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Overview of Meteorological and Sea Ice Conditions off Eastern Canada during 1996

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ABSTRACT

A review of meteorological and sea ice conditions off eastern Canada during 1996 is presented. Annual air temperatures warmed for the second year in succession and were above normal, in contrast to the cold conditions of the early 1990s. Seasonally, winter temperatures were above normal in all regions for the first time in over a decade. This relatively warm air is believed to be due to weaker northwest winds which carried less cold Arctic air southward. The reduced winds are associated with a weakening of the Icelandic Low, which is reflected in the low NAO index for 1996. The decrease in the NAO index relative to 1995 was the largest annual decline in over one hundred year's of record. The warmer-than-normal winter air temperatures and accompanying weaker-than-normal northwest winds caused ice to form late, be of reduced areal extent than normal and retreat sooner than normal off Newfoundland and southern Labrador. In addition, the number of icebergs reaching the Grand Banks decreased by approximately 2 times that observed in 1995 and the early years of the 1990s. The Gulf of St. Lawrence experienced a normal ice year but ice conditions were relatively light on the Scotian Shelf where it appeared late and left early. In general, 1996 off eastern Canada was the warmest and had the least amount of ice of any year since the mid-1980s.

RÉSUMÉ

Est présenté un examen de l'état du temps et des glaces de mer sur la côte est du Canada en 1996. La température de l'air a augmenté pour la deuxième année consécutive, se situant au-dessus de la normale, par opposition au temps froid observé au début des années 90. Pour la première fois en plus d'une décennie, la température en hiver se situait au-dessus de la normale dans toutes les régions. On croit qu'un norois moins fort, transportant moins d'air arctique vers le sud, soit à l'origine de la température relativement élevée de l'air. La baisse du vent est le résultat d'un affaiblissement de la dépression d'Islande, réfléchi dans le faible index ONA pour 1996. La baisse de l'index ONA par rapport à 1995 est la plus forte baisse annuelle enregistrée depuis plus d'un siècle. Les températures hivernales de l'air plus élevées que la normale et le norois d'accompagnement moins fort que la normale ont retardé la formation des glaces, qui ont couvert une moins grande superficie et ont disparu plus tôt que d'habitude au large de Terre-Neuve et du sud du Labrador. En outre, le nombre d'icebergs qui ont atteint les Grands Bancs était presque deux fois moins élevé qu'en 1995 et au début des années 90. La couverture de glaces dans le golfe du Saint-Laurent se comparait à la moyenne, mais la glace s'est formée tard sur la plate-forme néo-écossaise et a disparu tôt. En général, 1996 s'est révélée sur la côte est du Canada l'année la plus chaude et la moins sujette aux glaces depuis le milieu des années 80.

INTRODUCTION

This paper examines the meteorological and sea ice conditions during 1996 off eastern Canada (Fig. 1). Specifically, it discusses air temperature trends, atmospheric sea level pressures and associated winds, sea ice coverage and iceberg drift. It compliments the oceanographic reviews of the waters in and around Newfoundland, the Gulf of St. Lawrence, Scotian Shelf and Gulf of Maine, which together constitute the annual physical environmental overviews to DFO's Fisheries Oceanography Committee. Environmental conditions are compared with those of the preceding year as well as to the long-term means. The latter comparisons are usually expressed as anomalies, i.e. deviations from their long-term mean, and where possible, the latter have been standardized to a 30-yr (1961-90) base period in accordance with the convention of meteorologists and the recommendations of the Northwest Atlantic Fisheries Organization (NAFO). Having a standardized base period allows direct comparison of anomalies both between sites and variables.

METEOROLOGICAL OBSERVATIONS

Air Temperatures

The German Weather Service publishes monthly mean temperature anomalies relative to the 1961-90 means for the North Atlantic Ocean in their publication *Die Grosswetterlagen Europas*. At the time of writing only data up to and including November 1996 were available. During January, negative anomalies of less than 1°C were observed over most of the Labrador Sea, Newfoundland, and the northeastern Scotian Shelf (Fig. 2). In contrast, over the Gulf of St. Lawrence, the remainder of the Scotian Shelf and the Gulf of Maine, temperatures were slightly above normal. From February to May over the Labrador Sea temperatures were above normal with the maximum values in April when anomalies ranged from 1-6°C. The highest anomalies during this month were along the Labrador coast. High anomalies (1-4°C) also were observed during February. Warmer-than-normal air temperatures also dominated the southern regions of Atlantic Canada from February to April. From June to November, air temperature anomalies throughout the entire northwest Atlantic were typically less than 1°C from the normal, with both the amplitude and sign of the anomalies varying spatially and from month to month.

Monthly air temperature anomalies for 1995 and 1996 relative to their 1961-90 mean at Godthaab in Greenland, Iqaluit on Baffin Island, Cartwright on the Labrador coast, St. John's in Newfoundland, Magdalen Islands in the Gulf of St. Lawrence and Sable Island on the Scotian Shelf (see Fig. 1 for locations) are shown in Fig. 3. The predominance of warmer-than-normal air temperatures in the first half of 1996 is clearly evident, with the exception being Iqaluit where only 2 of the first 6 months experienced positive anomalies. However, these two months were well above normal. At Godthaab, June to November anomalies were negative but rose to 2°C above normal in December. Cartwright shows a somewhat similar pattern to Godthaab except that very warm temperatures were observed in August. In contrast to these Labrador Sea stations, in the Gulf of St. Lawrence air temperatures tended to be warmer-than-normal throughout the year. Note that for all sites, December shows extremely warm conditions.

The 1996 annual mean air temperatures at all six sites were above normal and, with the exception of Iqaluit, exceeded the 1995 mean. The maximum annual anomaly (1.2°C) was, however, at Iqaluit (mean of -8.1°C). All sites around the perimeter of the Labrador Sea had anomalies equal to or exceeding 0.6°C. On the Magdalen Islands in the Gulf of St. Lawrence, the annual anomaly was 1°C while the minimum anomaly of the six sites was at Sable Island (0.1°C).

The time series of annual temperature anomalies for the six sites show the positive values in 1996 and the general increase that began around 1994 (Fig. 4). Note that the interannual variability since 1960 at Godthaab, Iqaluit, Cartwright, and, to a lesser extent, St. John's have been dominated by the large amplitude fluctuations with minima in the early 1970s, early to mid-1980s and the early 1990s, suggesting a quasi-decadal period. Indeed, the recent rise in temperature is consistent with a continuation of this near decadal pattern. A general downward trend at these sites, in addition to the near decadal oscillations, has resulted in temperature anomalies since 1970 being predominantly below normal. Temperature anomalies at the Magdalen Islands and Sable Island have been of much lower amplitude and show no signs of a general downward trend since 1970. They do, however, contain minima in the early 1970s (both sites), the mid-1980s (Sable Island only) and in the 1990s (Magdalen Islands only).

Sea Surface Air Pressures

Climatic conditions in the Labrador Sea area are closely linked to the large-scale pressure patterns and atmospheric circulation. Monthly mean sea-surface pressures over the North Atlantic are published in *Die Grosswetterlagen Europas*. The long-term seasonal mean pressure patterns are dominated by the Icelandic Low centred between Greenland and Iceland and the Bermuda-Azores High centred between Florida and northern Africa (Thompson and Hazen, 1983). The strengths of the Low and High vary seasonally from a winter maximum to a summer minimum. Seasonal anomalies of the sea-surface pressure for 1996, relative to the 1961-90 means, are shown in Fig. 5. Winter includes December 1995 to February 1996, spring is March to May, summer is June to August and autumn is September to November.

In winter, positive air pressure anomalies covered the northern North Atlantic with a maximum (exceeding 10 mb) centred over eastern Norway. In contrast, a center of negative anomalies (maximum exceeding -8 mb) was observed over the southeastern North Atlantic. This pattern represents a weakening of both the Icelandic Low and the Bermuda-Azores High and a significant shift in 1996 from the rest of the 1990s when these pressure systems were more intense-than-normal. Winds tend to blow counterclockwise around lows and clockwise around highs, therefore the anomalous pressure pattern would tend to reduce the mean westerly winds over the northern North Atlantic, especially over eastern sections and Great Britain. Note that the anomalous winds are from the east and would oppose the mean westerly winds, thereby resulting in weaker westerly winds. Anomalous southerly winds over East Greenland would oppose the southward flowing East Greenland Current, perhaps contributing to a decrease in its transport.

