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Meteorological Conditions and Their Impacts Over the Northwest Atlantic in the 1970's

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Abstract

The decade of the 1970's was a period when anomalies or extremes in meteorological conditions had significant impacts on fisheries and other activities in the Northwest Atlantic. Higher wind speeds were more frequent, low pressure centers were fewer but deeper, and the winter circulation around the Icelandic Low was more intense than in the previous decade. Precipitation increased over eastern Canada in the last part of the decade, and record wet periods in 1979 and 1980 had a detrimental effect on the fishing industry in Newfoundland and Nova Scotia. Although recent global air temperatures indicate a warming trend, a cooling trend persisted over stations in the North Atlantic. Severe ice conditions off Newfoundland in the first half of the decade played havoc with the spring fishery, and record numbers of icebergs in the Grand Bank area presented great danger to ships operating in and crossing the region.

Introduction

The 1970's was a decade of remarkable weather extremes with devastating consequences for people around the world. Television documentaries and news accounts presented the dramatic effects of unusual climate on the sea and on land, examples of which are: the deaths of a half million people in Sahel and Bangladesh due to famine following drought and floods; the poor harvest weather and droughts in the USSR, Australia and North America, which had a worldwide effect on the food supply and hence on prices; the occurrence of unusually warm ocean water off Peru (El Nino) which contributed to the reduction in the anchovy fishery from more than 12 million tons in 1970 to 2 million tons in 1973; and the extremely cold weather and heavy snowfall during the winter of 1976/77 in eastern North America and the Texas heat wave in the summer of 1980, each of which caused a $20 billion loss to the American economy. The North Atlantic had its share of climatic extremes during the past decade, some of the more newsworthy events being listed in Table 1.

TABLE 1. Some significant North Atlantic records, 1970-79.

Year	Recorded event
1971 (Sep-Dec)	Norway: stormiest in 30 years, 75 days when wind above Force 8.
1972	Eastern Canadian Arctic: mean annual temperature 4°C below normal.
1973 (autumn)	Shetland Islands: stormiest in 40 years.
1975 (summer)	Reykjavik, Iceland: coldest since 1920
1976 (February)	Caribou, Maine: 95.70 kPa SLP.
1976 (summer)	Great Britain: warmest in 300 years, record drought.
1977 (January)	Bahama Islands: snow recorded.
	St. Anthony, Nfld: 94.02 kPa SLP, record low for North America.
1978	Halifax, Nova Scotia: record high precipitation of 1,671 mm.
	Norway and Iceland: below-normal temperatures in every month.
1979	St. John's, Nfld: record high precipitation of 1,978 mm.
	Akurejri, Iceland: 2.4°C below normal.
	Iceland: annual sunshine lowest since record started in 1880.
	Norway: coldest year since 1923, twice the normal number of days with gales.

The Northwest Atlantic Ocean is being submitted to many forms of exploitation. Fisheries thrive for many species, and maritime nations are making a concerted effort to control and conserve this renewable resource. In the future, offshore drilling, undersea mining and marine transportation of hydrocarbons and other products will become more frequent and widespread. Climate has a significant social, economic and environmental impact on these and, indeed, on most coastal and offshore activities. Man's tendency to forget the past when planning such activities makes a review of the climate of past decades, or even centuries, a prudent and worthwhile effort from time to time.

This paper presents a selection of the significant meteorological events and climatological anomalies of the past decade. For a unified perspective, however, this review begins with the discussion of the movement and evolution of low and high pressure systems in the recent decade and the past, followed by a description of winds, precipitation, temperature and sea-ice patterns and their impacts.

Climatic Variations

Pressure patterns

The area of horizontal air and water gradients around the Gulf Stream from the Grand Bank to south of Cape Hatteras is a favored spawning area for the development and intensification of low pressure systems, particularly during the winter. The systems tend to move northeastward along the east coast of the United States, passing across or just east of the Atlantic provinces of Canada. Many lows continue northward either to Baffin Bay or, more frequently, to a position near Iceland where they weaken and are replaced by successive incoming lows. The "Icelandic Low" is a semi-permanent feature that is sometimes called a "graveyard for Atlantic storms". The general movement, rapid development and intensity of migrating lows and the average position and intensity of the Icelandic Low have important implications for the regional climate of the Northwest Atlantic. Particularly in winter, the strong and persistent northerly air flow transports pack ice from the Arctic southward along the Labrador coast. Waves which develop from these winds over the Labrador Sea propagate southward as swell to mix with locally generated waves east of Newfoundland, resulting in extremely rough sea conditions which create serious problems to mariners and those attempting to develop the offshore mineral resources of the area.

The intensity and movement of low and high pressure systems were investigated by Zishka and Smith (1980). The frequency, genesis and lysis (destruction or cessation) and relative variability of lows over North America during 1950-77 are shown for January (Fig. 1 and July (Fig. 2), analyzed by 2° quadrangle grid. The frequency maxima of the individual cyclone events shift northward in summer to follow the zone of strong horizontal air temperature gradient. The birth or genesis area for lows off the northeastern United States is well marked in this analysis but the lysis or "graveyard" area east of Greenland is not, probably because it is

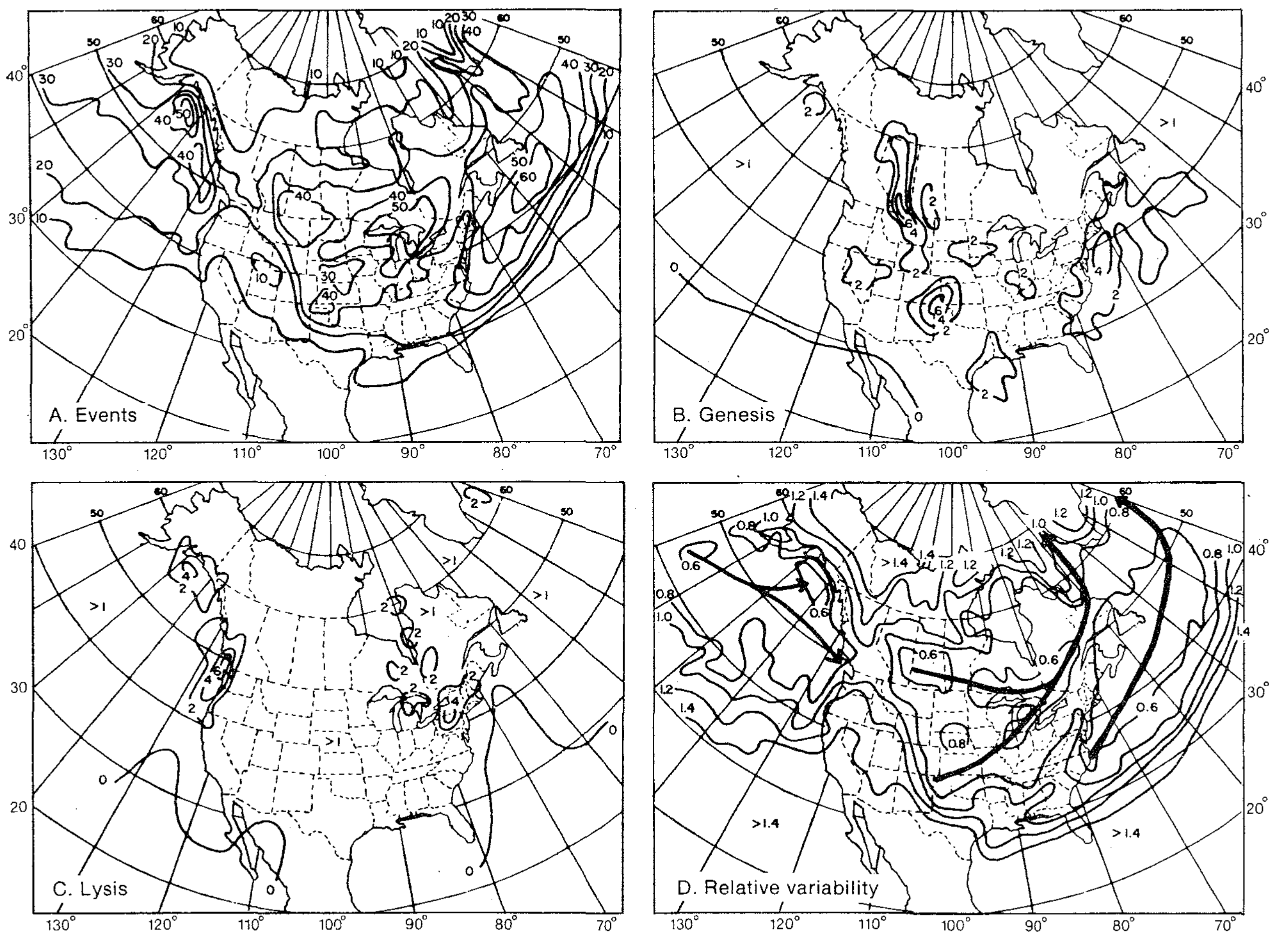


Fig. 1. Areal distribution, for January cyclones over North America and environs in 1950-77, of (**A**) events, (**B**) genesis, (**C**) lysis, and (**D**) relative variability with preferred propagation tracks superimposed. (Values represent 28-year totals; areas in (**B**) and (**C**) in which quadrangles contain a frequency but do not form centers defined by three contiguous quadrangles are designated by >1). (From Zishka and Smith, 1980.)

