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Sea Ice and Iceberg Conditions, 1970-1979

by

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An iceberg is a mass of ice which originated on land and has broken away from its parent formation on the coast and either floats in the ocean or is stranded on a shoal. An iceberg usually refers to an irregular mass of ice formed by the calving of a glacier along a coast where a glacier terminus reaches the ocean. An iceberg should be distinguished from a floeberg which is a mass of hummocked multiyear sea ice formed by the piling up (rafting) of many sea ice floes by lateral pressure. Sea ice on the other hand is formed by freezing seawater. These two distinct types of origin are the reason for the distinctly different characteristics and distribution of sea ice and icebergs.

The areas of the eastern Arctic which produce icebergs that drift onto the Grand Banks are (Figure 1):

1. The west coast of Greenland (Principally from Disko Bay to Cape York, Greenland)

2. Ellesmere Island

3. An occasional iceberg from East Greenland

4. Very rarely an ice island may enter Robeson Channel and break up creating many tabular icebergs (The last such occurence was 1963). Greenland produces approximately 98% of all icebergs drifting in Baffin Bay and the Labrador Sea. These icebergs are produced by approximately 20 glaciers. Murray (1969) stated that Melville Bay is the principal source of icebergs that drift into the North Atlantic. Recent field work in West Greenland by Dr. R. C. Kollmeyer (personal conversation) confirmed that this is true.

Once an iceberg is calved there is very little likelihood that it will ever reach the Grand Banks of Newfoundland. Of approximately 40,000 icebergs calved annually, there are only an average of 377 (1900-1979 average) which drift south of 48°N latitude. There are four primary factors which determine if an iceberg will ever make it to the Grand Banks. They are:

- The annual iceberg production
- The environmental conditions (meteorological and oceanographic). prevalent as the iceberg drifts free of the fjord. (These conditions will determine how the iceberg transits Baffin Bay.)
- Atmospheric and oceanic milieu during the transit of Baffin Bay.
- The rate of deterioration as the iceberg drifts toward the Grand Banks.

Icebergs that are drifting southward (in the Baffin Land and Labrador Currents) can also be eliminated by several specific factors. These are drifting either eastward into the comparatively warmer ice-free water found there and deteriorating or drifting westward and becoming trapped in the bays and shoal areas along the coast. (The major traps are Hudson Strait, Belle Isle Strait, and Notre Dame Bay.)

Kelly, (1968), using information obtained from International Ice Patrol ice reconnaissance flights, produced a chart of smoothed iceberg density for September – October, 1968 (Figure2). His work suggests four main routes for iceberg drift in Baffin Bay. These are:

- From Disko Bay, Greenland to Cape Dyer, Baffin Island and hence southward. Arrow "A" in Figure 2.
- Northwestward from the Unamak Fjord, Greenland across Baffin Bay to Baffin Island and thence southward. Arrow "B" in Figure 2.
- Southwestward from Melville Bay, Greenland across Baffin Bay and then southward. Arrow "C" in Figure 2.
- The classical route, northwestward from northwestern Melville Bay, Greenland counterclockwise around Baffin Bay and thence southward in the Baffin Land and Labrador Currents. Arrow "D" in Figure 2.

The path that a drifting iceberg follows is influenced by the wind,the current, and the earth's rotation. The wind can directly influence the path that a drifting iceberg follows. The wind velocity to a large extent is directly related to the position and intensity of the Icelandic Low (Figure 3). The main atmospheric features of interest in the North Atlantic are the Icelandic Low and the Bermuda-Azores High. These features are only a portion of the two zonal belts of high and low pressure that girdle the earth.

The Icelandic Low is not a single low, but rather it represents an area where lows are formed or intensified. Such extratropical cyclogenesis occurs in areas of strong baroclinicity. There are two such areas in the eastern Arctic:

- East Greenland
- East of Newfoundland

Baroclinicity occurs when the density and the pressure surfaces are not horizontal. Since atmospheric density is directly proportional to temperature, baroclinic areas occur where there are large horizontal temperature gradients. Such areas are land water interfaces or regions of differing sea surface temperatures. These baroclinic regions cause any low arriving there to be intensified.