Anomalous southerly winds in winter over Baffin Bay and the Labrador Sea would have caused weaker-than-usual northwesterly winds while over Newfoundland, the Gulf of St. Lawrence and the Scotian Shelf/Gulf of Maine winds would have been more northeasterly than normal for the second year in a row. The anomaly pressure pattern established in the winter extended into spring although the peak values decreased slightly and shifted westward (anomalies of 7.9 mb near Iceland and -6 mb near the Azores). This would have contributed to a continuation of weaker westerly winds than normal across the North Atlantic and northwesterly over the Labrador Sea. In summer, an anomalous low developed east of Newfoundland with a maximum pressure anomaly of -2.3 mb. This would produce weaker southerly and southwesterly winds than usual over Newfoundland, the Gulf of St. Lawrence and the Gulf of Maine. The autumn saw a return to the winter and spring anomaly pattern with positive values in the north and negative to the south. However, this pattern shifted northward such that the center of the positive anomaly was over Greenland and the low lay between Newfoundland and Great Britain. An anomalous high also developed off northwest Africa. This pattern would have resulted in anomalous northeasterly winds over south Labrador and the Atlantic provinces of Canada.

NAO Index

The North Atlantic Oscillation (NAO) Index is the difference in winter (December, January and February) sea level pressures between the Azores and Iceland and is a measure of the strength of the winter westerly winds over the northern North Atlantic (Rogers, 1984). A high NAO index corresponds to an intensification of the Icelandic Low and Azores High. Strong northwest winds, cold air and sea temperatures and heavy ice in the Labrador Sea area are also associated with a high positive NAO index (Colbourne et al. 1994; Drinkwater 1996). The annual NAO index is derived from the measured mean sea level pressures at Ponta Delgada in the Azores minus those at Akureyri in Iceland. The small number of missing data early in the time series was filled using pressures from nearby stations. The NAO anomalies were calculated by subtracting the 1961-90 mean.

In 1996, the NAO index fell dramatically relative to last year producing an anomaly that was strongly negative (Fig. 6). This reverses the trend of very high NAO anomalies that had persisted since the late 1980s and indicates a significant shift in the large-scale atmosphere circulation. Indeed, the decrease from 1995 to 1996 was the single largest annual decline in the NAO index in over 100 year's of record. However, the decline also fits the pattern of near decadal variability that has persisted since the 1960s, and was therefore expected, although its amplitude was much greater than predicted based upon past variability.

SEA ICE OBSERVATIONS

Information on the location and concentration of sea ice is available from the daily ice charts published by Ice Central of Environment Canada in Ottawa. The long-term medians, maximum and minimum positions of the ice edge (concentrations above 10%) based on the composite for the years 1962 to 1987 are taken from Coté (1989).

Newfoundland and Labrador

At the end of 1995, sea ice lay off the southern Labrador coast in the vicinity of Hamilton Inlet resulting in an areal coverage that was slightly less than the long-term mean for that time of the year (Fig. 7). This was in large part due to above normal air temperatures during the second half of December that slowed ice formation, coupled with strong northeasterly winds over south Labrador that pushed ice inshore. During the first half of January 1996, ice spread rapidly south to St. Anthony on Newfoundland's northern Peninsula and offshore, such that the ice edge was near its long-term median position by the middle of the month. Moderating air temperatures and southwesterly winds slowed the ice advancement during the second half of the month and by the end of January the ice coverage off northern Newfoundland was again less than the long-term normal. Continuing positive temperature anomalies and strong southwesterly winds caused the southern ice edge to retreat northward during February, which is very unusual for this time of the year. Several strong wind storms also broke up and loosen the ice. By 1 March the ice edge was well north of its long-term median position but offshore it lay close to the maximum. Variable temperatures and wind through March left the southern ice edge far north of the long-term median location by April and between the median and maximum locations offshore. During April the ice retreated quickly northward. By 1 May, ice was limited to southern Labrador and was patchy. Ice remained off the mouth of Hamilton Inlet through June but by 1 July it had disappeared.

An analysis of the time of onset, duration and last presence of sea ice at 24 sites (Fig. 8) off the east coast of Newfoundland and southern Labrador and in the Gulf of St. Lawrence was carried out by Ice Central of Environment Canada until 1994. For each site, the extracted data include ice duration in weeks, as well as minimum, maximum and mean duration for years when ice was present (Table 1). For the last two years, we have continued the analysis. In 1996, ice first appeared off southern Labrador in early January, approximately 1 week later-than-normal (Fig. 9, positive anomaly). On the Newfoundland and Labrador shelves, the ice generally appeared later-than-normal by <1 week except in a region offshore where it arrived up to two weeks early. Ice was not observed during the season at the far offshore sites N27 and N70, and at the southern sites N108 through to N114 and at N228. However, ice has never been observed at sites N27 and N70, in 36 years of observations has only reached N114 five times, and has only been observed in 15 of the 37 years of record at N112. In contrast, at N110, N112 and N228 the absence of ice through the year is relative rare, having occurred only 17, 20 and 30% of the time respectively, at the 3 sites. At sites N25 and N68 ice has appeared in so few years that a long-term mean and annual anomalies have little meaning. Ice began to disappear in March from the furthest offshore sites (Fig. 10). Ice retreated from northern Newfoundland waters during April, from southern Labrador in May but lasted off the region south of Hamilton Inlet until 20 June. At most sites this resulted in ice disappearing early-than-normal, including up to 4 weeks early off the northern tip of Newfoundland. Exceptions to this are sites N19 off Hamilton Inlet where the ice remained slightly later-than-normal and at N23 where the last ice was observed 1 week later-than-normal. The duration of the ice season ranged from less than 5 weeks far offshore to just over 15 weeks off Hamilton Inlet on the southern Labrador (Fig. 11). Note that the duration is not simply the date of the first presence minus the last presence because the ice may disappear for a time and then reappear. The ice duration was shorter-than-normal (negative anomaly) over most of the Labrador and Newfoundland waters but were longer-than-normal by up to 6 weeks at site N23 offshore of Labrador.

The time series of the areal extent of ice on the Newfoundland and southern Labrador shelves (between 45-55°N; I. Peterson, personal communication, Bedford Institute) show the peak extent during 1996 declined for the second consecutive year, was well below the high values in the early 1990s and was the lowest in almost 20 years (Fig. 12). The monthly means plotted separately show that in all months of 1996 ice coverage was less than that observed during the last few years (Fig. 13). These data indicate 1996 was an average to lighter-than-average ice year on the Labrador and Newfoundland shelves. Note that during January through April there has been a general increase in the area of ice over the past 30 y but no such trend exists during May through July. Variations of ice area reflect similar changes in ice volume as the two are highly correlated based on studies we have carried out in the Gulf of St. Lawrence.

Icebergs

The number of icebergs that pass south of 48°N latitude in each year is monitored by the International Ice Patrol Division of the United States Coast Guard. Since 1983, data have been collected with SLAR (Side-Looking Airborne Radar). During the 1995/96 iceberg season (October to September), a total of 611 icebergs were spotted south of 48°N. The monthly totals for March to August were 4, 297, 187, 108, 14, and 1 (Fig. 14). No icebergs were spotted between October, 1995, and February, 1996, inclusive, or in September, 1996. All icebergs in 1996 were observed during the primary iceberg season of March to July, higher than the mean in 1983-96 of 89%. The percentage of the total number of icebergs by month for the 1995/96 season shows that proportionally more penetrated south of 48°N in April and May then on average during the years icebergs have been detected using SLAR (1983-96). Indeed, almost 50% of the icebergs in 1996 arrived in April. The total number of icebergs in 1996 was above the long-term mean but was well down from the high numbers during the earlier years of the 1990s (Fig. 14). The decline in iceberg numbers matches the decline in sea ice extent and follows from the warmer air temperatures and reduced northwest winds. Note that periods of large number of icebergs reaching south of 48°N occurred in the early 1970s, the mid-1980s and the early to mid-1990s, all periods of cold air temperatures, strong NW winds and extensive ice cover.

Gulf of St. Lawrence

Near normal air temperatures over the Gulf of St. Lawrence during December 1995 resulted in ice being close to their long-term mean positions at the end of that year (Fig. 15). Ice had formed in the St. Lawrence Estuary and along the coast from Baie des Chaleur to Pictou, Nova Scotia. Ice advanced at its normal rate through January and the ice edge lay near the long-term median location by 1 February. However, the ice was looser than normal, in large part because of several strong wind storms that caused considerable ice destruction. Uncharacteristically warm temperatures during February slowed the ice advance and left the ice edge north of the long term median by 1 March. Winds also pushed ice away from the shores of northern Prince Edward Island, off Cape Breton, western Newfoundland and out of the St. Lawrence Estuary. Wind storms continued to keep the ice loose. Ice coverage remained near the long-term median by 1 April but continued to be thinner and looser than normal. Above normal temperatures during April resulted in rapid melting so that by mid-month most of the ice had disappeared from the Gulf. By 1 May the only significant amount of ice left in the Gulf was located in the Strait of Belle Isle and this disappeared by the 5 May. In summary, the ice coverage in the Gulf was near normal during 1996 but it was thinner and looser than normal.