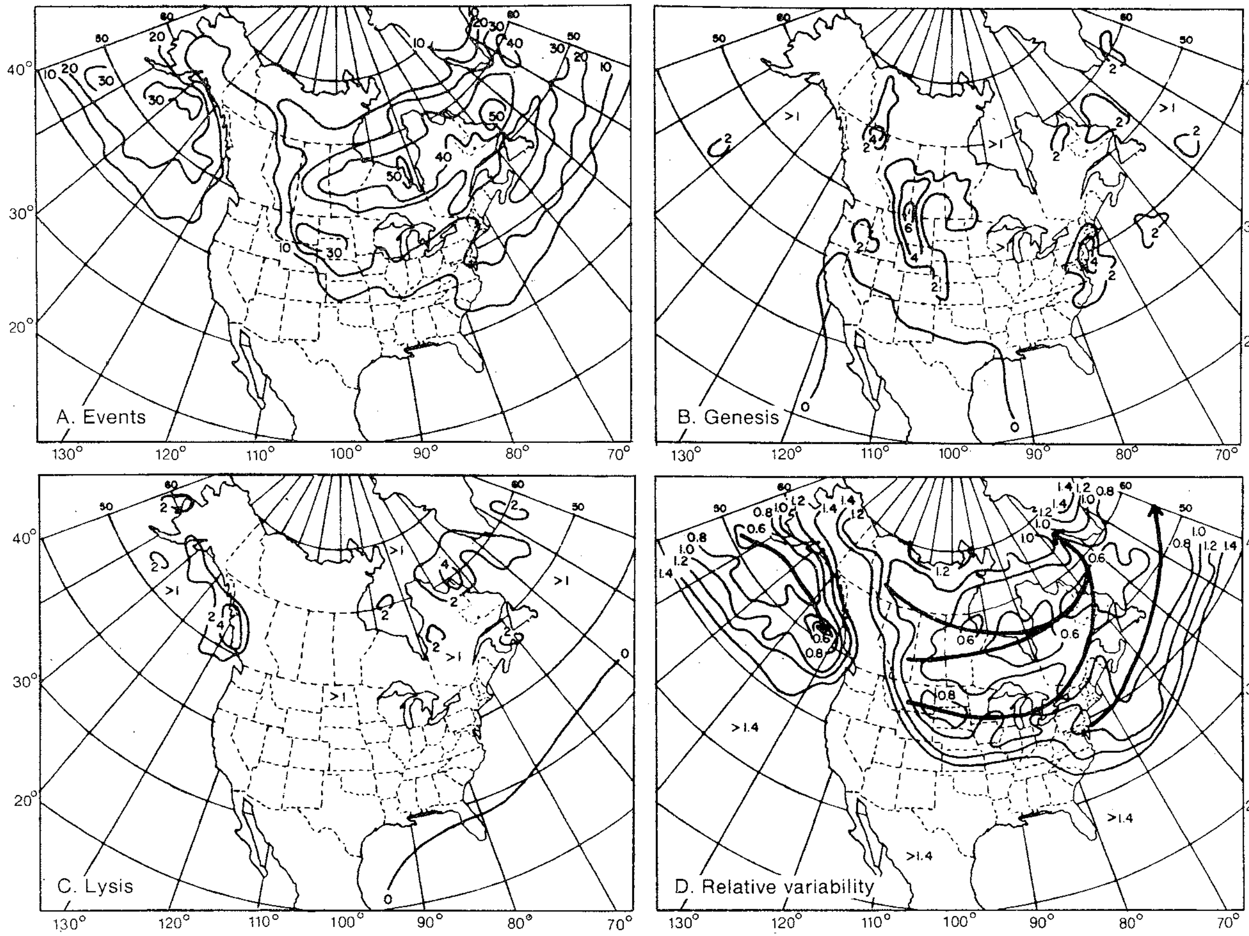


Fig. 2. As in Fig. 1, except that the distributions are for July cyclones in 1950-77. (From Zishka and Smith, 1980.)

just outside the area of investigation. Relative variability is the mean absolute difference between individual year-event frequencies and the 28-year mean frequency divided by that mean. It gives some indication of interannual variability. Zishka and Smith (1980) have superimposed their analyses of a preferred track (bold lines) on the "relative variability" charts. Year-to-year variation in the number and mean minimum pressure of January and July cyclones are illustrated in Fig. 3. Both the number of lows and their central pressures have decreased over the 1950-77 period. Another observations is that, if central pressure is taken as a measure of storm intensity, North America had fewer but more intense storms during the 1970's.

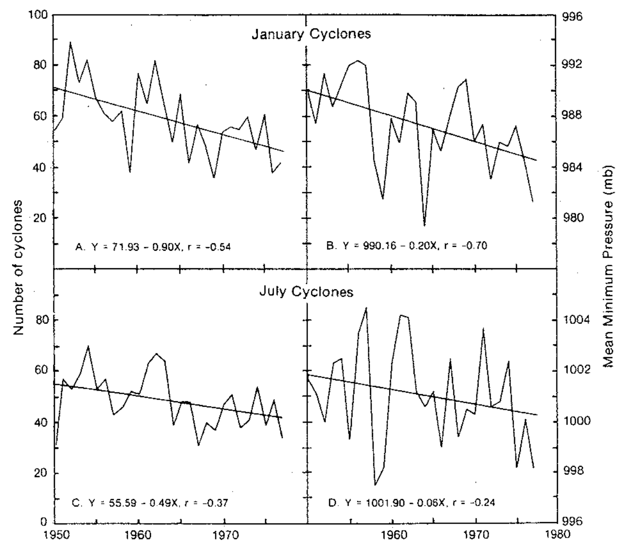


Fig. 3. Trends in frequency (left) and mean minimum pressure (right), with linear regression lines (X = years minus 1950), for January and July cyclones over North America and environs, 1950-77. (After Zishka and Smith, 1980.)

The areal distribution of cyclone events in January and July of the 1950-54 and 1970-74 pentads are shown in Fig. 4. Although the number of cyclones was fewer in 1970-74 than in 1950-54, the predominant cyclone tract appears to have been displaced farther southward in the later period, perhaps indicating a more southerly intrusion of Arctic air over the Scotian

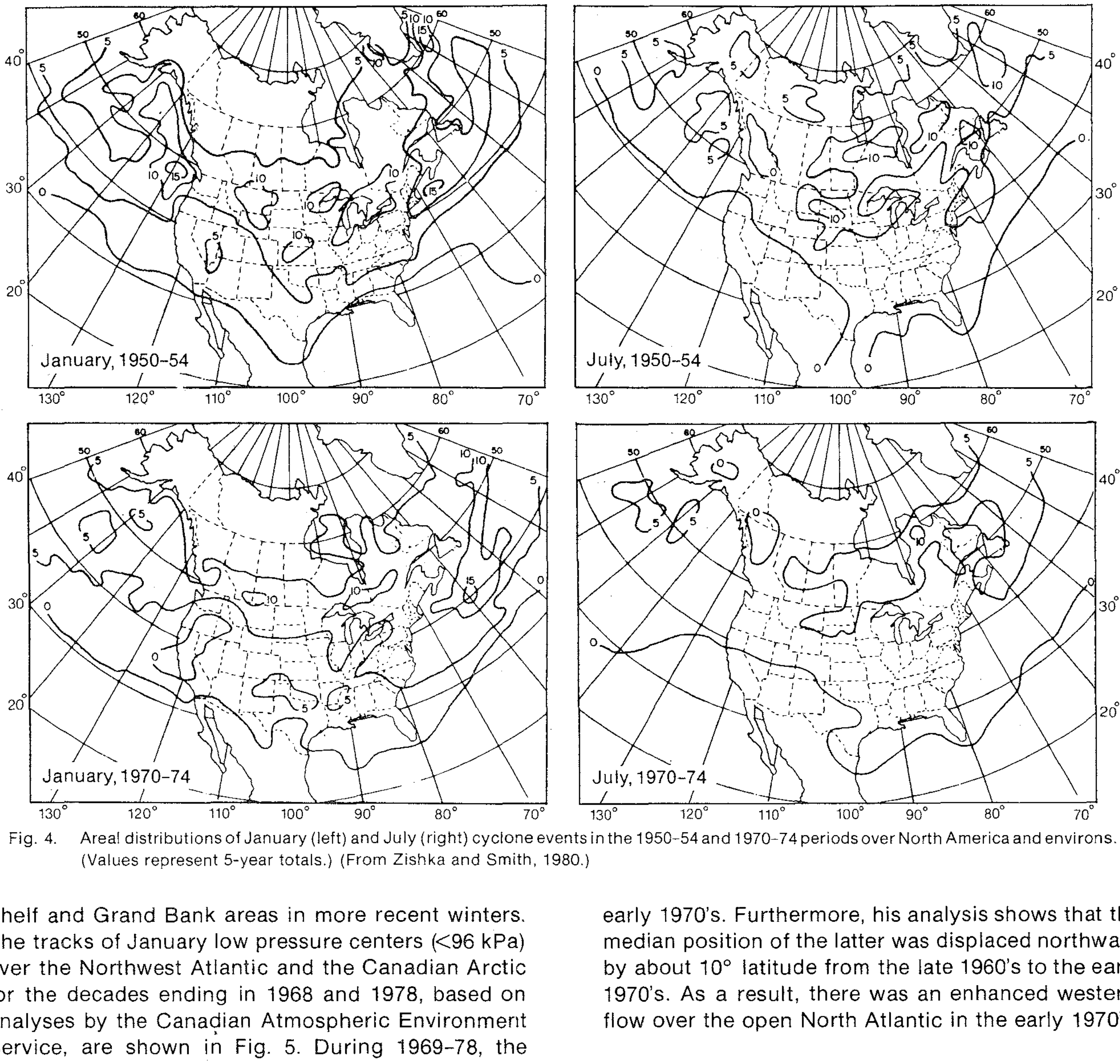


Fig. 4. Areal distributions of January (left) and July (right) cyclone events in the 1950-54 and 1970-74 periods over North America and environs. (Values represent 5-year totals.) (From Zishka and Smith, 1980.)

Shelf and Grand Bank areas in more recent winters. The tracks of January low pressure centers (<96 kPa) over the Northwest Atlantic and the Canadian Arctic for the decades ending in 1968 and 1978, based on analyses by the Canadian Atmospheric Environment Service, are shown in Fig. 5. During 1969-78, the majority of these lows migrated northeastward to become part of the Icelandic Low. In the earlier period, however, nearly half of the lows stalled in the northern Labrador Sea-Davis Strait area, indicating that blocking may have existed. In a blocking situation, a low tends to persist in one area for a relatively long period of time. Two other points are evident from the analyses: the notion of a predominant storm track is at best an idealization, and the number of storms during 1969-78 was fewer than in 1959-68.