When one realizes that virtually every low which crosses the continental United States or southern Canada enters one of these areas, the reason for the occurrence of the Icelandic Low as a persistent feature is clear. The location and intensity of the Icelandic Low is a very important factor which determines the severity of the iceberg season. A preceding winter with a well developed Icelandic Low in the proper location will favor a severe iceberg season, i.e., a large iceberg count on the Grand Banks. It alone however, does not guarantee that a large iceberg count will occur. The normally developed and positioned Icelandic Low will set up an atmospheric circulation pattern which will transport the icebergs out of the fjords of west Greenland across Baffin Bay and down the coast of Labrador. It will also pull cold continental air from Canada which insures that the icebergs will be moving in a protective field of sea ice and therefore not deteriorating significantly. The lack of icebergs south of Hudson Strait in the fall and winter, as contrast to the remainder of the year is directly attributable to the absence of sea ice and comparative warm sea surface temperatures which occur after July. A delay for any significant amount of time as it drifts south may prove fatal to an iceberg.

The Baffin Land and Labrador Currents are another major part of the transportation system which move the icebergs southward. These currents, which are much slower than the wind, act on the much larger subsurface portion of the iceberg. A well developed current system is a necessary but not sufficient condition for a heavy ice year. 1958 is an example of a light year in which the Labrador Current was well developed.

Perhaps the most important characteristic of seawater when considering sea ice is the manner that seawater density varies with salinity. If the salinity is greater than 24.7 ^{o}/oo, the density of the water increases steadily with decreasing temperature until the freezing point is reached. This insures that cooling of the surface causes convective currents which produce thick isothermal layers of water which have a temperature equal to the freezing point seawater. The wide continental shelves of Labrador and Newfoundland allow the shallow water to become thoroughly chilled. This chilled layer provides an environment in which an iceberg can drift without any significant deterioration occuring. The sea ice distribution also tends to reflect the continental shelf topography.

Sea ice on the Grand Banks is at its maximum extent from March through May (Figure 4). Naturally this a variable quantity; in heavy sea ice years, long strips of sea ice are found drifting parallel to the current as far south as 43^{o}N latitude. This was more common in the early 1930 s than presently.

Sea ice drift is directly affected by the wind and near surface currents. Sea ice which has drifted out of the Labrador Current into the Labrador Sea, i.e., away from the continental shelf, deteriorates rapidly because of the higher surface water temperatures in the Labrador Sea. Hence, the prevailing wind direction will also have tremendous influence on the extent of the sea ice.

Icebergs and sea ice do not drift at the same rates since wind induced forces are not the same. The wind force on sea ice is a complex function of the vertical wind velocity profile and the sea ice roughness. The wind force on an iceberg is due to form drag, i.e., drag that is directly related to the geometry of the iceberg. Sea ice and icebergs also respond differently to currents. Again water force on the sea ice is dependent upon the sea ice roughness parameter and the vertical current velocity profile beneath the sea ice. The current force on the iceberg is an integration of the velocity shear acting on the subsurface portion of the iceberg. Hence, when the wind blows, the iceberg and the sea ice respond differently. Obviously, there is also a large mass difference.

Observations of iceberg wakes in sea ice show that the wakes are generally downwind. This implies that the sea ice moves faster than the iceberg, under influence of the wind.

Close pack sea ice, i.e., concentrations greater than 7 octas has a large direct and indirect influence on the drift of icebergs. Such heavy ice concentrations can exert forces on the iceberg by direct collisions. Wind and current forces may cause sea ice convergence areas in which the icebergs become firmly locked.

The sea ice indirectly influences iceberg drift by hindering the formation of wind driven currents. The wind profile over an ice field is also altered resulting in modified wind forces on the iceberg. Observations of icebergs in thick winter close ice indicate that the iceberg moves with the sea ice implying that the forces acting on the ice floes are directly transferred to the iceberg. This is not true in young ice (which is thinner) or in open polar ice.

In the Antarctic observations covering a two year interval show that 90% of the time growlers and fragments of the iceberg drift downwind from the iceberg. When there is a sudden wind shift, these fragments may be found on the upwind side of the iceberg (Lebedev, 1957).

Morgan (1971) clearly showed that the long term trend in the number of icebergs drifting south of 48^{o}N latitude had decreased significantly since the mid-1930 ies (Table 1). He also examined the internal consistency of the iceberg count record and determined that it was consistent with the available environmental data.