Ice in the Gulf of St. Lawrence generally appeared within a week of its usual arrival date although it tended to be later-than-normal (Fig. 9). Exceptions were north of Anticosti Island where the ice was 3 weeks late and off Baie des Chaleurs which was near normal but slightly early. No ice was observed at grid point G35 off southern Newfoundland. On the eastern side of the Gulf, ice lasted longer than normal by upwards of 2 weeks in the Estuary but on the western side it left early (Fig. 10). In the Strait of Belle Isle the ice disappeared 2-4 weeks early. The ice duration (Fig. 11) was shorter-than-normal (by 1-4 weeks) throughout the Gulf with the shortest duration relative to the mean being in the Strait of Belle Isle and in the Cabot Strait region. No records for maximum or minimum ice duration or first or last presence were set anywhere in the Gulf in 1996.

Scotian Shelf

Sea ice normally flows out of the Gulf of St. Lawrence, pushed by northwest winds and the mean ocean current pattern. Seaward of Cabot Strait, ice can appear as early as January and remain as late as May. Based on ice records since the 1960s, ice often extents onto the Scotian Shelf covering a large area of the northeastern region and will extent along the Atlantic coast of Nova Scotia south to Halifax. Historical records suggest that back in the late 1800s ice extended as far south as the Gulf of Maine on rare occasions (A. Ruffman, Halifax, personal communication). The monthly estimates of the ice area seaward of Cabot Strait since the 1960s shows that less ice than normal was transported onto the Scotian Shelf during 1996 (Fig. 16) and it was significantly less than 1995 in all months (Fig. 17). The loose and thin ice observed in the Gulf likely contributed to its rapid break-up and melting once it reached the Scotian Shelf. The data indicate that 1996 was a light ice year on the Scotian Shelf.

OUTLOOK FOR 1997

Reports from Ice Central in Ottawa indicate that the first half of January 1997 was extremely warm, continuing the conditions observed in December 1996. The second half of January and the first half of February have seen temperatures drop below normal. Initially, ice coverage especially in the Gulf of St. Lawrence was smaller-than-usual but by mid-February the ice edge lay near the long-term median. Based upon the previously observed decadal variability in air temperatures and NAO index, coupled with the warming trend of the last 2 year, it might be expected that the atmospheric conditions in Labrador and Newfoundland will continue to moderate. Thus we expect that 1997 will have above normal air temperatures, weaker winds and less ice than normal.

SUMMARY

During 1996, a significant change occurred in the large-scale atmospheric circulation pattern. The Icelandic Low which has for over a decade been more intense than the long-term average, weakened. The Bermuda-Azores High also weakened. This resulted in a decline in the NAO index, the single largest annual decrease on record in over 100 years. Associated with the weakening of the Icelandic Low northwest winds would have been weaker than normal over the Labrador Sea which would account for the wintertime air temperatures being, on average, warmer-than-normal and the warmest in approximately a decade. Warmer air temperatures and weaker northwest winds resulted in later-than-normal ice formation, less areal extent of ice than normal and a shorter duration of ice, over much of the Labrador/Newfoundland shelves and in the Gulf of St. Lawrence/Scotian Shelf. In turn, the warm temperatures, weak winds and less ice all contributed towards a large reduction in the number of icebergs reaching the Grand Banks in 1996 relative to 1995 and the earlier years of the 1990s. Only time will tell whether 1996 signifies the end of the long-term trend of increasing NAO index (and associated cold conditions during winter in the Labrador Sea area) or simply represents a large annual deviation from this trend. During spring, air temperature anomalies continued to remain above normal consistent with the air pressure pattern and weaker northwest winds over the Labrador Sea. During the summer and autumn, air temperatures tended to fluctuate about their long-term means.

ACKNOWLEDGEMENTS

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REFERENCES

Colbourne, E., S. Narayanan and S. Prinsenberg. 1994. Climatic changes and environmental conditions in the Northwest Atlantic, 1970-1993. ICES mar. Sci. Symp. 198: 311-322.

Coté, P.W. 1989. Ice limits eastern Canadian seaboard. Environment Canada, Ottawa. 39 p. (Unpublished Manuscript)

Drinkwater, K.F. 1996. Climate and oceanographic variability in the Northwest Atlantic during the 1980s and early-1990s. J. Northw. Atl. Fish. Sci. 18: 77-97.

Rogers, J.C. 1984. The association between the North Atlantic Oscillation and the Southern Oscillation in the Northern Hemisphere. Mon. Wea. Rev. 112: 1999-2015.

Thompson, K.R. and M.G. Hazen. 1983. Interseasonal changes in wind stress and Ekman upwelling: North Atlantic, 1950-80. Can. Tech. Rep. Fish. Aquat. Sci. 1214, 175 p.

TABLE 1. Historical data on presence and duration of sea ice at 24 sites off eastern Canada and ice duration at these sites in the 1995/96 (October-September) ice year with 1994/95 data in parentheses.

				Ice Duration (in weeks)				
				When ice present				
Site	Seasons Studied	# of Yrs	Yrs ice	Min	Max	Mean	Overall Mean	95/96 (94/95)
G-7	67/68-95/96	29	29	6	16	10.8	10.8	8 (14)
G-10	76/77-95/96	20	20	3	17	12.4	12.4	10 (17)
G-12	67/68-95/96	29	29	2	15	11.7	11.7	10 (13)
G-22	76/77-95/96	20	20	7	17	12.3	12.3	12 (17)
G-31	68/69-95/96	28	27	8	17	12.6	12.1	11 (12)
G-33	71/72-95/96	25	25	2	14	10.8	10.8	8 (10)
G-35	59/60-95/96	37	19	1	11	3.5	1.8	0 (0)
G-86	76/77-95/96	20	20	6	23	16.7	16.7	12 (18)
G-87	70/71-95/96	26	25	1	12	7.6	7.3	1 (7)
N-19	66/67-95/96	30	30	17	32	23.9	23.9	20 (25)
N-21	67/68-95/96	29	29	5	28	18.6	18.6	13 (18)
N-23	59/60-95/96	37	31	1	17	5.1	4.2	11 (1)
N-25	59/60-95/96	37	2	1	1	1.0	0.1	0 (0)
N-27	59/60-95/96	37	0	0	0	0.0	0.0	0 (0)
N-62	67/68-95/96	29	29	8	27	18.7	18.7	13 (16)
N-64	59/60-95/96	37	36	3	25	13.2	12.8	8 (13)
N-66	59/60-95/96	37	31	1	17	8.6	7.1	5 (5)
N-68	59/60-95/96	37	17	1	10	3.5	1.6	1 (0)
N-70	60/61-95/96	36	0	0	0	0.0	0.0	0 (0)
N-108	59/60-95/96	37	30	1	17	6.3	5.3	0 (10)
N-110	59/60-95/96	37	29	1	16	5.6	4.6	0 (7)
N-112	59/60-95/96	37	15	1	10	4.1	1.7	0 (0)
N-114	59/60-95/96	37	5	1	2	1.6	0.2	0 (0)
N-228	59/60-95/96	37	25	1	14	5.9	4.1	0 (10)

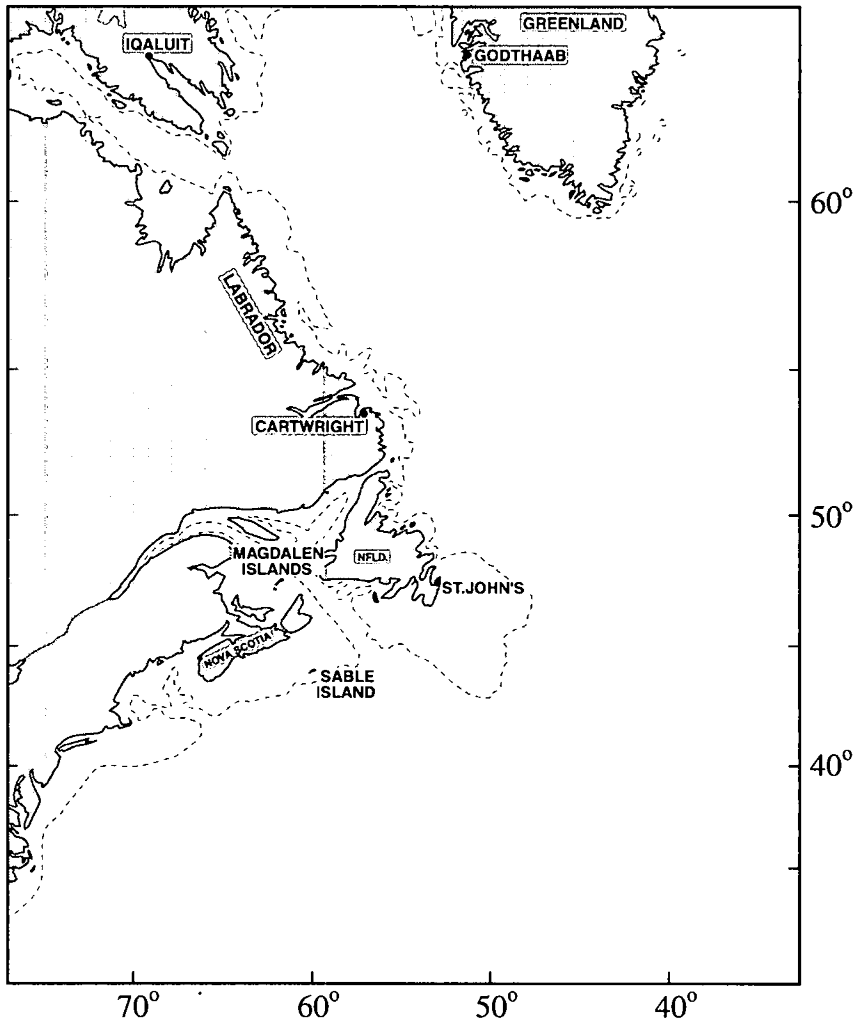

Fig. 1. Eastern Canada and Greenland showing coastal air temperature stations.

