NAFO Sci. Coun. Studies, 5: 39-42

Sea Ice and Iceberg Conditions, 1970-79

T. C. Wolford
U. S. Coast Guard Oceanographic Unit
Washington, D. C. 20593, USA

Abstract

The number of icebergs (averaged by decades) drifting south of 48° N in the Northwest Atlantic decreased steadily between 1932-41 and 1962-71. Extraordinarily heavy ice conditions occurred in 1972, 1973 and 1974 when 1,588, 846 and 1,387 icebergs were sighted south of 48° N. The previous record was 1,329 icebergs in 1929. After these three heavy ice years, the annual number of icebergs drifting south of 48° N averaged only 123 during 1975-81, the range being from 23 to 300. The record number of icebergs in 1972 has been attributed to favorable oceanographic and meteorological conditions for iceberg drift prior to and during the ice season.

Introduction

An iceberg is a mass of ice which has broken away from its parent formation on land near the coast and either floats in the ocean or becomes stranded in shallow water. An iceberg, which originated from a glacier, is different from a floeberg, which is a mass of hummocked multiyear sea ice formed by piling up (rafting) of 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 Arctic which produce icebergs that drift southward to the Grand Bank are the west coast of Greenland, principally from Disko Bay to Cape York, and Ellesmere Island in the Canadian Arctic (Fig. 1). An occasional iceberg may come from East Greenland, and very rarely an ice island may enter Robeson Channel (between Ellesmere Island and Northwest Greenland) and break up into many tabular icebergs, the last such occurrence being in 1963. Greenland produces approximately 98% of all icebergs drifting in Baffin Bay and the Labrador Sea. These icebergs are produced by about 20 glaciers. Murray (1969) stated that Melville Bay is the principal source of icebergs that drift into the Northwest Atlantic.

Iceberg and Sea Ice Drift

Once an iceberg breaks away from a glacier, there is very little likelihood that it will ever reach the Grand Bank off Newfoundland. Of approximately 40,000 icebergs produced annually, only a few drift south of 48° N latitude (average of 377 annually during 1900-79). There are four primary factors which determine if an iceberg will ever reach the Grand Bank: (a) annual iceberg production, (b) prevailing environmental (meteorological and oceanographic) conditions as the iceberg drifts free of the fjord, (c) atmospheric and oceanic milieu during its transit of Baffin Bay, and (d) rate of deterioration as it drifts toward the Grand Bank. Icebergs drifting southward in the Baffin Island and Labrador Currents can also be eliminated by drifting eastward into warmer water of the Labrador Sea and

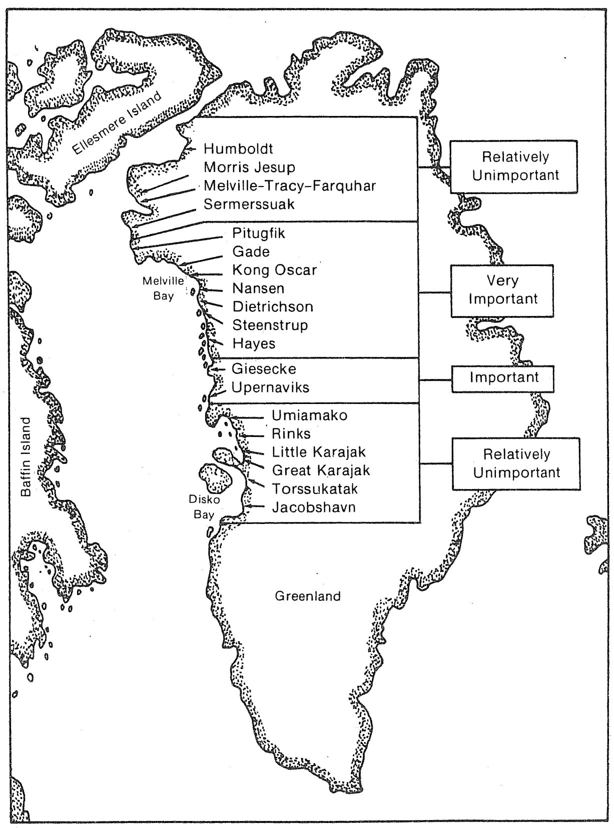

Fig. 1. Principal iceberg producing glaciers along West Greenland. (The most productive iceberg-producing glaciers are located in Melville Bay.)