Painting (1977) noted a marked decrease in the frequency of blocking anticyclones, particularly in winter, from the 1965-69 to the 1970-74 periods at mid-latitudes between 10°E and 80°W. His analysis of the difference in averages of mean sea-level pressure (Fig. 6) shows the Icelandic Low and the Atlantic Subtropical High to have intensified in winter during the early 1970's. Furthermore, his analysis shows that the median position of the latter was displaced northward by about 10° latitude from the late 1960's to the early 1970's. As a result, there was an enhanced westerly flow over the open North Atlantic in the early 1970's.

Winds

Changes in mean wind velocity are important in driving ocean currents and moving pack ice, which affect fish migration and availability. Cushing (1980) stated that shifts in the mean position of the Icelandic Low, and consequently wind direction, may have altered the strength of the Irminger Current and that these events led to the rise and decline of the West Greenland cod fishery. The extremes of wind also have their effects on fishing operations.

The use of information on pressure gradients is a logical way of investigating decadal variations in wind speed. Figures 7 and 8 show the frequency distributions of geostrophic wind speeds during the decades ending in 1968 and 1978 respectively for a selection of locations in the North Atlantic. The frequency of

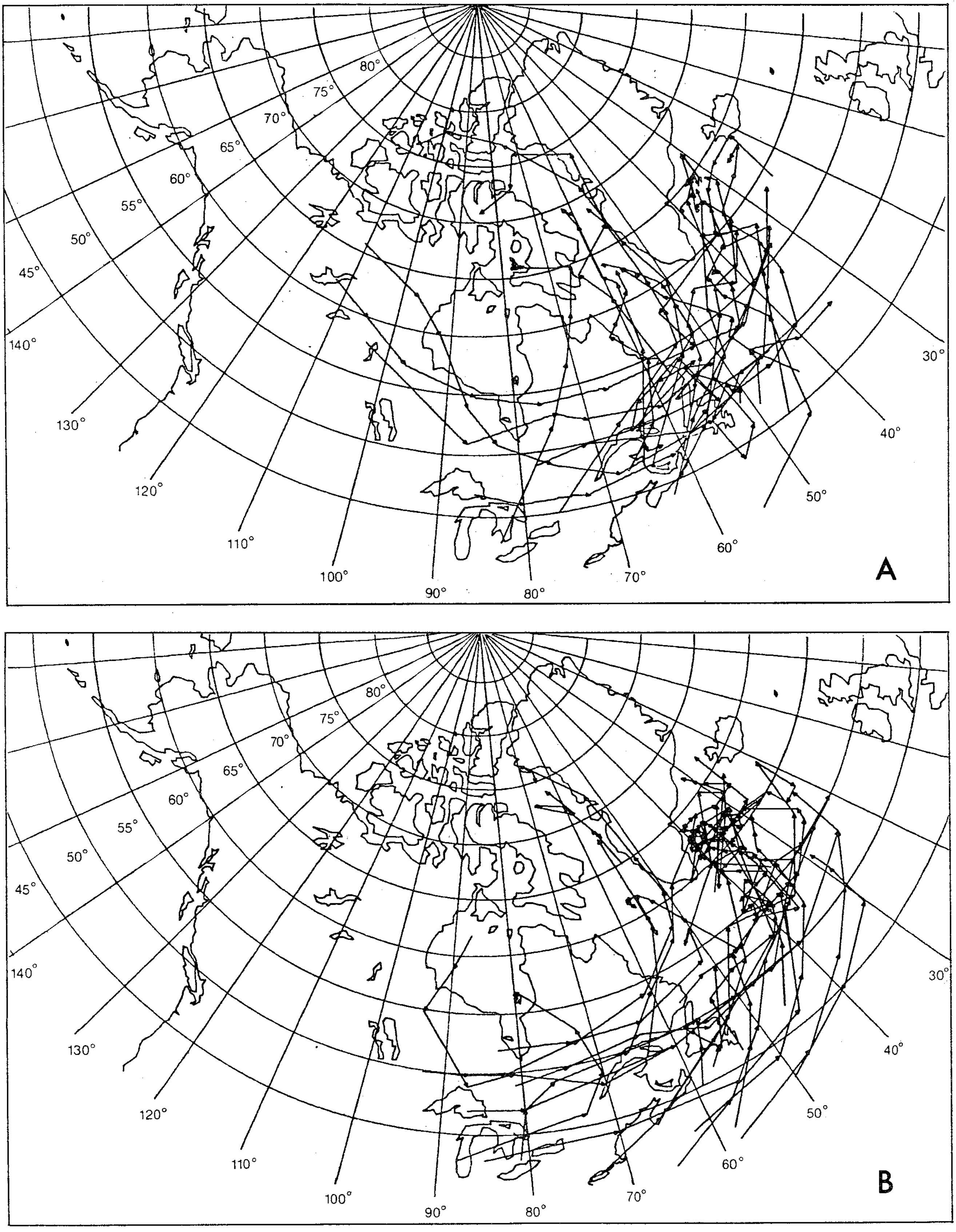


Fig. 5. Tracks of low pressure centers less than 960 mb (96 kPa) over eastern Canada and the Northwest Atlantic during (**A**) January 1959-68 and (**B**) January 1969-78.

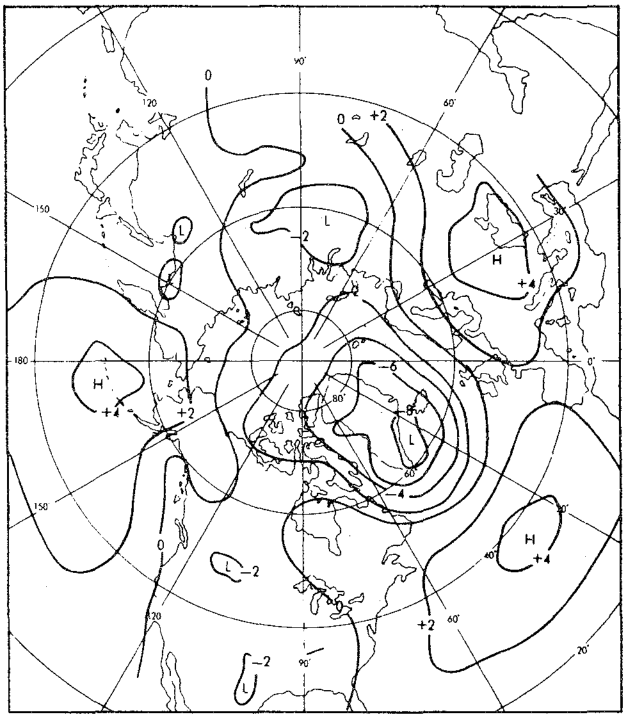


Fig. 6. Differences in averages of mean sea-level pressure (mb) over the northern hemisphere in the winters of 1965–69 and 1970–74. (Values refer to 1970–74 minus 1965–69.) (After Painting, 1977.)

occurrence of higher wind speeds appears to have been greater in the more recent decade at most northern stations in both January and July. Design and strategy for offshore drilling and mining operations based on earlier climate data may be insufficient if the climate continues to be more severe than in the earlier decades.

Monthly mean geostrophic wind speeds at a point near Ocean Weather Station Bravo in the Labrador Sea (Fig. 9) confirm the notion that winds were, on the average, stronger in the 1970's than in the 1960's. The wind speeds in the 1960's did not peak as high in winter as in the 1970's, indicating higher than usual wind speeds in the 1970's or more equally distributed winds with respect to direction in the 1960's. The frequency of strong winds may vary considerably from year to year at a particular location, as is evident from Fig. 10, which depicts the hourly frequency of gales at Sable Island on the Scotian Shelf by month and year for the 1959–79 period (G. A. McKay, Atmospheric Environment Service, Halifax, Nova Scotia, pers. comm.). Unlike the consistent pattern of increase in winds from the 1960's to the 1970's over the northern parts of the North Atlantic, the decadal frequency of gales did not change much at Sable Island but exhibited greater variability in the 1970's, with a record high of 655 hr of gales in 1972 and a record low of 175 hr in 1975.

Precipitation

Precipitation measurements over ocean areas are very scarce, the primary source of data being from ocean weather stations and occasionally from research vessels. Dorman and Bourke (1981) analyzed the long-term ocean precipitation patterns from the available weather and visibility reports (Fig. 11). Their esitmates appear to be 30–50% lower than observations at Sable Island and other Canadian coastal stations. The frequent occurrence of fog to the north of the Gulf Stream may be partly responsible for the underestimates. Since precipitation at coastal stations is affected by orography, conditions at these stations may not be representative of precipitation offshore, but they should, however, give an indication of year-to-year variation of runoff into smaller estuaries. The pattern of mean annual precipitation in eastern Canada since 1891 (Fig. 12) indicates a slow increase in rainfall since the 1930's with the actual values being persistently higher than normal in the 1970's (except 1978).

The decade ended with two consecutive wet years in the Canadian Atlantic region. In 1979, record rainfalls of 1671 and 1976 mm were recorded at Halifax and Saint John respectively. In 1980, the people of Newfoundland experienced the wettest, dullest summer on record; rainfall at St. John's was 450 mm during June to August (about 5 times the normal value), and record low amounts of sunshine were set in July and August (only 26% of possible values). The wet weather was not confined just to the summer in 1980, as both Gander and St. John's had record rainfalls (over 1400 mm) and the greatest number of days with measurable precipitation (230 and 244 days respectively) since records began in 1943.