Table 1

Average Number of Icebergs Drifting south of 48°N latitude by decade

Years	Annual Number of Icebergs
1932 – 1941	419
1942 – 1951	418
1952 – 1961	252
1962 – 1971	147
1972 – 1981	468

Although there was a decreasing trend in the average number of icebergs drifting south of 48°N latitude the annual variation was quite large. (from zero icebergs in 1966 to 1083 in 1945).

This trend came to an abrupt end in 1972 with a totally unexpected number of icebergs drifting south of 48°N latitude including the longest iceberg and heaviest iceberg season on record.

A record number of 1587,850 and 1386 icebergs drifted south of 48°N latitude in 1972, 1973, and 1974 respectively (and as Table 1 indicates the trend reverses) to place these iceberg counts in perspective there had been 4 previous years when the iceberg counts had exceeded 1000. (Table 2).

Table 2

Years in which iceberg counts greater than 1000 occured 1900-1981

Year	Number of icebergs drifting south of 48°N latitude
1909	1042
1912	1041
* 1929	1329
1945	1083
1972	1587
1973	1385

* previous record iceberg count year

What had occured in three years were two years whose iceberg counts had exceed the previous record year 43 years earlier! 1973 with an iceberg count of 850 had only been equaled once in 1939 and exceed in 1935 with 872 icebergs and in 1957 with 931 icebergs (excluding the previous indicated years in Table 2). Strangely enough after these three extraordinarily heavy years the number of icebergs drifting south became very low averaging 84 icebergs (Table 3) (1981 is presented for completeness).

Scobie and Schultz, 1976 studied the meterological and oceanographic conditions which produced the 1972 record iceberg count. They concluded "The record number of icebergs drifting into the North Atlantic Ocean . . . was a result of all critical meteorological and oceanographic factors being favorable for such iceberg drifts prior to and during the ice season. The single most important factor in this record year was the increased intensity (and favorable location) of the Icelandic Low. This resulted in favorable northwesterly winds carrying colder than normal air temperatures which in turn helped produce greater sea ice extent, (which reduced the iceberg deterioration rate) and lower sea surface temperatures."

Kukla and Kukla (1974) studied the snow and sea ice extent using satellite images and computer processing. They indicated that the weather from 1968 to 1971 was normal while 1972 and 1973 were anomalous on a global basis. These anomalous conditions produced a record coverage of 66.7×10^6 km^2 on 10 February 1972.

As a personal note from the author I would like to relate the feelings which existed in 1972 as the record year progressed. The first feeling was, "Why is it such a heavy year?" and the second was , "When is it going to end?".

TABLE 3 - ESTIMATED NUMBER OF ICEBERGS SOUTH OF LATITUDE 48N

	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SOUTH OF 48N TOTAL	# BERGS SIGHTED TOTAL
1970	0	0	0	0	0	0	0	5	2	70	8	0	85	2350
1971	0	0	0	0	0	0	31	4	20	7	11	0	73	1106
1972	0	0	0	0	0	40	185	501	559	225	48	26	1584	8045
1973	4*	0	0	6	54	110	134	212	159	151	19	1	850	4904
1974	0	0	0	0	0	1	99	345	446	266	168	61	1386	7218
1975	1	0	0	0	0	24	41	10	20	5	0	0	101	910
1976	0	0	0	0	0	0	33	13	67	35	3	0	151	1535
1977	0	0	0	0	2	8	34	92	91	55	15	3	300	1075
1978	0	0	0	0	0	0	5	28	35	7	0	0	75	1834
1979	0	0	0	0	0	5	20	81	34	9	3	0	152	564
1980	0	0	0	0	1	3	7	0	9	4	0	0	23	197
1981	0	0	0	0	0	0	48	10	5	0	0	0	63	180

*The 1972 Season ended on September 4th. Three of these bergs actually drifted south of 48^{o}N during the 1972 Ice Season. To provide statistical continuity they are included in the September monthly tabulation for the 1973 Ice Season.