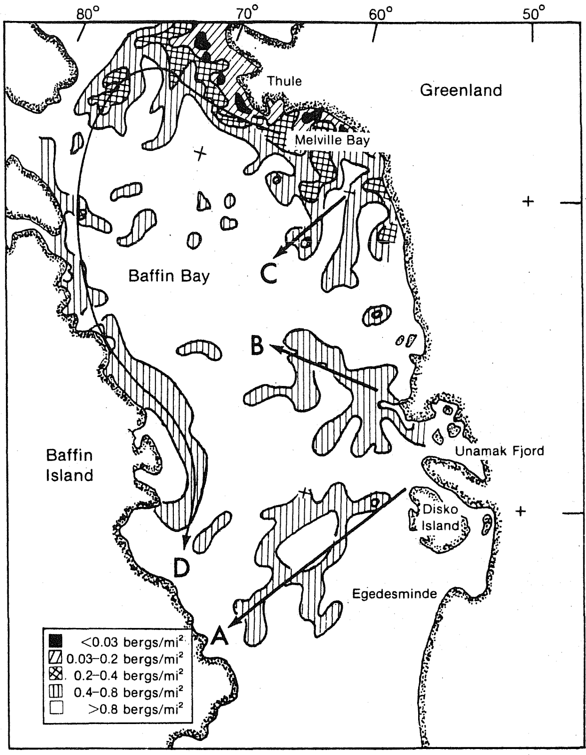

Fig. 2. Iceberg density observed by the International Ice Patrol, September–October 1968. (The arrows represent possible main routes of iceberg drift out of Baffin Bay.) (After Kelly, 1968.)

deteriorating or by drifting close to the coast and becoming trapped in bays and shoal areas. The major traps are Hudson Strait, Strait of Belle, and Notre Dame Bay in Newfoundland.

Kelly (1968), using information from International Ice Patrol reconnaissance flights, produced a chart of smoothed iceberg density for September–October 1968. His work indicates four main routes of iceberg drift in Baffin Bay, as indicated by arrows in Fig. 2: (a) from Disko Bay in West Greenland to Cape Dyer in Baffin Island and then southward, (b) northwestward from Unamak Fjord in West Greenland across Baffin Bay and then southward, (c) southwestward from Melville Bay in Greenland across Baffin Bay, and (d) the classical northwestward route from Melville Bay counterclockwise around Baffin and then southward in the Baffin Island and Labrador Currents. The path which an iceberg follows is influenced by winds, currents and the earth's rotation. The wind velocity in the area is to a large extent directly related to the position and intensity of the Icelandic Low (Fig. 3).

The main atmospheric features of interest in the North Atlantic are the Iceland Low and the Bermuda-Azores High. The Icelandic Low is not a single low but rather an area where lows accumulate and are intensified. Such extratropical cyclogenesis occurs in areas of strong baroclinicity, where the density and pressure surfaces are not horizontal. Since atmospheric density

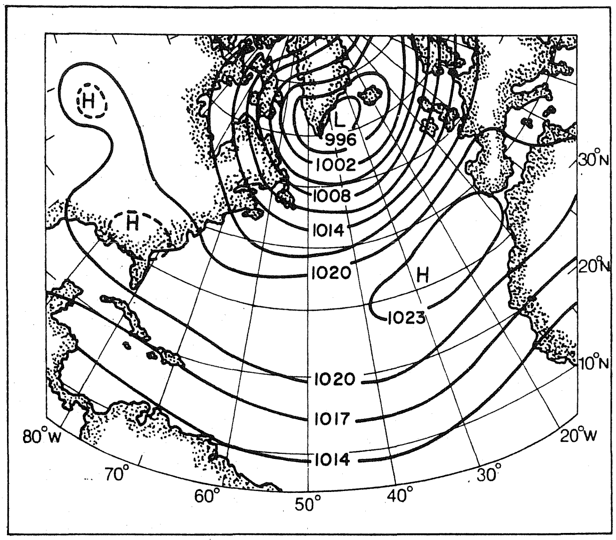

Fig. 3. Normal sea level pressure (mb) distribution for January. (A fully developed Icelandic Low will cause offshore winds to move icebergs from West Greenland glaciers across Baffin Bay and northwest winds to drift them along the Labrador coast.) (After Chase, 1956.)

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. There are two such areas in the North Atlantic: East Greenland and the Labrador Sea. These baroclinic regions cause any low arriving there to be intensified.