The excessive wetness in Newfoundland during 1980 had a disastrous effect on agriculture, outdoor recreation and tourism, as well as on certain aspects of the fishing industry. Novak (1981) has compiled an extensive list of socio-economic impacts on the Newfoundland fishery due to the prolonged wet weather. It was blamed for loss of wages by workers in fish plants and by crews on fishing vessels. The year was particularly poor for drying squid and salted fish, because there were no prolonged sequences of dry days. During July and October, there were no more than two consecutive days without precipitation at St. John's, and Gander had an astonishing low total of only 14 summer days without measurable precipitation.

Precipitation, with its effects on streamflow, turbidity, sediment transport and estuarine salinity, has consequences for marine ecosystems. Heavy rainfall over the eastern United States in 1979, due in part to two major hurricanes, caused excessive runoff in many

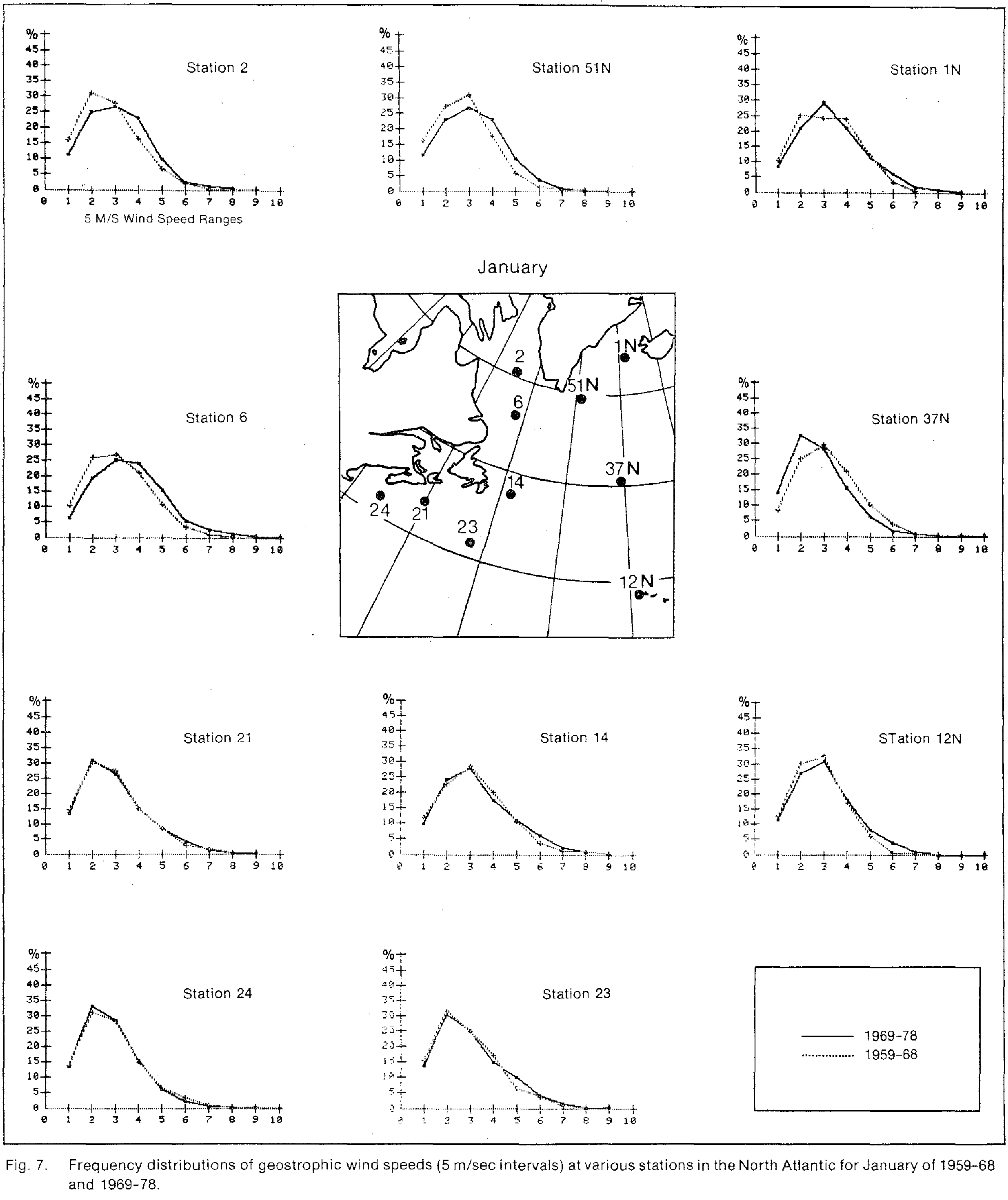


Fig. 7. Frequency distributions of geostrophic wind speeds (5 m/sec intervals) at various stations in the North Atlantic for January of 1959-68 and 1969-78.

Virginian rivers, and the resulting low salinity threatened the oyster populations in the James River area (Austin, 1979). The drought over the southeastern United States in 1980 increased salinities, but with negative side effects. It was feared that the oyster drill, *Urosalpinix*, which was flushed out of river tributaries by a hurricane in 1972, would recover and damage the oyster stocks.

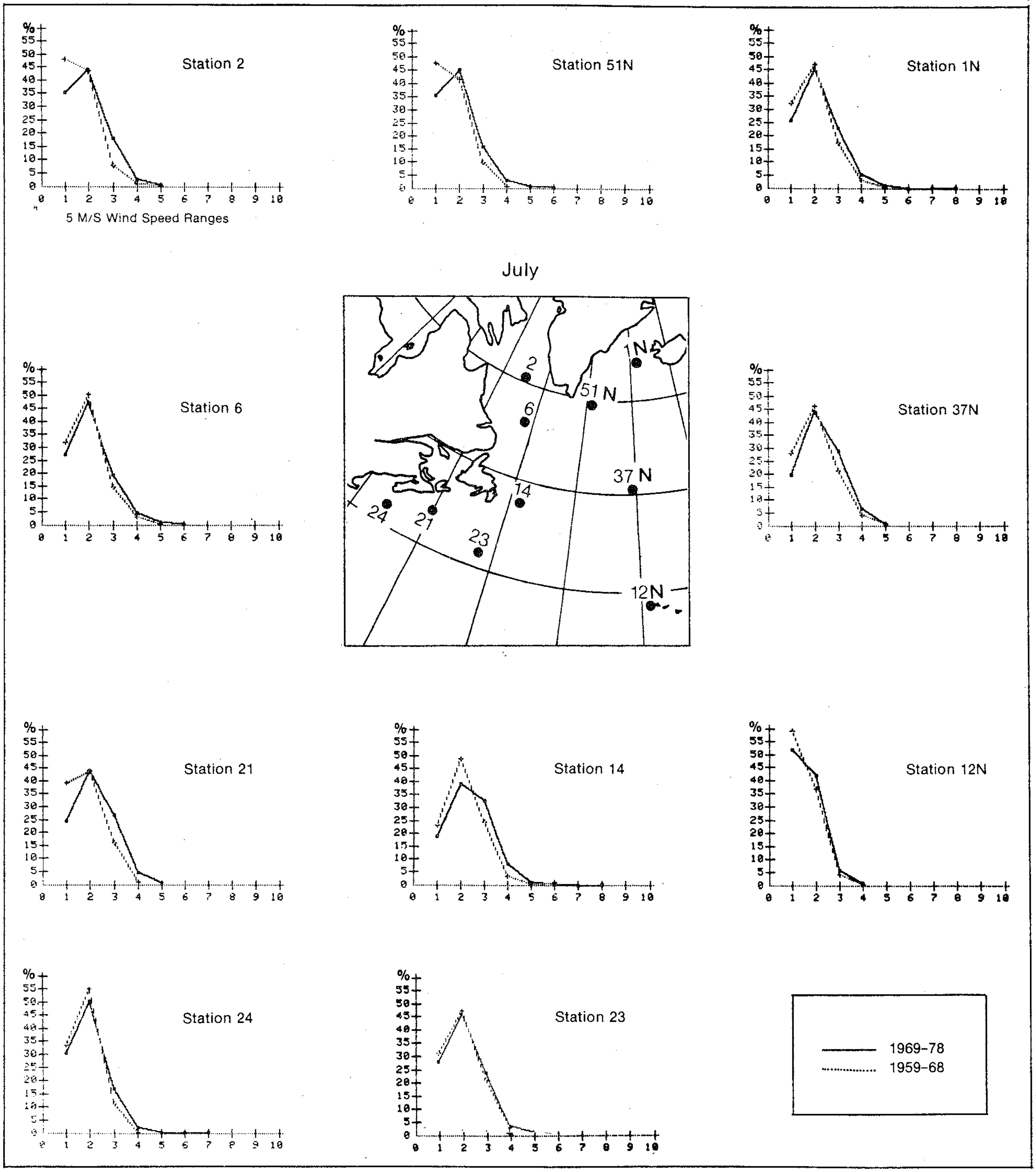


Fig. 8. Frequency distributions of geostrophic wind speeds (5 m/sec intervals) at various stations in the North Atlantic for July of 1959-68 and 1969-78.

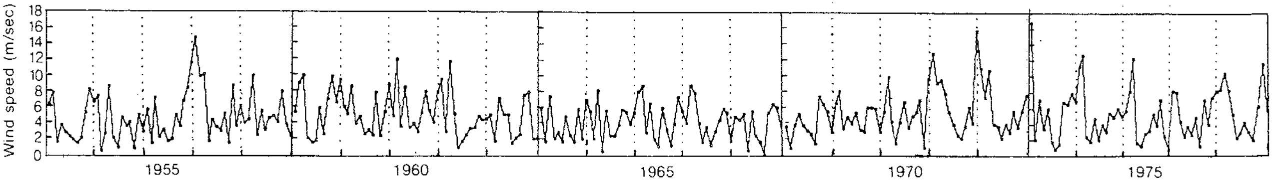


Fig. 9. Monthly mean geostrophic wind speed (m/sec) at Station 6 (see Fig. 8) in the Labrador Sea, 1954-78.