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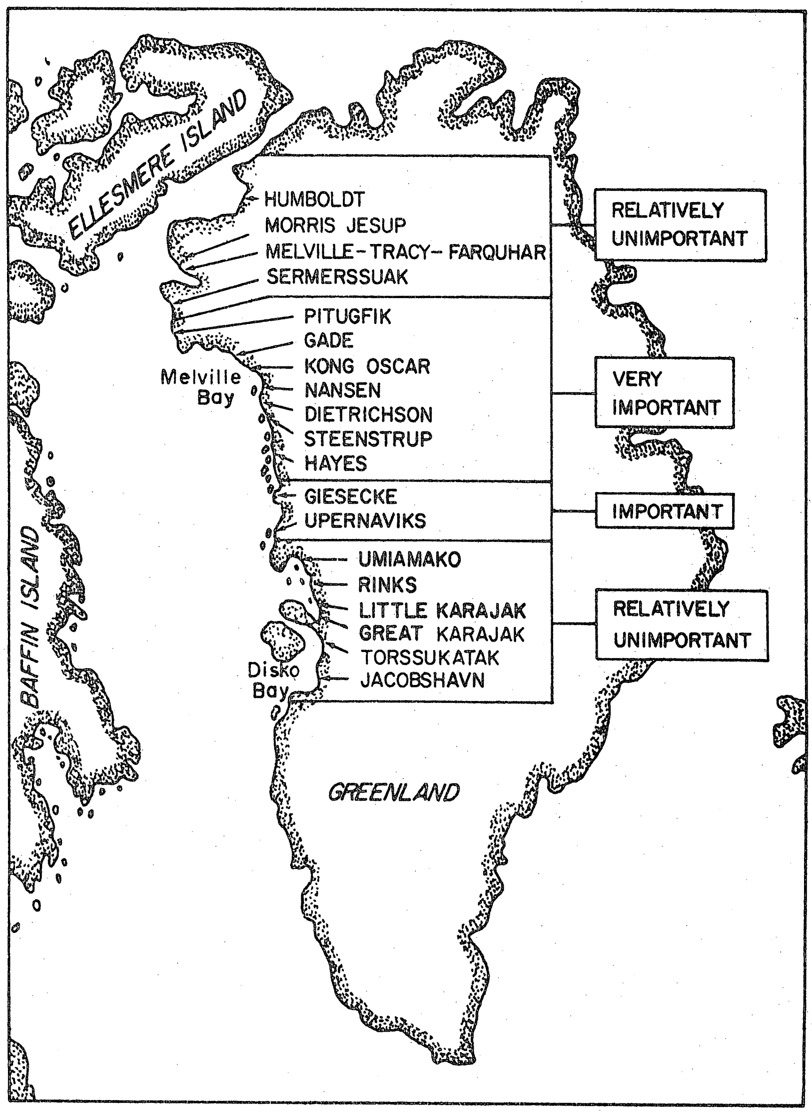

Figure 1. Principal Iceberg Producing Glaciers along West Greenland Coast. The most productive iceberg producing glaciers are located in Melville Bay.