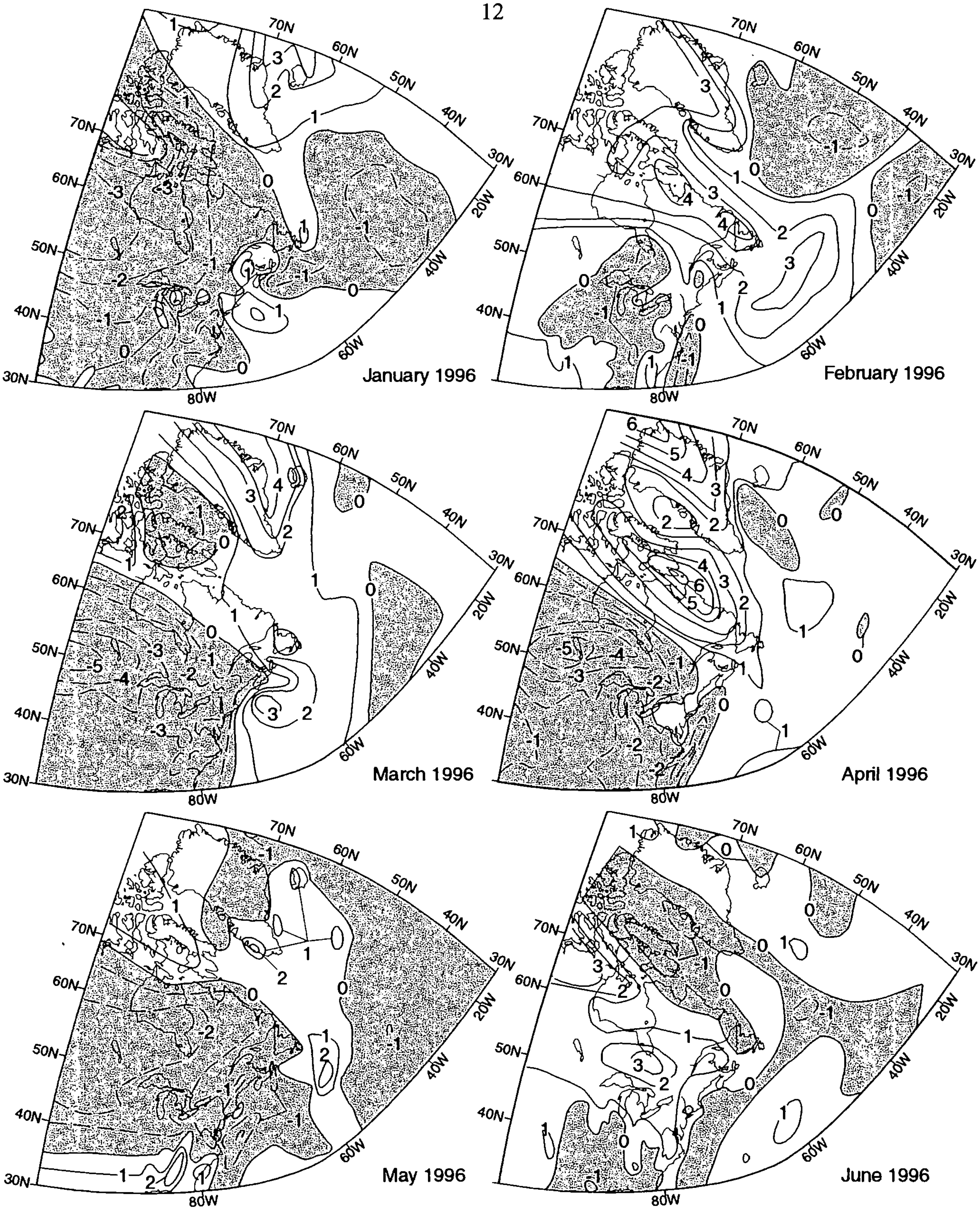

Fig. 2. Monthly air temperature anomalies (in °C) over the northwest Atlantic in 1996 relative to the 1961-90 means (from *Grosswetterlagen Europas).* The shaded anomalies indicate areas of below normal temperatures.

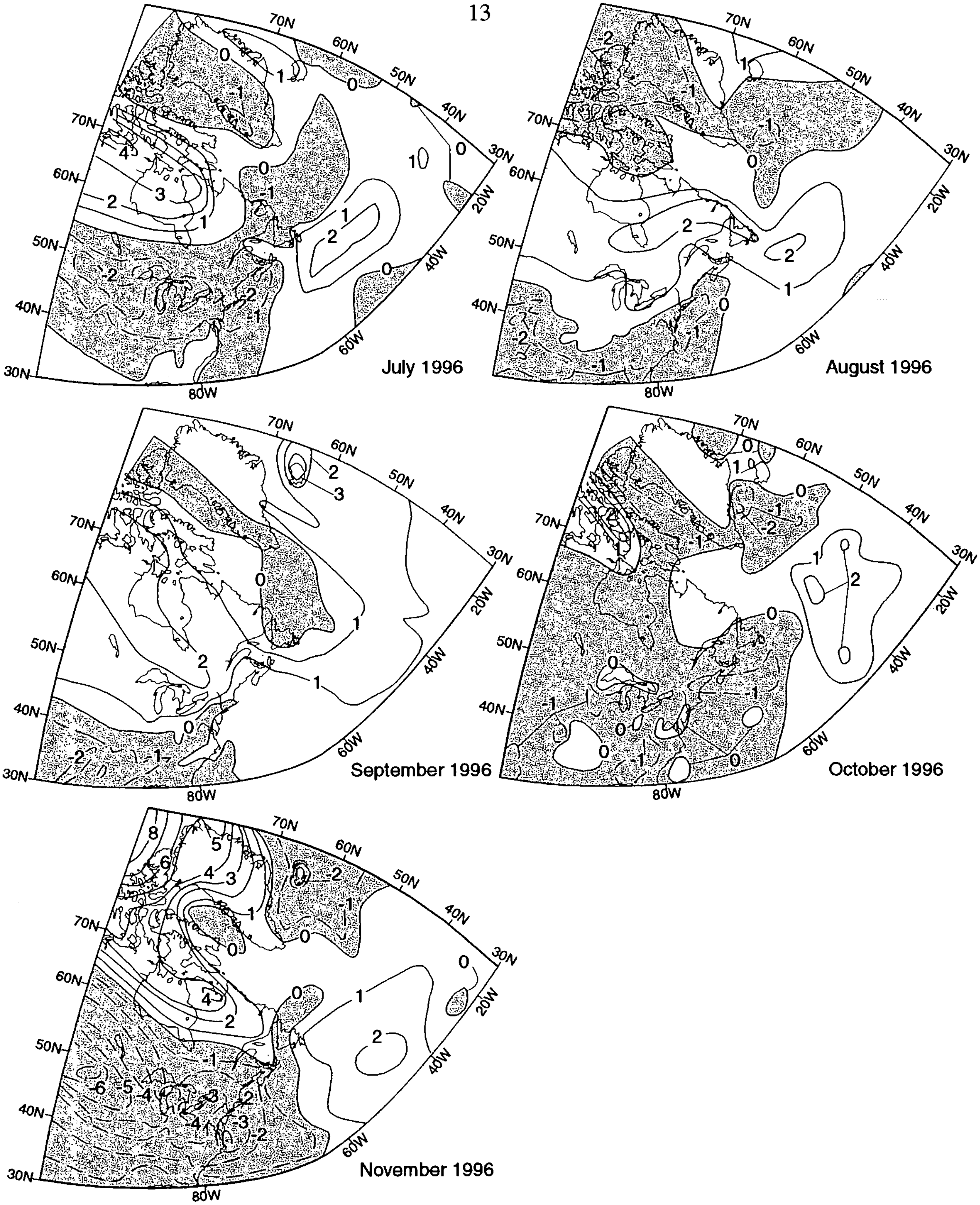

Fig. 2.continued Monthly air temperature anomalies (in °C) over the northwest Atlantic in 1996 relative to the 1961-90 means (from *Grosswetterlagen Europas).* The shaded anomalies indicate areas of below normal temperatures.

