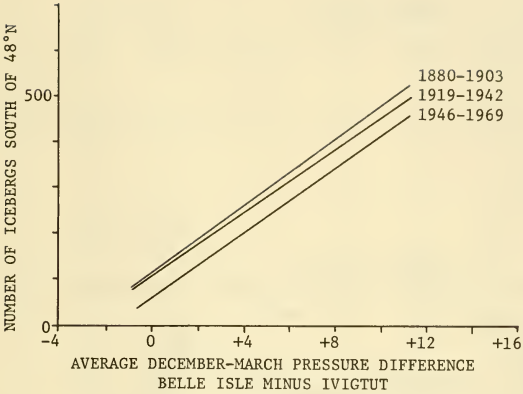

Figure 2

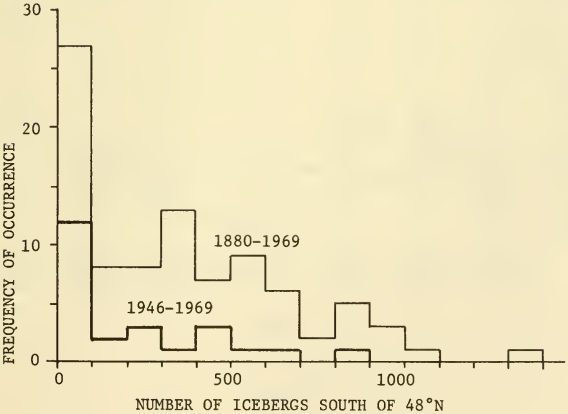

Figure 3

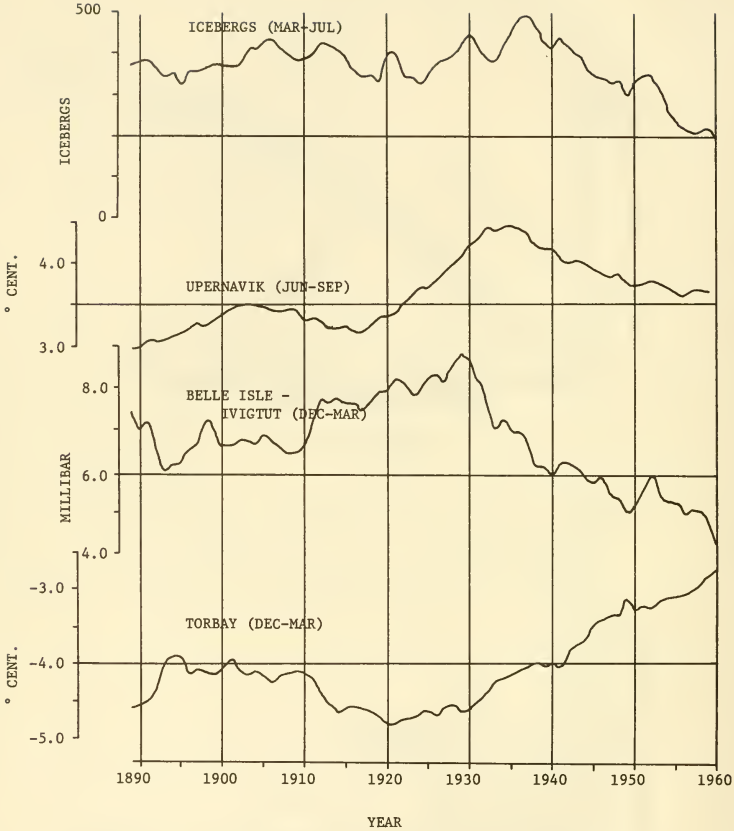

Figure 4

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