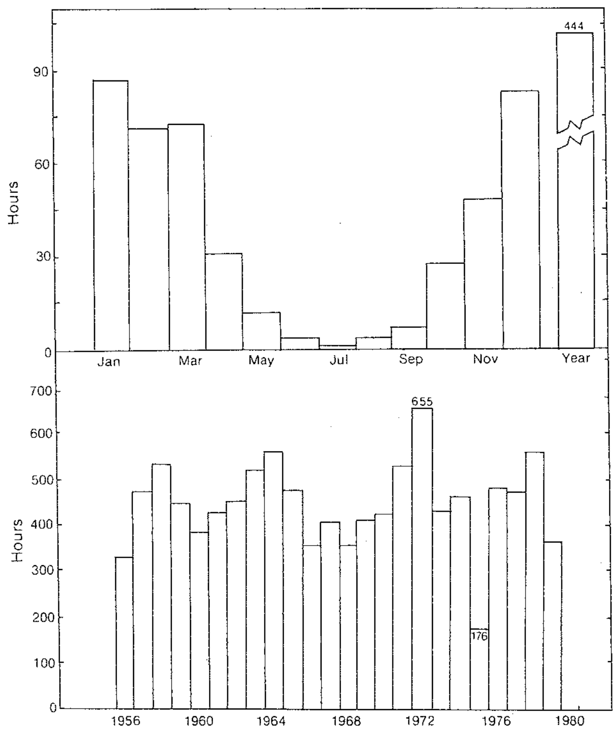


Fig. 10. Hourly frequency of gales (≥50 km/hr) by month (upper) and year (lower) at Sable Island on the Scotian Shelf, 1956–79.

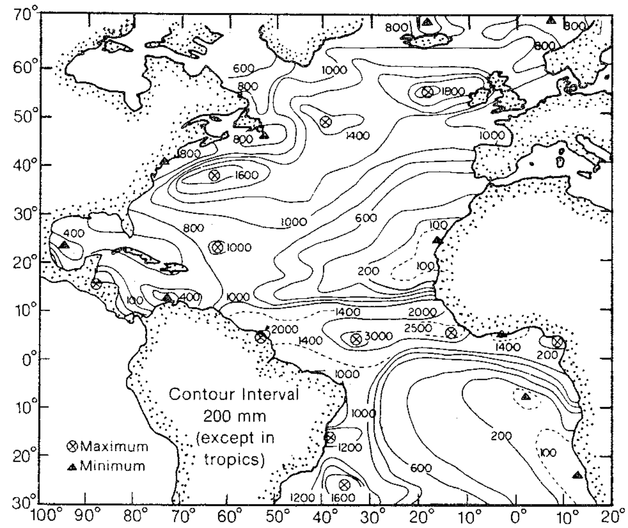


Fig. 11. Long-term annual rainfall (mm) over the Atlantic Ocean. (From Dorman and Bourke, 1981.)

Temperature

The ability of the world's population to feed itself may be approaching its capacity, and strides in communications enable the population to be instantly alerted to vagarities in climate and their impacts. The effects of early autumn and late spring frosts on commodities, such as wheat, coffee and oranges, are widely and instantly understood, and variations in global air temperature is recognized as a threat to the food supply. There is the possibility that glacial episodes are initiated rather suddenly, and it is known that man is capable of influencing the global climate. Agricultural methods and other activities have been noted as contributing to a dust veil, which could eventually result in another prolonged cold period. Ice-core data from the Canadian Arctic and Greenland led Koerner and Fisher (MS 1979) to suspect that another cold period may already be underway, but not necessarily a consequence of atmospheric turbidity. On the other hand, the global concentration of carbon dioxide has been increasing, possibly due to the increase in use of fossil fuels. The extrapolation of current socio-economic trends and the results of climatic models indicate that there will be a global warming which will be felt most strongly in the high latitudes.

Although many analyses of temperature data on local and global scales have been published, there is no clear-cut prediction as to what will happen and when. Yamamoto and Fisher (1980) applied an optimum interpolation method to air temperatures from 370 stations in the northern hemisphere (Fig. 13) and noted that temperatures were slowly increasing from the successive cold episodes of the 1960's. The temperature curves of Jones and Wigley (1980a, 1980b, 1980c) also show a trend to higher temperatures in all seasons in the northern hemisphere (Fig. 14). However, several lengthy cold events gripped parts of the North Atlantic and environs during the 1970's. In 1972, strong cold air advection peristed over Canada during most of the year. Eastern North America experienced the coldest winter on record in 1976/77. Cold weather prevailed over most of northeastern Europe in 1979.

The difference in heights between the 500 mb and 1,000 mb pressure levels gives an indication of temperature within the layer, a useful approximation being a mean temperature increase of 1° C for an increase of 20 gpm in thickness. Analyses of the 1,000-500 mb thickness have been made by Painting (1977), Kukla *et al.* (1977), Harley (1980), and others. Painting's (1977) analysis of the difference between thickness averages in the 1971–74 and 1961–70 winters (Fig. 15) indicated a significant cooling over Canada and the Northwest Atlantic and a warming over Europe, but the differences were not significant when the data were examined on an annual basis. Harley (1980), using pentadal means of annual 1,000-500 mb thickness over the northern hemisphere (Fig. 16), found no significant cooling or warming over the 1949–73 period. However, for the thickness difference between the 1969–73 and 1974–78 periods (Fig. 16E), the relatively large anomaly east of Newfoundland appears to have been quite significant. The decline in thickness here and over eastern North America might be taken as an indication

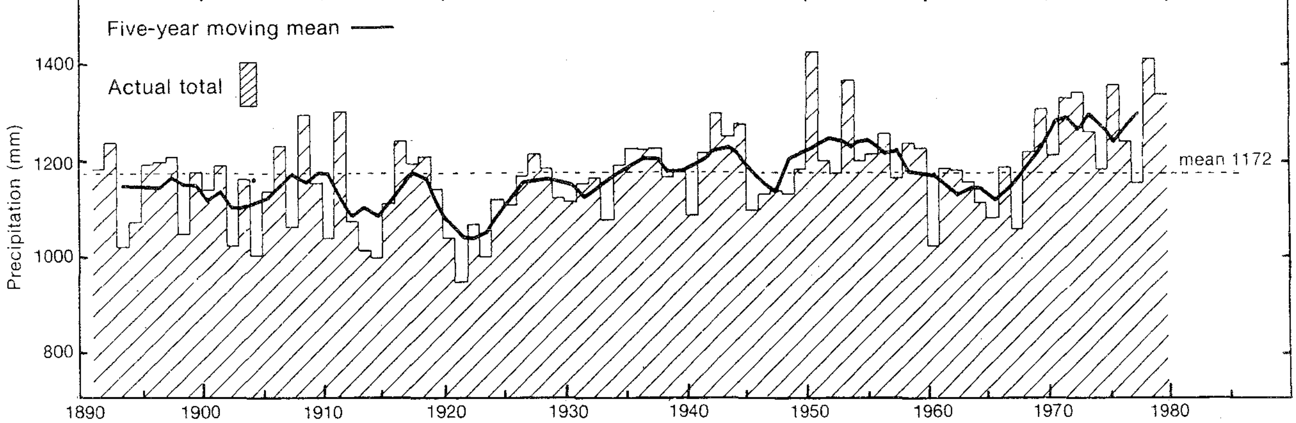


Fig. 12. Mean annual precipitation (mm) over southeastern Canada, based on observations at Beatrice (Quebec), Fredericton (New Brunswick), and St. John's (Newfoundland), 1891–1980.

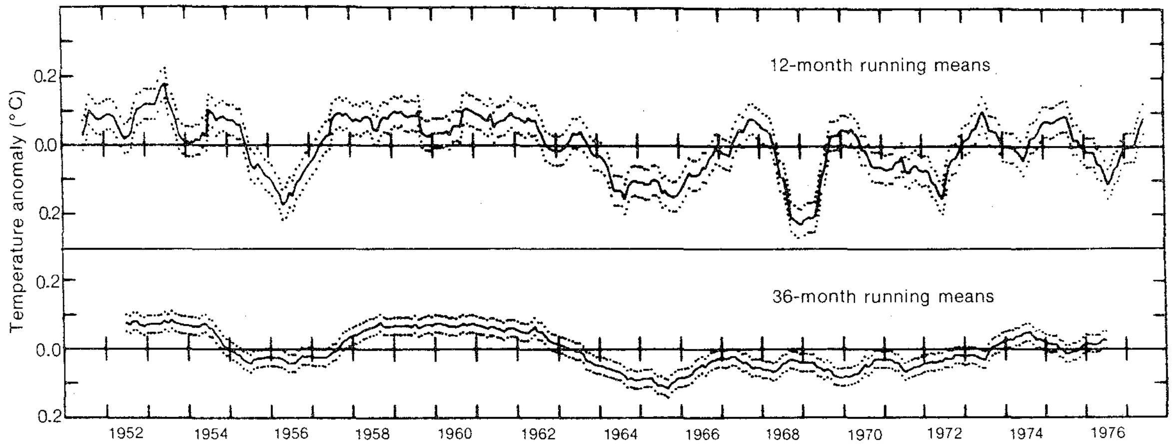


Fig. 13. Mean monthly surface air temperature anomalies (and 95% confidence limits) for the northern hemisphere, 1951–77. (After Yamamoto and Hoshiai, 1980.)

of changes in the steering flow at 500 mb, which seems to have persisted, particularly during the severely cold winters in the late 1970's.

The monthly trends in air and sea-surface temperatures for an area off southeastern Newfoundland are shown in Fig. 17 for the 1970–79 period relative to the means for 1869–1971 (normal). The air temperature during 1970–79 was, on the average, 0.8°C lower than normal, but examination of the monthly anomalies indicated that the summers were warmer and the winters were colder than normal during the 1970–79 decade. The latter trend is also reflected in sea-surface temperatures, but the annual mean for 1970–79 was only 0.1°C below normal.