When one realizes that virtually every low which crosses the United States and 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 off Newfoundland. A winter with a well-developed Icelandic Low in the proper location will favor a severe iceberg season in the following year (i.e. a large number of icebergs on the Grand Bank), but this does not guarantee that there will be a large number of icebergs. The normally-developed and positioned Icelandic Low establishes the atmospheric circulation pattern which transports icebergs out of the West Greenland fjords, across Baffin Bay and southward along the Labrador coast. It also draws cold continental air from northern Canada, thus ensuring that the icebergs move in a protective field of sea ice which prevents significant deterioration. The lack of icebergs south of Hudson Strait in autumn and early winter, in contrast to other seasons of the year, is directly attributable to the absence of sea ice and the presence of comparatively higher sea-surface temperatures during summer and autumn.

The Baffin Island and Labrador Currents represent a major part of the transportation system which moves icebergs southward. Although these currents are much slower than the wind, they act on a much larger subsurface portion of the iceberg. A well-developed current is a necessary but not a sufficient condition for heavy ice conditions. For example, 1958 was a year when the Labrador Current was well-developed but ice conditions were light.

Perhaps, the most important characteristic of seawater when considering sea ice is the manner in which seawater density varies with salinity. When the salinity of seawater is greater than 24.7 ‰, the density increases steadily with decreasing temperature until the freezing point is reached. This insures that cooling of the surface water causes convective currents which produce thick isothermal layers of water with temperature equal to the freezing point of seawater. The wide continental shelves off 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. The sea-ice distribution also tends to reflect the topography of the continental shelf.

Sea ice off Newfoundland (Fig. 4) is at its maximum extent from March to May. However, there is considerable variation from year to year. In years of heavy ice conditions, long strips of sea ice are found drifting parallel to the current as far south as 43° N. This was more common in the early 1930's than in recent years. Sea-ice drift is directly affected by winds and near-surface currents. Sea ice, which has drifted away from the continental shelf into the Labrador Sea, deteriorates rapidly due to the higher surface temperatures. Hence, the prevailing wind direction has a great influence on the extent of sea ice.

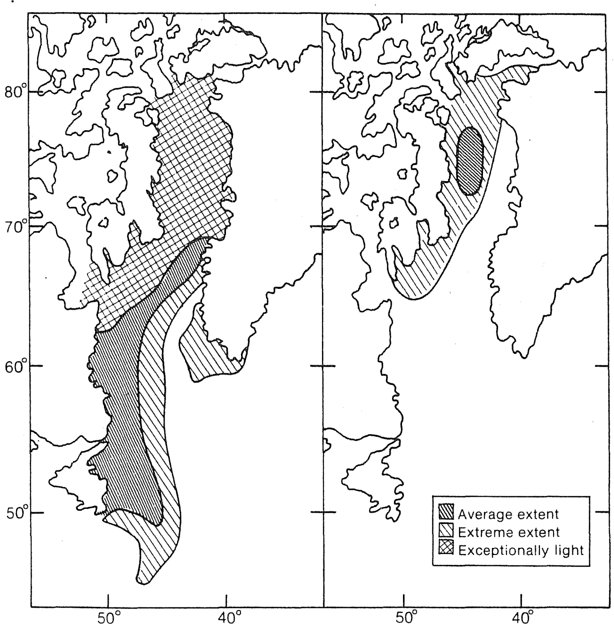

Fig. 4. Mean sea-ice limits for heavy and light sea-ice years. (After Lebedev, 1965).

Icebergs and sea ice do not drift at the same speeds because wind-induced forces are not the same. The wind force on sea ice is a complex function of vertical wind velocity profile and sea-ice roughness. The wind force on icebergs is directly related to its shape. Sea ice and icebergs also respond differently to currents. Again, water force on sea ice is dependent upon the sea roughness parameter and the vertical current velocity profile beneath the ice. The current force on the iceberg is an integration of the velocity shear acting on the subsurface portion of iceberg. Obviously, there is also a large difference in mass between sea ice and an iceberg.

Observations on icebergs in sea ice show that iceberg wakes are downwind. This implies that the sea ice moves faster than the icebergs under the influence of wind. Close pack ice (i.e. concentrations greater than 8/10) has a large direct and indirect influence on the dirft of icebergs. Such heavy ice concentrations can exert forces on the iceberg by direct collisions. Wind and current forces may cause ice convergence areas in which icebergs become firmly trapped.

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 icebergs. Observations of icebergs in closely-packed ice indicate that they move with the sea ice, implying that the forces acting on the ice floes are directly transferred to the icebergs. This is not the case in relatively thin ice or in open polar ice.