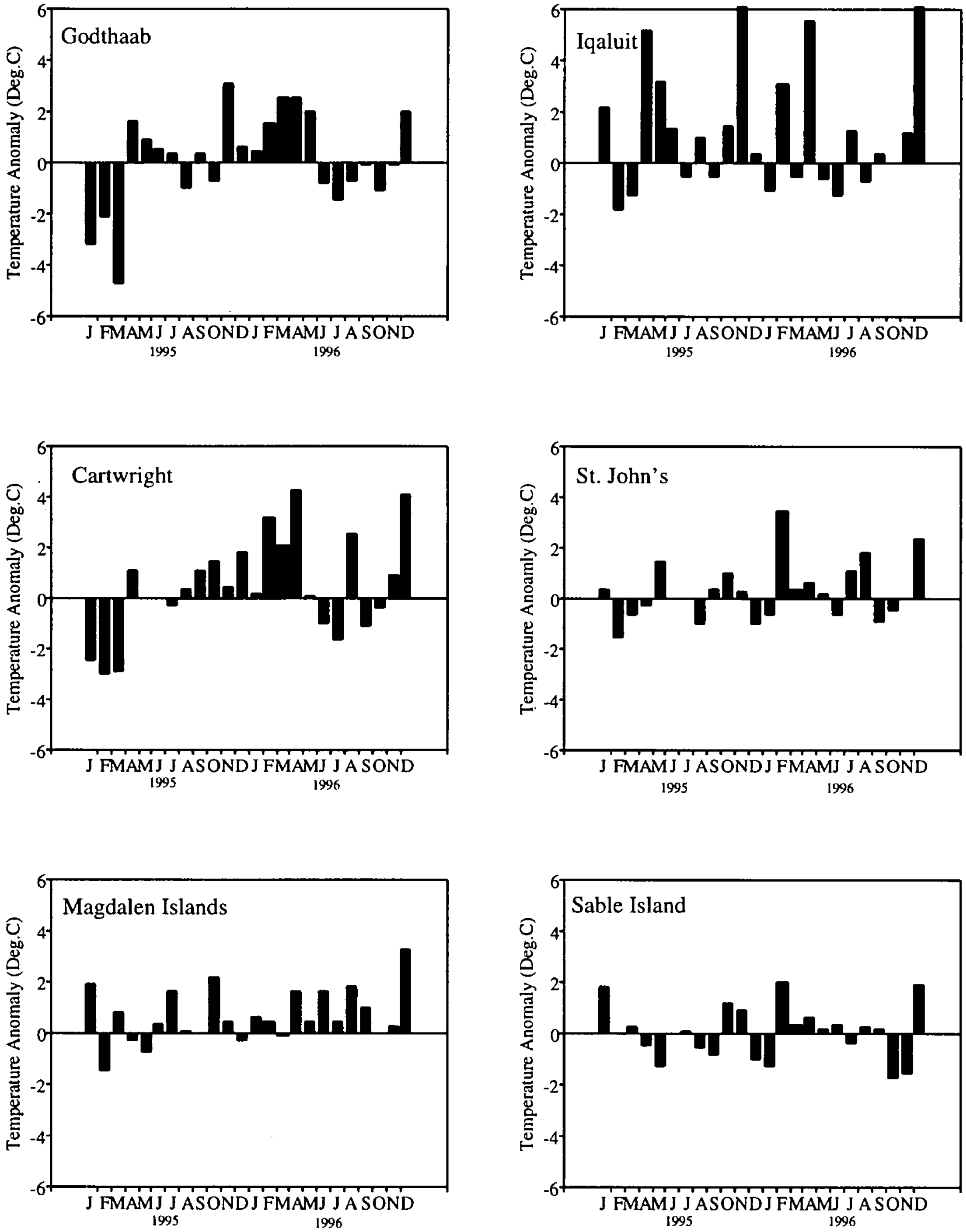

Fig. 3. Monthly air temperature anomalies in 1995 and 1996 at selected coastal sites (see Fig. 1 for locations).

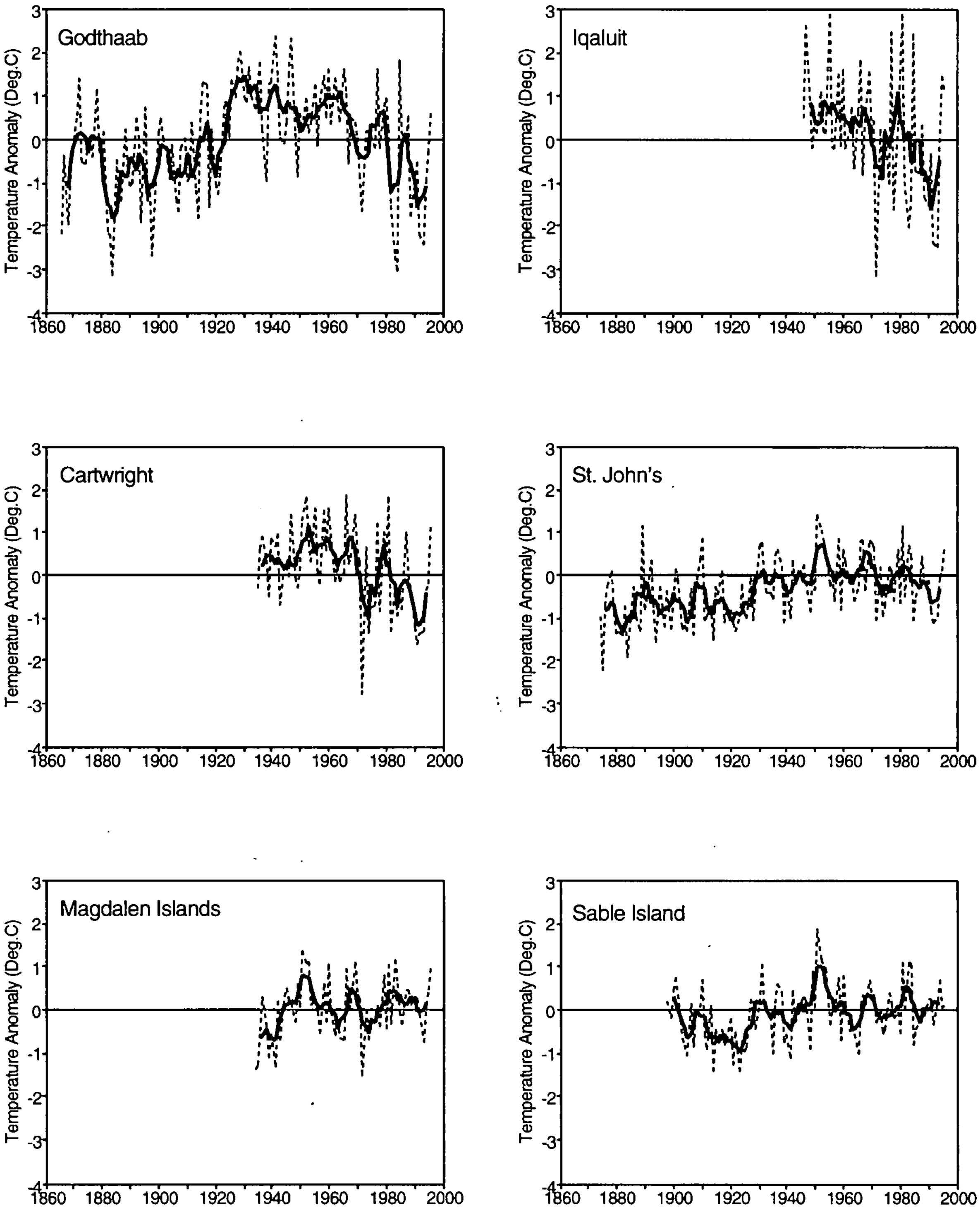

Fig. 4. Annual and 5-yr running means of air temperature anomalies at selected sites.