Annual and 5-year mean air temperatures at eastern Canadian weather stations (Beatrice, Quebec; Fredericton, New Brunswick; St. John's, Newfoundland) (Fig. 18A) indicate a gradual warming to a peak in the early 1950's, followed by a cooling trend which persisted through the 1970's. Similar data for Vestmanneyjar in Iceland (Fig. 18B) show a warming trend to about 1930, followed by a general cooling trend to 1970. After a slight amelioration during the early 1970's, the mean temperature at Iceland in 1979 was the coldest on record.

Sea ice

The formation, state and movement of sea ice are governed by the interaction of wind, current, sea state, and air and sea temperatures. As atmospheric conditions vary considerably from month to month and year to year, so do sea conditions. Figure 19 shows the end-of-month distribution of pack ice concentrations greater than 1/10th during the 1971–80 decade. Interannual differences are considerable. The early 1970's were bad ice years for the east coast of Canada and West Greenland. Pack ice formed early in the year along the Gulf of St. Lawrence, Newfoundland and Labrador coasts and remained until late in the season. Ice conditions were particularly severe in 1972, when record high freezing degree-day accumulations were about 40% above normal at coastal weather stations in the Atlantic provinces of Canada (Markham, 1980).

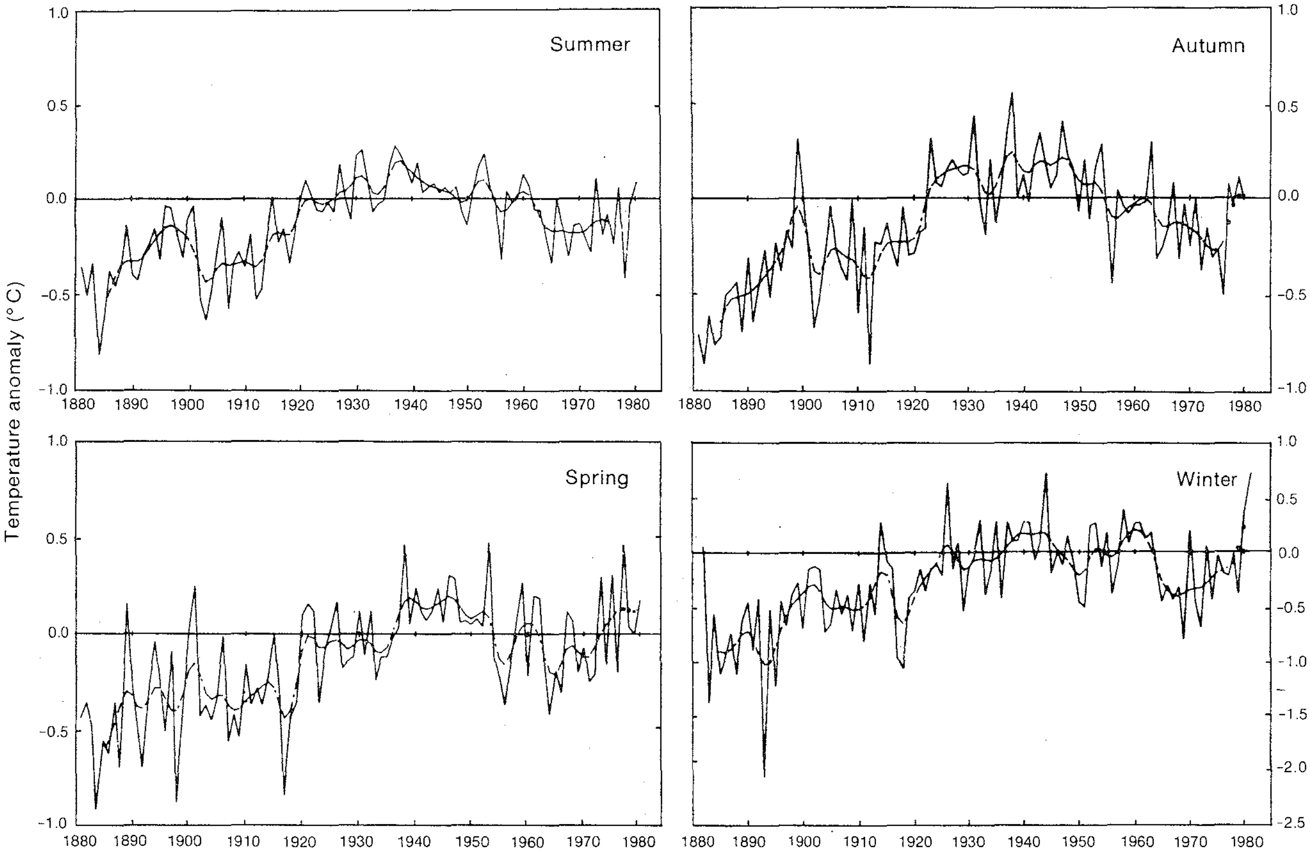


Fig. 14. Seasonal mean air temperature anomalies (°C) for the northern hemisphere in 1881-1980, relative to the mean for 1946-50. (After Jones and Wigley, 1980.)

In the Northeast Atlantic, Sigtryggsson (1969) reported frequent encroachment of ice to northern Iceland during the latter part of the 1960's, but this does not seem to have happened as frequently in the 1970's (Fig. 19), although there was considerable year-to-year variation as indicated by conditions at the end of July in 1974 and in 1975, for example. In 1974, the southern limit of pack ice along East Greenland was about 1,000 km north of Cape Farewell, whereas in 1975 it extended southward around Cape Farewell and a tongue of ice extended eastward close to Iceland. However, ice conditons in that region at the end of June were similar in both years. The early breakup of the ice in 1974 was due to increased northerly flow of warm air, whereas the decreased sea-level pressures over Greenland in 1975, and consequently the persistent southern flow of cold air, kept the pack ice intact along the east coast of Greenland.

Some 20,000-40,000 icebergs break away from the West Greenland glaciers each year and begin a journey that may take 24 months to reach the Grand Bank. A yearly average of 280 bergs drift south of 48°N off eastern Newfoundland, based on the data for 1946-73 from Markham (1980). Extensive sea ice and record numbers of icebergs drifted southward along the Canadian east coast during the springs of 1972, 1973 and

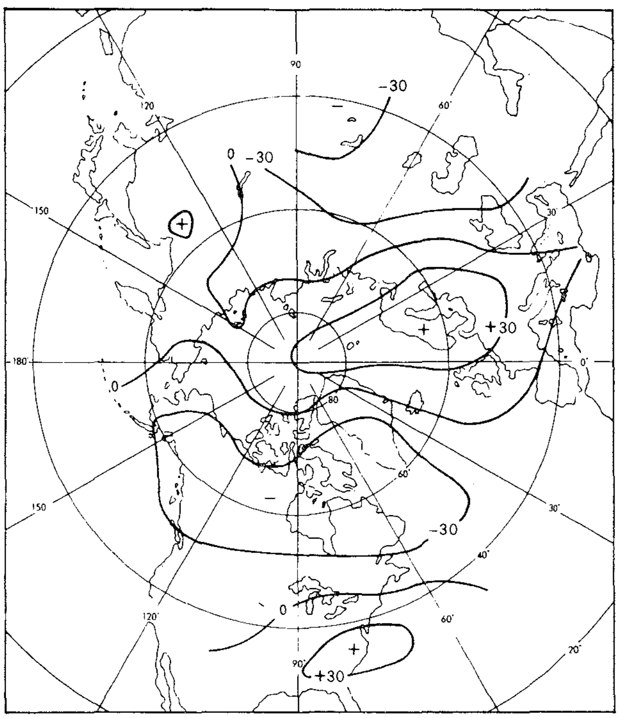
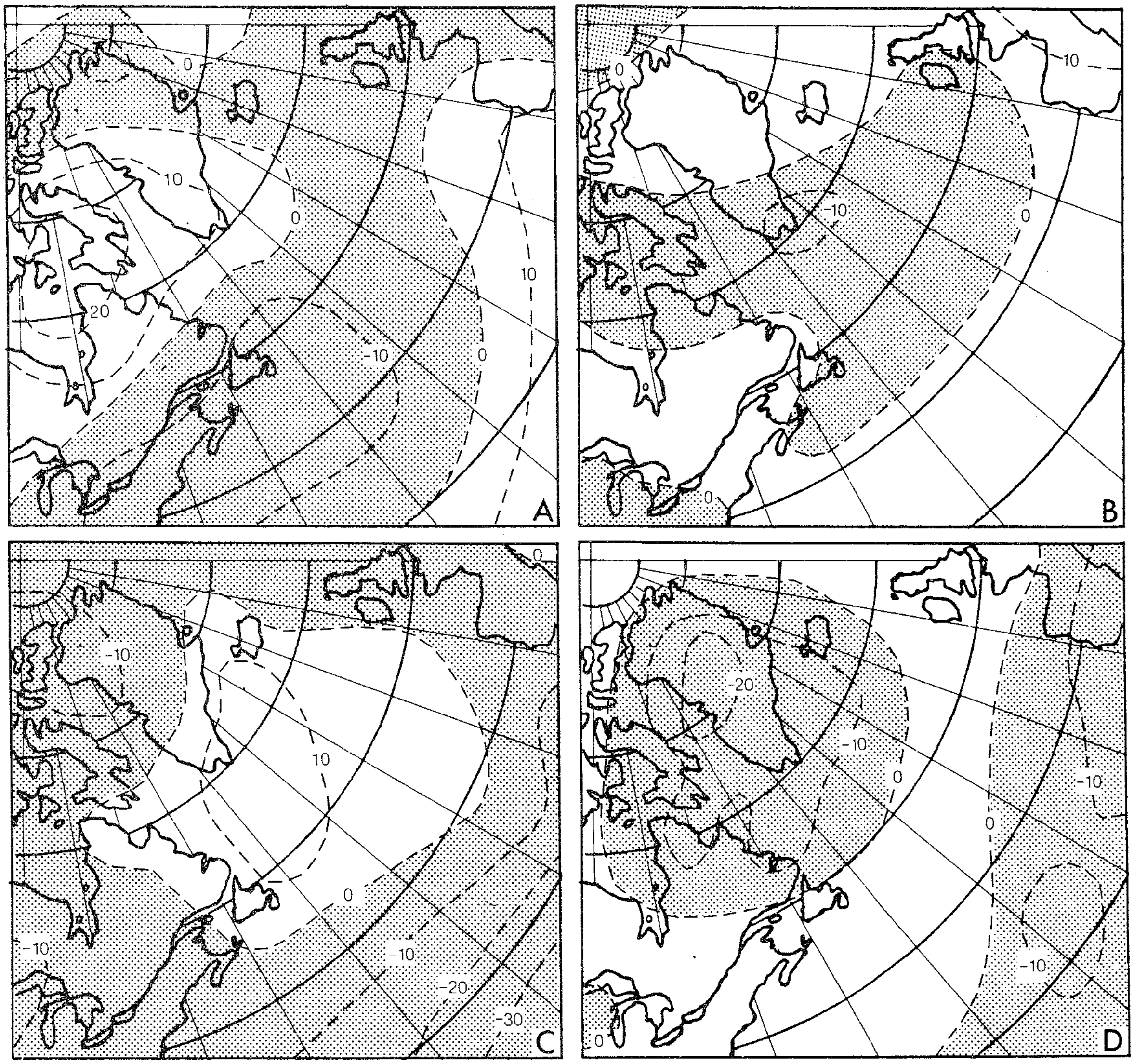