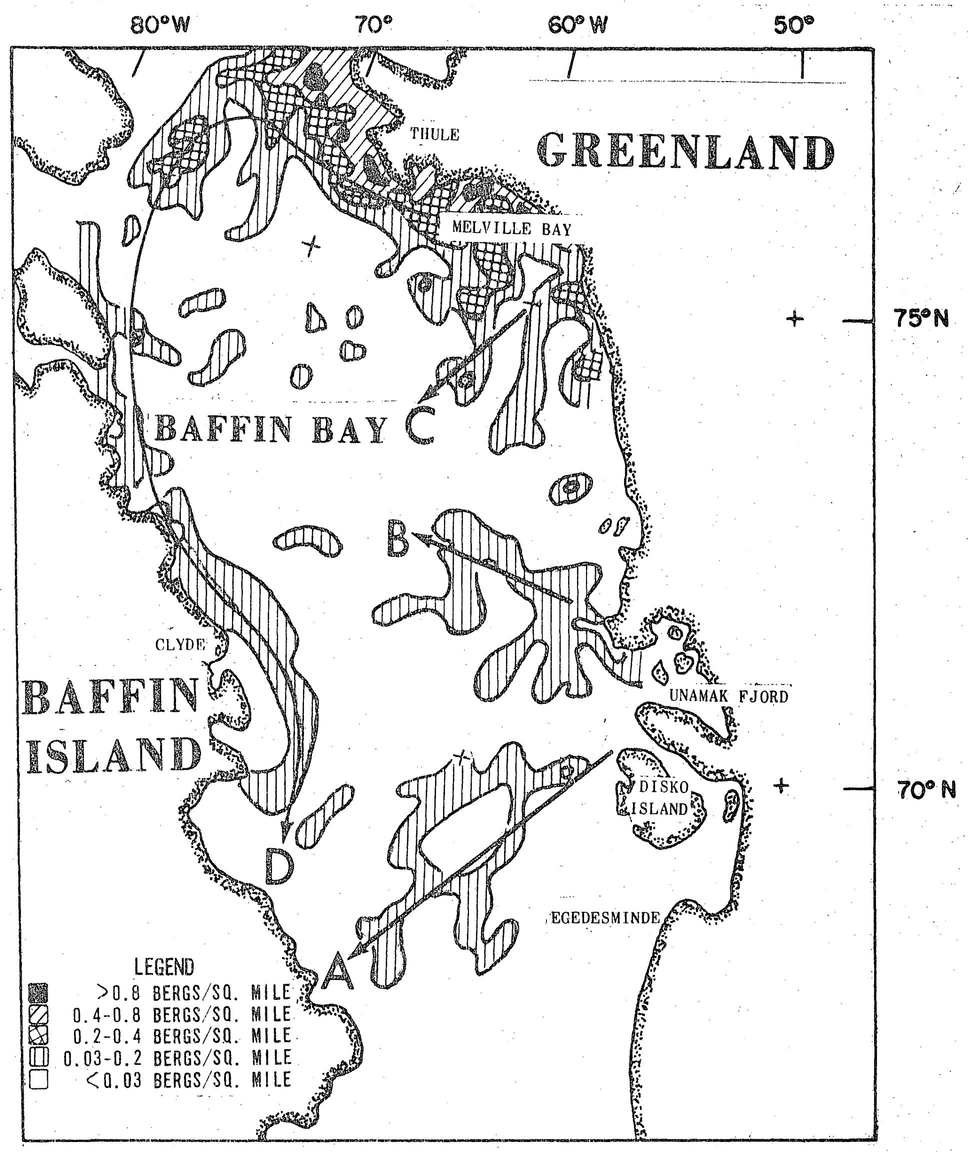

Figure 2. Iceberg density (icebergs/nmi) observed by the International Ice Patrol, September - October, 1968. The arrows represent what are believed to be the main routes for icebergs to drift out of Baffin Bay. The time required for an iceberg to exit Baffin Bay drifting along path A is a small fraction of the time required by an iceberg drifting along track D.