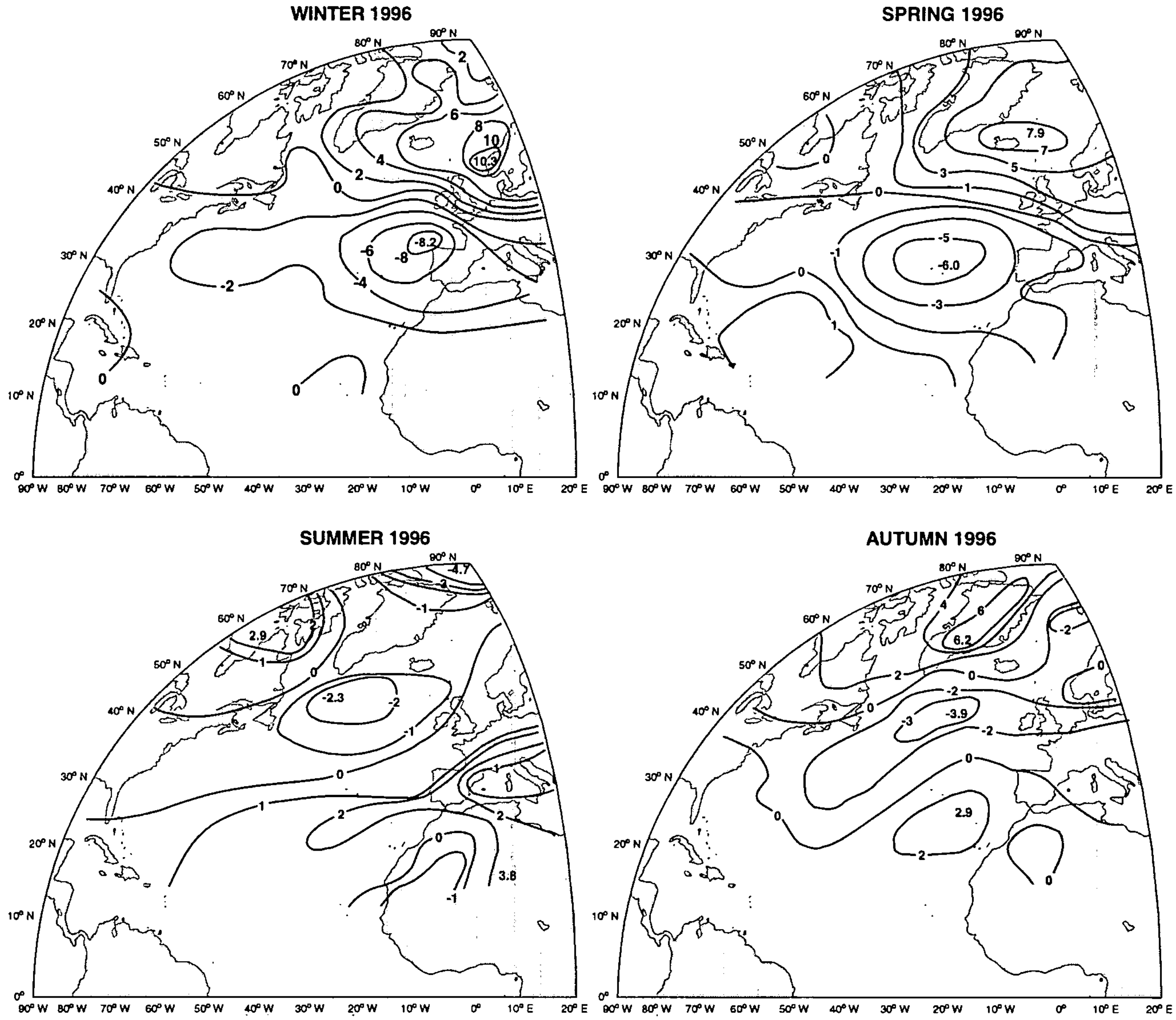

Fig. 5. Seasonal sea-surface air pressure anomalies (in mb) over the North Atlantic in 1996 relative to the 1961-90 means.

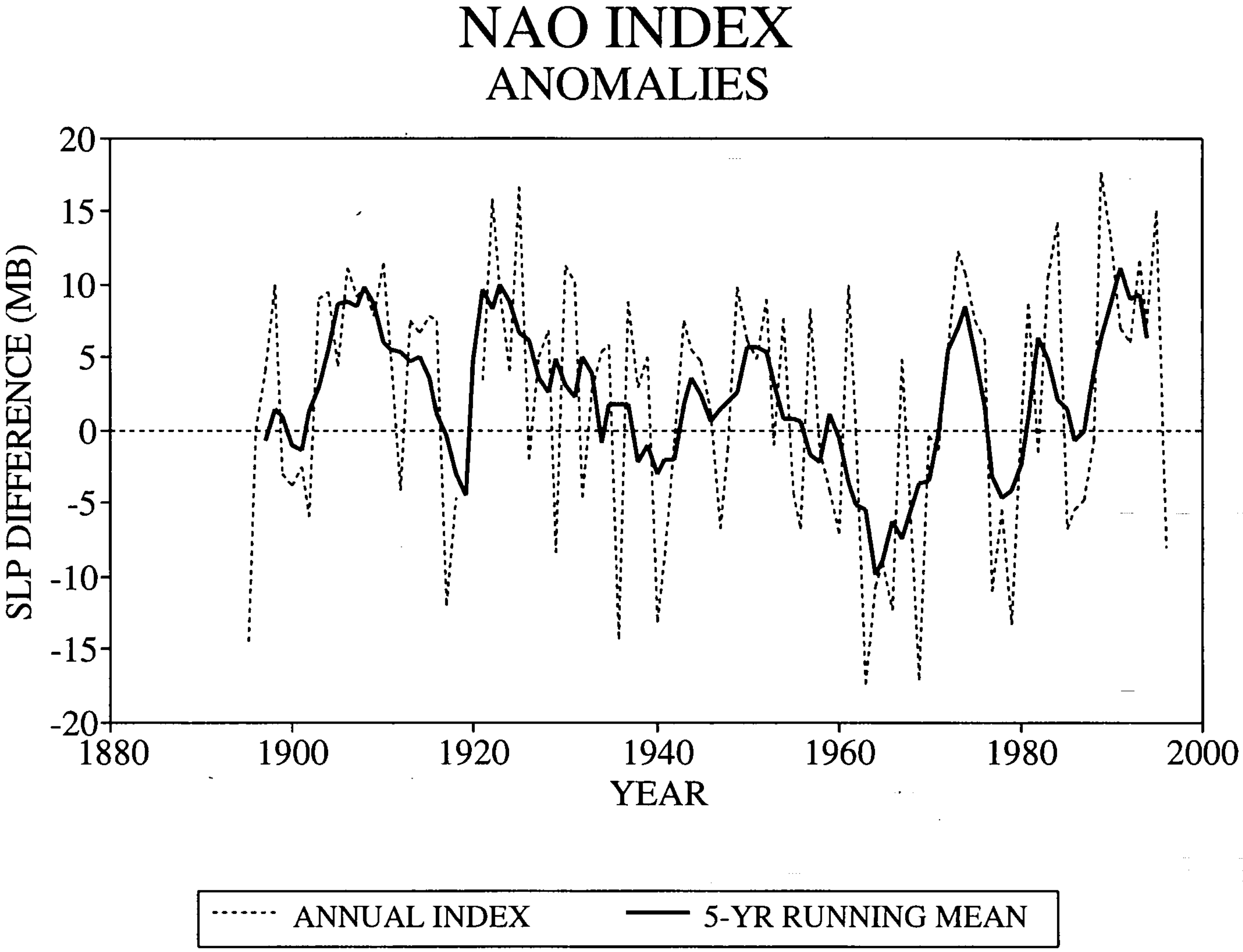

Fig. 6. Anomalies of the North Atlantic Oscillation Index, defined as the winter (December, January, February) sea level pressure at Ponta Delgada in the Azores minus Akureyri in Iceland, relative to the 1961-90 mean.