Fig. 15. Difference of averages in 1,000-500 mb thickness (1971-74 minus 1961-70) in winter for the northern hemisphere. (After Painting, 1977.)



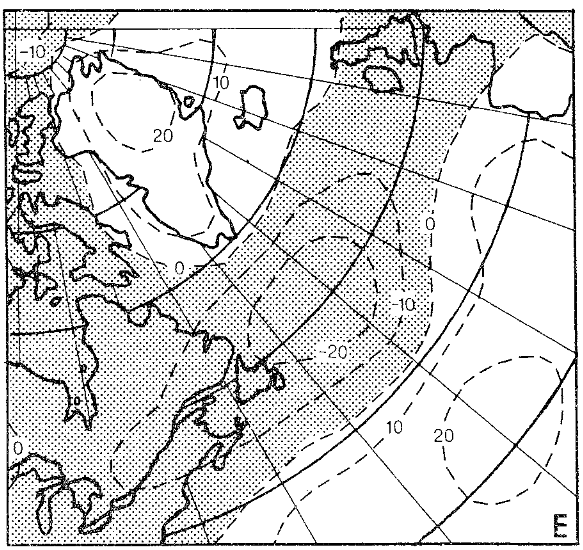


Fig. 16. Five-year mean 1,000–500 mb thickness changes for the northern hemisphere: **A**, 1949–53 to 1954–58; **B**, 1954–58 to 1959–63; **C**, 1959–63 to 1964–68; **D**, 1964–68 to 1969–73; and **E**, 1969–73 to 1974–78.

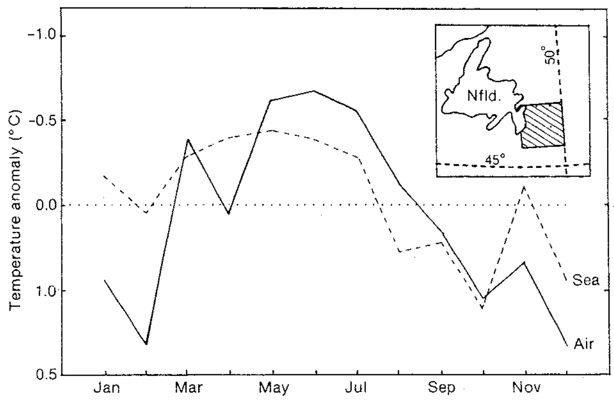


Fig. 17. Mean monthly sea-surface and air temperature anomalies for 1970-74 relative to normal (1869-1971), for an area off southeastern Newfoundland.

1974, due to a combination of strong northwesterly winds and record low temperatures. While ice conditions during 1968-71 were below normal, an all-time record (observations began in 1919) of 1,587 icebergs were reported south of 48°N in 1972, when International Ice Patrol operations began about a month earlier than usual on 29 February and extended to 4 September (Scobie, 1975). Ice conditions were so severe that U. S. Coast Guard patrol vessels were deployed to warn ships, operating between European and eastern North American ports, of the danger of the bergs. In 1973, 847 icebergs were observed south of 48°N. Like 1972, nearly 1,400 icebergs drifted to the Grand Bank area between March and August 1974, with 300 as far south as 46°N and one reaching 42°N. During early July 1974, more than 250 icebergs drifted ashore along eastern Newfoundland, a record for so late in the year.

Severe ice conditions are very hazardous to shipping and fishing along the east coast of Canada between mid-February and late April. During 1972, 1973 and 1974, and also in 1977, the threat extended to May and June, as severe storms with northeasterly winds pushed the ice into the bays and inlets along the east coast of Newfoundland inflecting heavy damage to fishing vessels and gear and to shore installations. In 1976-77, property damage and loss of revenue was in excess of $20 million (McKay, 1978).

Significant Climate Events and Storms

The Northwest Atlantic had its share of climatic anomalies or variations in the 1970's, the dominant events with significant consequences being prolonged cold periods, extensive sea ice, sustained drought, excessive precipitation, and devastating storms. Some of these events are highlighted in Fig. 20.

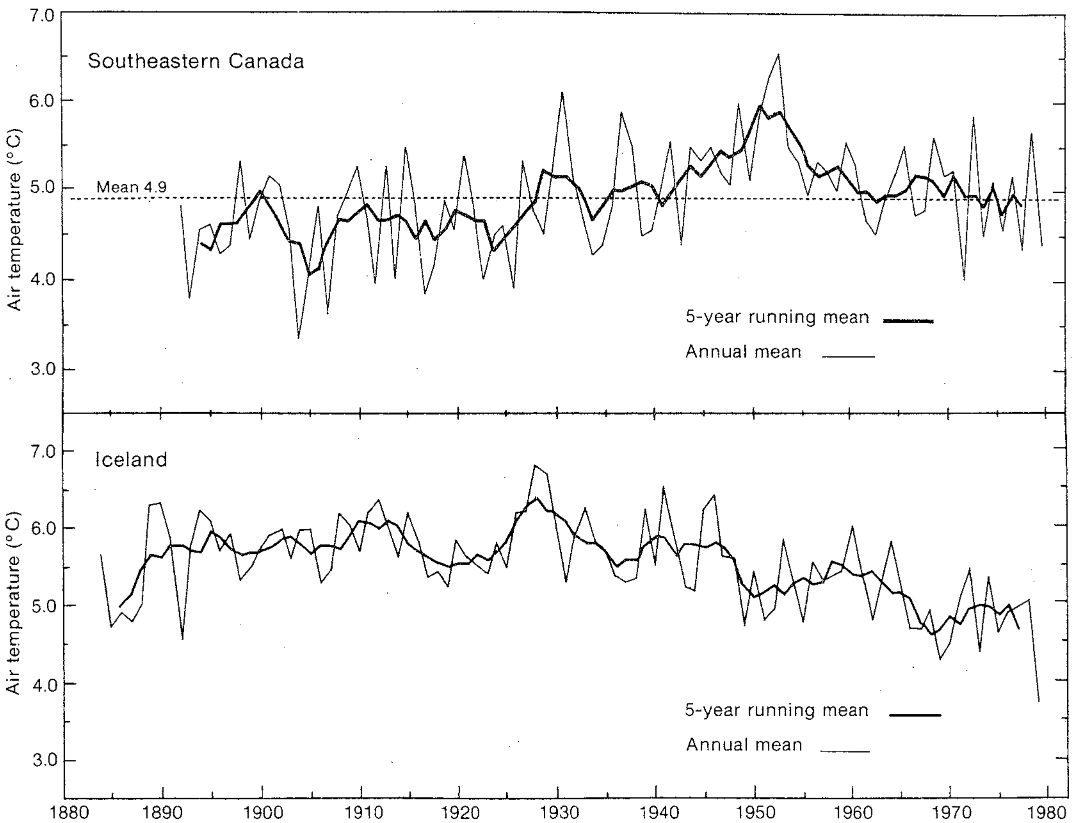


Fig. 18. Mean annual air temperatures in southeastern Canada, from observations at Beatrice (Quebec), Fredericton (New Brunswick) and St. John's (Newfoundland), 1891-1980; and mean annual air temperatures at Vestmanmaeyar, Iceland, 1884-1979.