Icebergs South of 48°N

Morgan (1971) has shown that the long-term trend in the number of icebergs drifting south of 48°N had decreased significantly since the mid-1930's, the annual averages being 419 in 1932-41, 418 in 1942-51, 252 in 1952-61, and 147 in 1962-71. Although there was a decreasing trend, the annual variation was quite large (zero in 1966 to 1,083 in 1945). Morgan (1971) also examined the internal consistency of the iceberg count record and determined that it was consistent with the available environmental data.

This trend came to an abrupt end in 1972 when the total number of icebergs drifting south of 48° N was the highest on record and the iceberg season was the longest on record. Iceberg sightings south of 48° N in 1972 and 1974 (Table 1) were higher than in any year since 1900, the previous record being in 1929. The intervening year (1973) also had a much higher iceberg

TABLE 1. Numbers of icebergs south of 48° N in relation to the numbers sighted in the International Ice Patrol area of the Northwest Atlantic, 1970–81.

Month	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Dec	—	—	—	6	—	—	—	—	—	—	—	—
Jan	—	—	—	54	—	—	—	2	—	—	1	—
Feb	—	—	40	110	1	24	—	8	—	5	3	—
Mar	—	31	185	134	99	41	33	34	5	20	7	48
Apr	5	4	501	212	345	10	13	92	28	81	—	10
May	2	20	559	159	446	20	67	91	35	34	9	5
Jun	70	7	225	151	266	5	35	55	7	9	4	—
Jul	8	11	48	19	168	—	3	15	—	3	—	—
Aug	—	—	26	1	61	—	—	3	—	—	—	—
Sep	—	—	4	—	1	—	—	—	—	—	—	—
S of 48°N	85	73	1,588	846	1,387	100	151	300	75	152	24	63
Sighted	2,350	1,106	8,045	4,904	7,218	910	1,535	1,075	1,834	564	197	180

count than the historical average of 377 per year during 1900–79. To place these iceberg counts in perspective, there had been only four previous years when iceberg counts south of 48°N exceeded 1,000:

Year	Icebergs	Year	Icebergs
1909	1,042	1945	1,083
1912	1,041	1972	1,587
1929	1,329	1974	1,385

In addition to the above counts, the number of icebergs in 1973 (Table 1) had only been exceeded in 1935 with 872, in 1939 with 850, and in 1957 with 931 icebergs. Strangely enough after these three extraordinarily heavy ice years, the number of icebergs drifting south of 48°N averaged only 123 during 1975–81.

Scobie and Schultz (1976) studied the meteorological and oceanographic conditions which produced the record count of icebergs in 1972. They concluded that all critical meteorological and oceanographic factors were favorable for such iceberg drifts prior to and during the 1972 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 with lower than normal air temperatures which in turn produced greater sea-ice extent (reducing iceberg deterioration) and lower sea-surface temperatures.

Kukla and Kukla (1974) studied the snow and sea-ice extent from satellite images and indicated that weather conditons during 1968–71 were normal but that 1972 and 1973 were anomalous years on a global basis. These anomalous conditions produced a record coverage of 66.7 million km^2 of snow and ice on 10 February 1972.

References

CHASE, J. 1956. The Bermuda-Azores high pressure cell: its surface wind circulation. Miscelânea Geofisica, Luanda, Angola, p. 29–54. (Coll. Papers Woods Hole Oceanogr. Inst., Contrib. No. 835.)

KELLY, J. R. 1968. Report of the International Ice Patrol Service in the North Atlantic Ocean, season of 1968. *Bull. U. S. Coast Guard*, **54**, 105 p.

KUKLA, G. J., and H. J. KUKLA. 1974. Increasing surface albedo in the northern hemisphere. *Science*, **183**: 709–714.

LEBEDEV, A. A. 1965. Variations in ice conditions in the Northwestern Atlantic. *Trudy Okeanogr. Inst.*, Moscow, **87**: 37–50. (In Russian.)

MORGAN, C. W. 1971. Report of the International Ice Patrol Service in the North Atlantic Ocean — season of 1971. *Bull. U. S. Coast Guard*, **57**, 26 p.

MURRAY, J. E. 1969. The drift, deterioration and distribution of icebergs in the North Atlantic Ocean. *Can. Inst. Mining and Metallurgy*, Calgary, Alberta, Spec. Vol. No. 10; 3–18.

SCOBIE, R. W., and R. H. SCHULTZ. 1976. Oceanography of the Grand Bank region of Newfoundland, March 1971-December 1972. *U. S. Coast Guard Oceanogr. Rep.*, No. CG 373-70, 298 p.