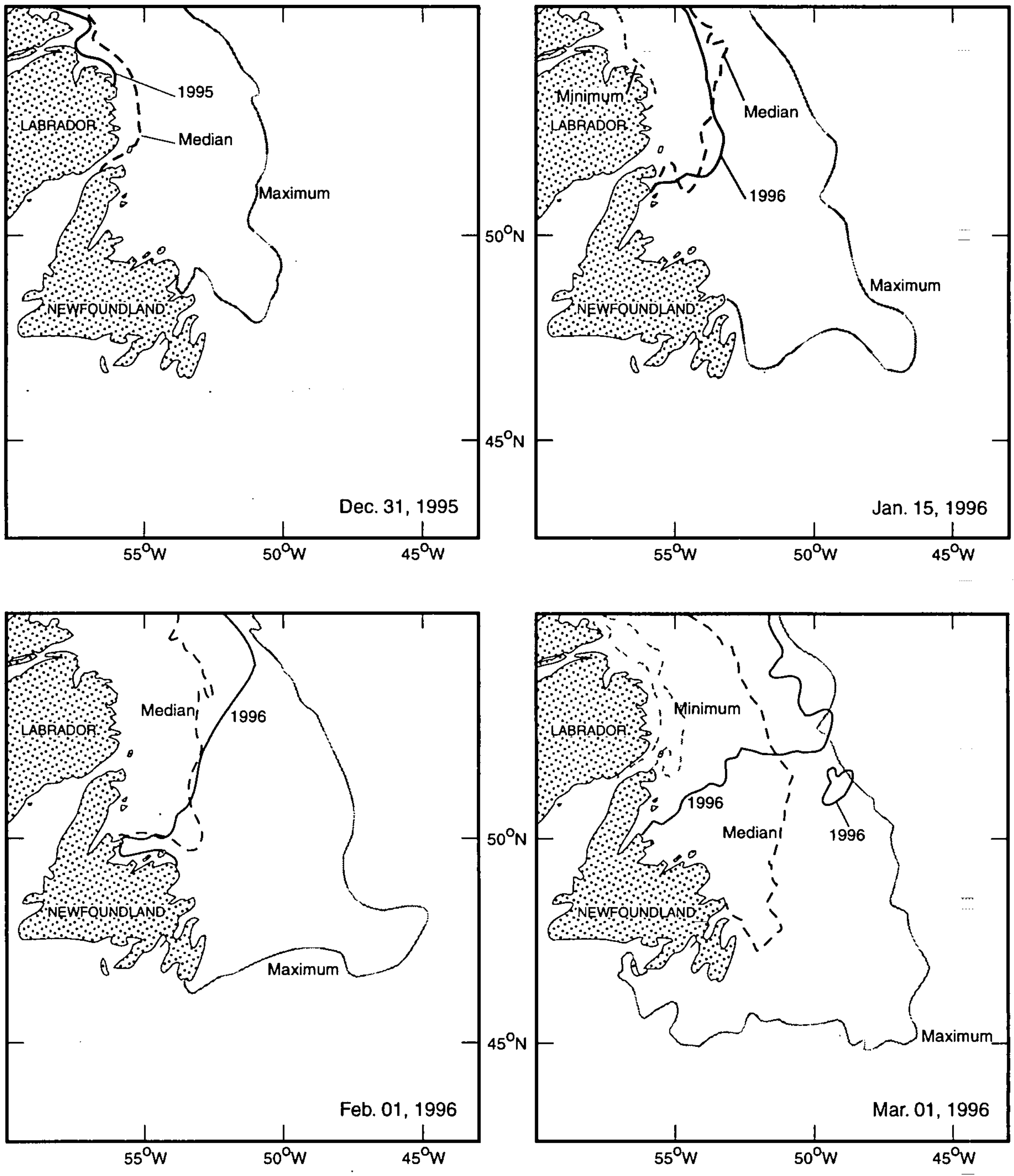

Fig. 7a. The location of the ice edge together with the historical (1962-1987) median and maximum positions off Newfoundland and Labrador between December 1995 and March 1996.

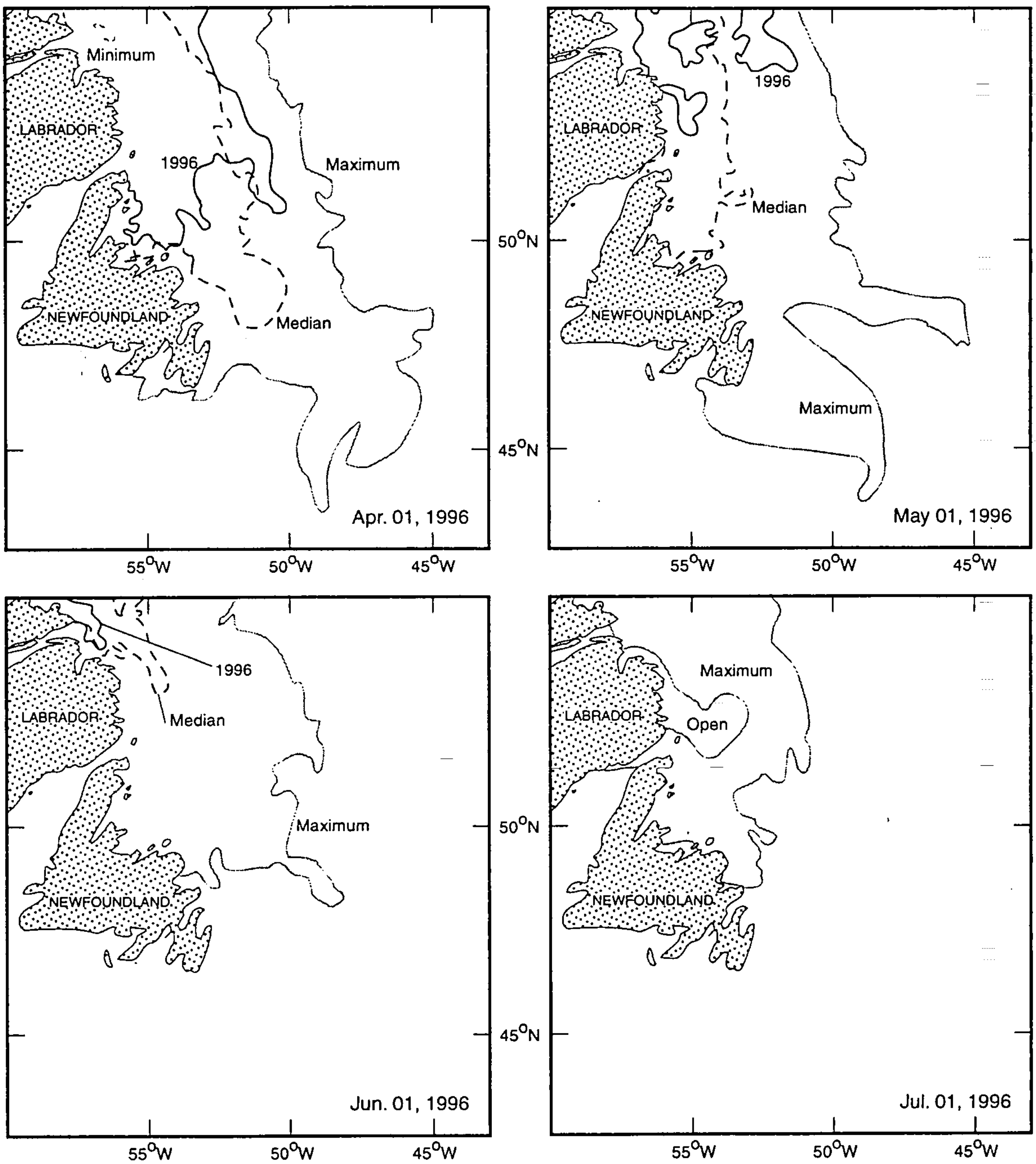

Fig. 7b. The location of the ice edge together with the historical (1962-1987) median and maximum positions off Newfoundland and Labrador between April1996 and July 1996.

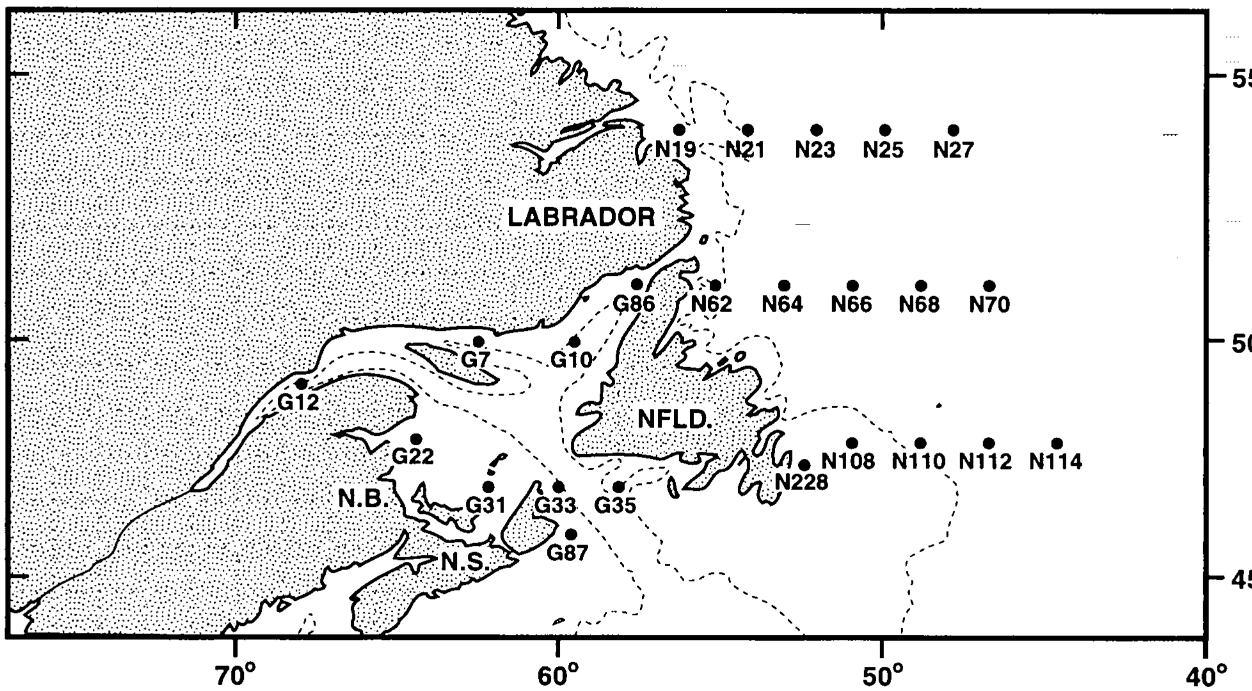

Fig. 8. Location of 24 grid points in the Northwest Atlantic where ice statistics have been extracted from ice charts.