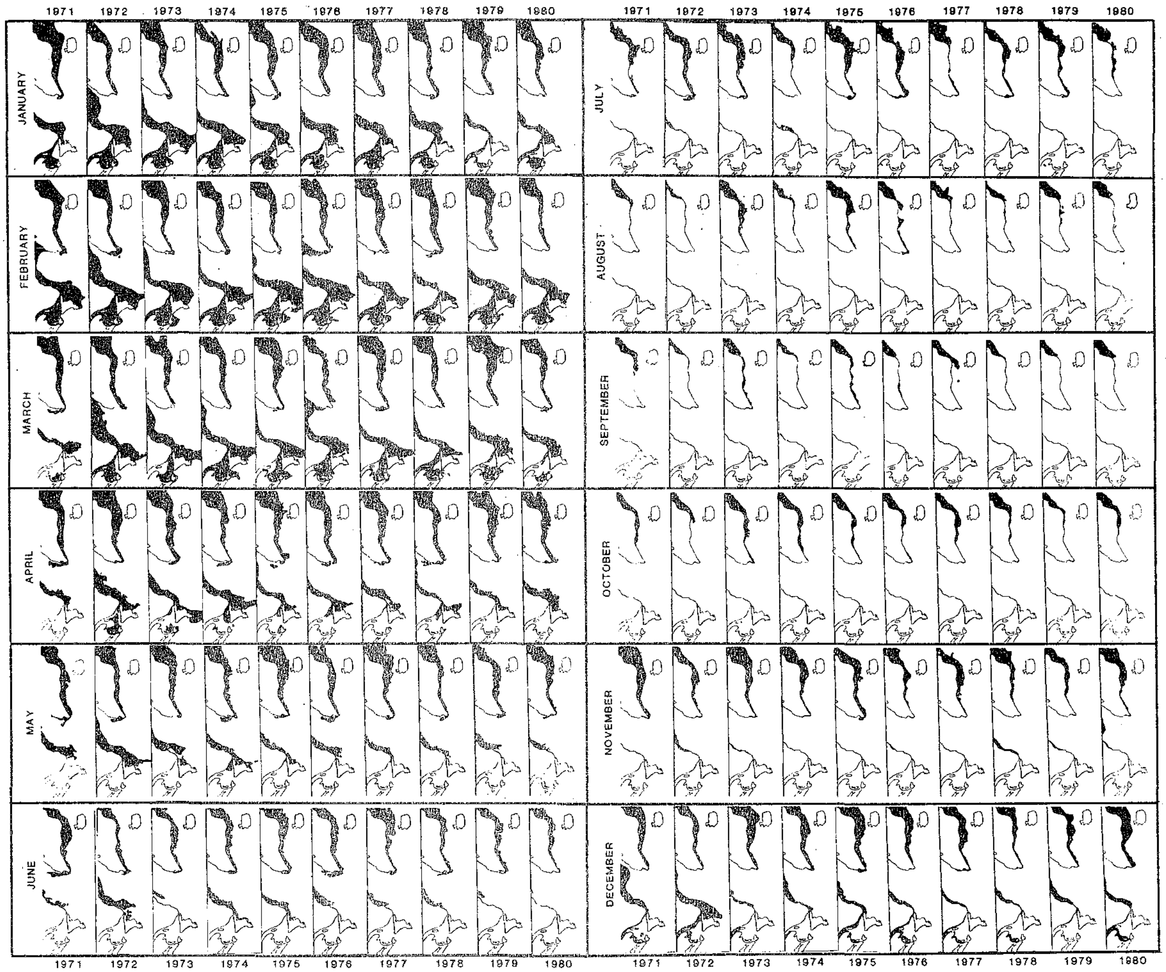


Fig. 19. Distribution of ice greater than 1/10 concentration at the end of the indicated months in the North Atlantic, 1971–80.

Violent storms that claim lives and inflict extensive property damage are normal occurrences in the North Atlantic each year. One only has to peruse the "Monster of the Month" feature in the Mariner's Weather Log to appreciate how regularly fierce gales blow and how vulnerable man is to these whims of nature. On several occasions during the last part of the 1970–79 decade, hurricane-force onshore winds coincided with amplified, astronomically-influenced perigean spring tides. Tidal flooding and erosional damage to low-lying coastal regions of eastern North America from Virginia to Nova Scotia and also in western Europe on the west and south coasts of Great Britain and on the north coasts of France and Germany. Damage to roads, fishing wharves, houses and seawalls was extensive, and evacuation of thousands of persons was required on several occasions. Of special significance during the 1970's was tidal flooding on 11–12 January 1974 in Great Britain, 16–17 March 1976 from Maine to Nova Scotia, 8–9 January 1978 in the New England states, 6–7 February 1978 from New Jersey to Nova Scotia, and 11–12 February 1978 in Great Britain. Damage from two storms in early 1976 is described below:

a) The storm on 1–2 January 1976 was described as the worst to strike northern Europe in 29 years. The intense gales caused more than 100 deaths and inflicted half a billion dollars across Europe from Ireland to the Ukraine. Strong winds with gusts to 165 km/hr blew across countries bordering the North Sea. Waves were 20 m high along the east coast of Great Britain. Flooding caused massive evacuations in Denmark and many ships were grounded or sank. The surge in the North Sea ruptured dykes in Belgium and flooded low-lying areas in Great Britain, Holland, Denmark and the Federal Republic of Germany.

b) On 1–2 February 1976, a severe storm moved along the Atlantic coast of North America and caused extensive damage from Cape Hatteras to northern Labrador. Record or near-low record low pressure

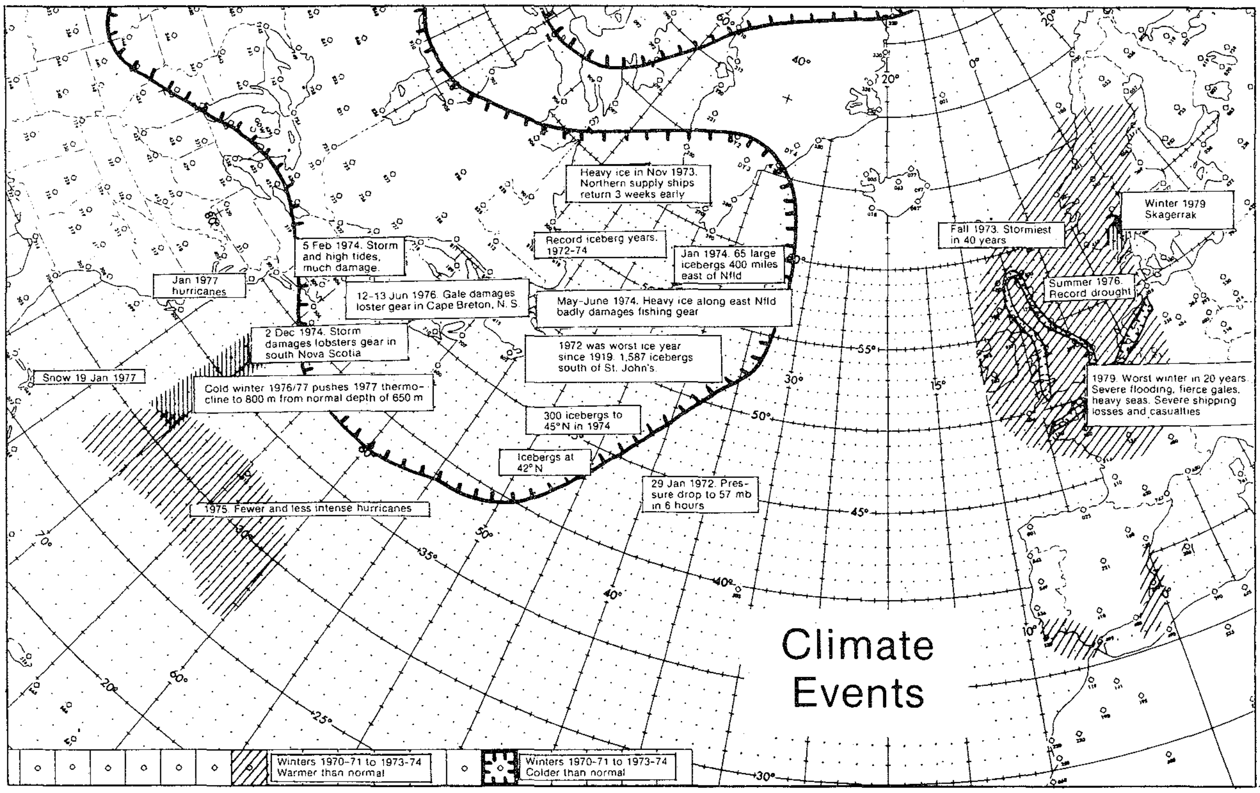


Fig. 20. Significant climate events in the North Atlantic during the 1970-79 decade.

occurred at several locations, 964 mb at Boston, Massachusetts, and 957 mb at Caribou, Maine. Winds from southwest to southeast at 55-95 km/hr or higher were prevalent throughout eastern Canada. On Grand Manan Island, New Brunswick, the wind averaged 115 km/hr for 20 consecutive hr. At sea, ships encountered hurricane-force winds and 12 m waves. For many communities in southwestern Nova Scotia and the Bay of Fundy, the period of strong winds coincided with the rising tide, resulting in exceptionably-high water levels; tide levels at Yarmouth, Nova Scotia, and Saint John, New Brunswick, were 6 m and 8 m respectively, about 1.5 m above predicted values and new records (Amirault and Gates, 1976). Property damage (estimated between $10 million and $50 million) was enormous, many wharves and waterfront structures were severely damaged, several large ships were grounded, and many collisions occurred.

Documenting newsworthy climate anomalies is much easier than reporting and interpreting the socio-economic disruption and losses associated with such events, because little reliable long-term statistical information on economic losses has been published. Although good loss estimates are available from insurance underwriters and various marine safety agencies for marine disasters, the losses suffered by fishermen operating from small vessels, many of which are not insured, are very difficult to estimate. However, statistics, based on the Fishing Vessel Insurance Plan operated by the Canada Department of Fisheries and Oceans, indicate that there has been a steady increase in weather-related damage claims during the 1970's. Since 1975, about 25% of all claims were listed as weather-related casualties, but these do not take into account incidents such as stranding and collision, in which weather may have been a contributing factor.

Conclusions

The 1970-79 decade was one of conspicuous climate anomaly in the Northwest Atlantic. Strong winds and devastating storms, cold winters, particularly wet or dry summers, and severe ice conditions were more prevalent in the 1970's than in preceding decades. The impacts of weather was enormous in terms of losses in lives, property and revenues, not only in eastern Canada but also in northeastern United States.

An important result of the growing consciousness of climate change and its impacts on society has been the beginning of national and international climate programs. There have been world conferences on the environment, food, water and climate. The World Climate Program has appealed strongly to the global community for improvement in understanding the climate and its impacts. In Canada, the Climate Program has been designed to help its citizens to respond better to climate variations, to predict climate and its change, and to better apply climate information for use in managing the resources. Understanding the role of the oceans in influencing climate is vital for defense against climate risks in offshore development and for capitalizing on the economic opportunities provided by improved knowledge of the impacts of climate on fishing operations. Better awareness of the importance of climate will provide a better capacity for man to cope with the surprises that climate is certain to bring.

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