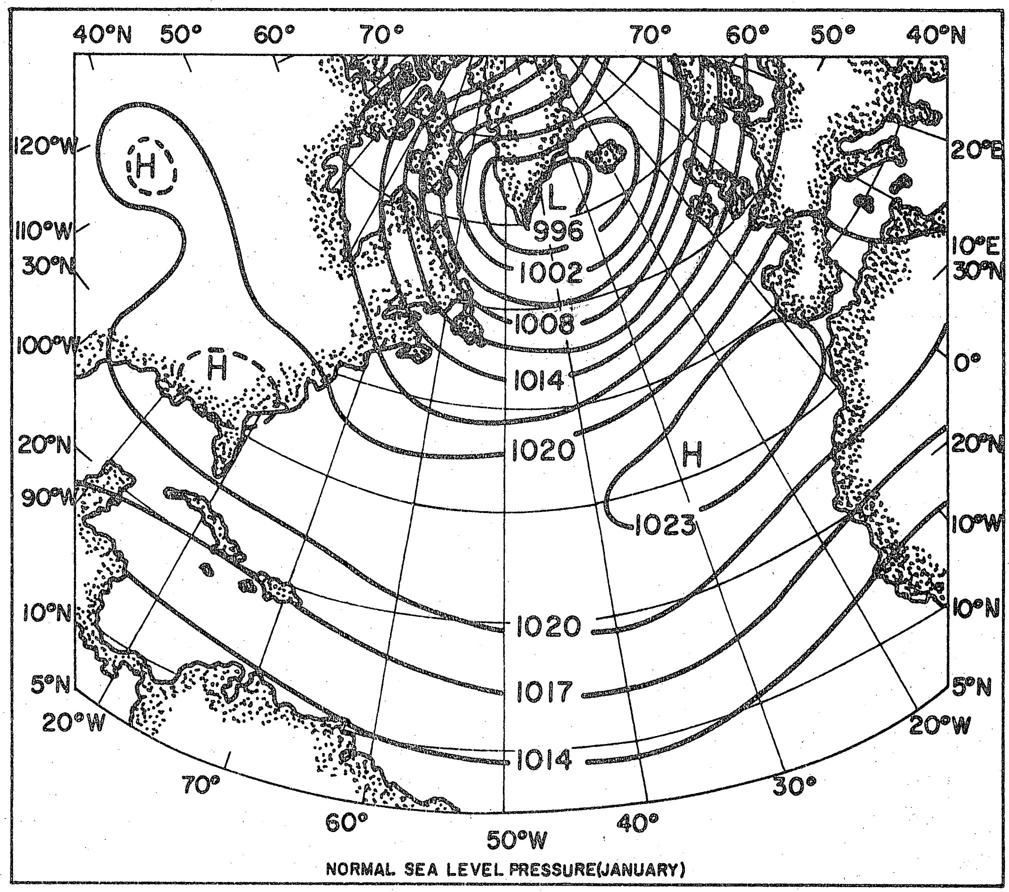

Figure 3. Normal sea level pressure distribution for January (pressure in millibars). A fully developed Icelandic Low will cause offshore winds to remove freshly calved iceberg from West Greenland glaciers and northwest winds to drift them along the Labrador coast. After Chase 1956.

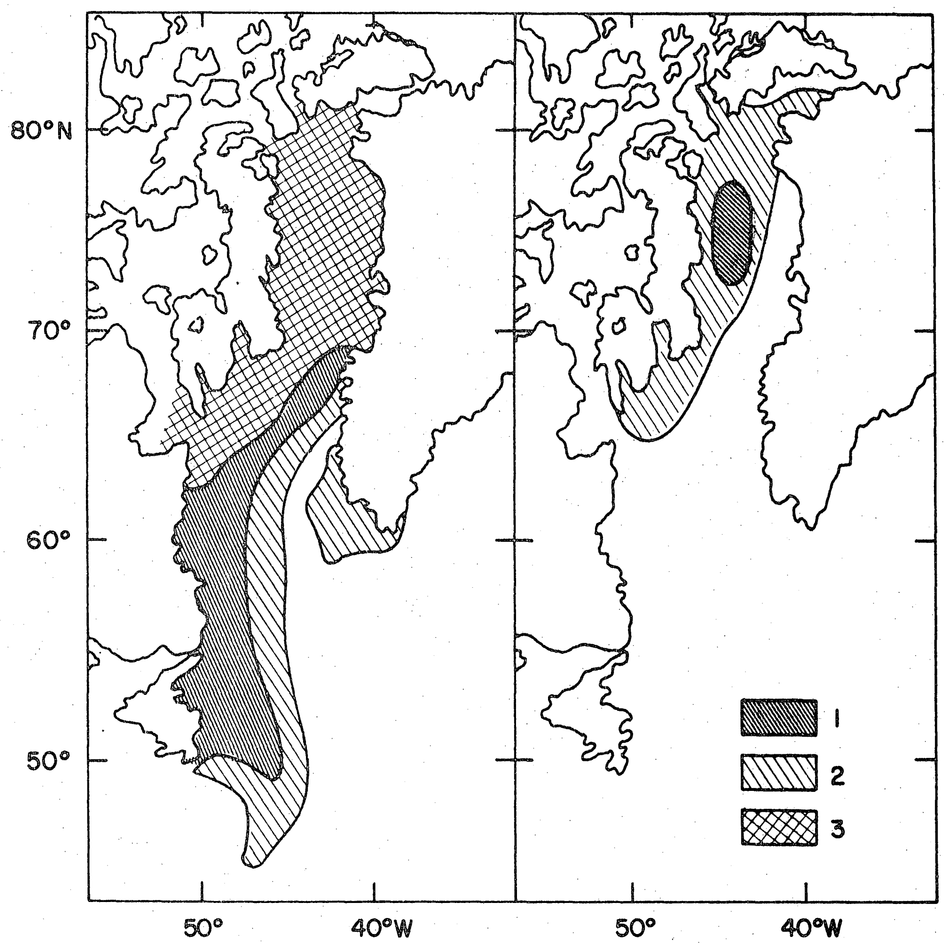

Figure 4. Mean sea ice limits for heavy and light sea ice years. 1. Average extent; 2. Extreme extent; 3. Exceptionally light. After Lebedev, 1965.