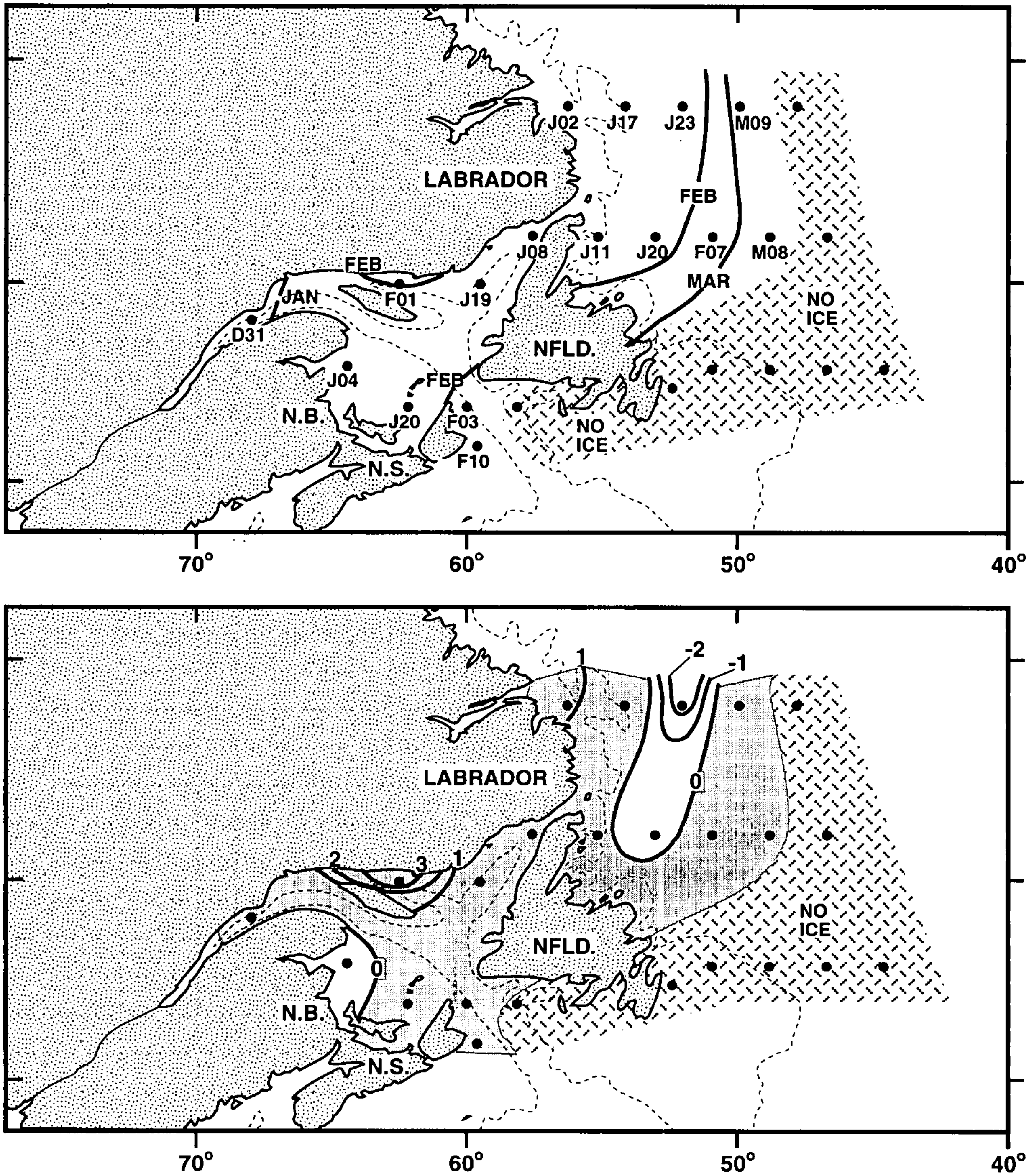

Fig. 9. The date in 1996 at which first ice appears at the grid points in Fig. 8 (top) and their anomalies, in weeks, from the long term mean (bottom). A negative anomaly indicates ice appeared earlier than normal.

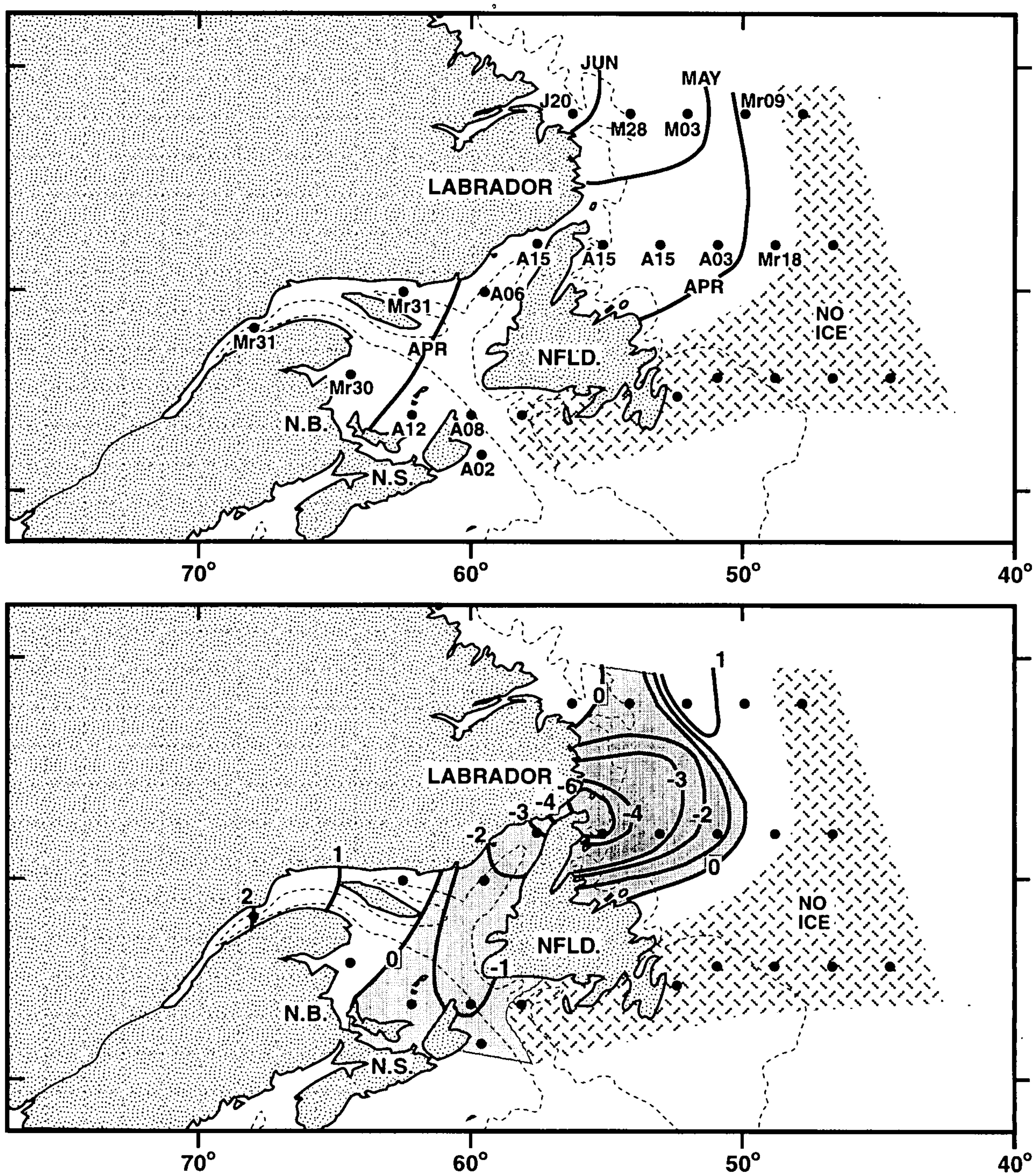

Fig. 10. The date in 1996 at which last ice appears at the grid points in Fig. 8 (top) and their anomalies from the long term mean in weeks (bottom). A positive anomaly indicates ice lasted longer than normal.

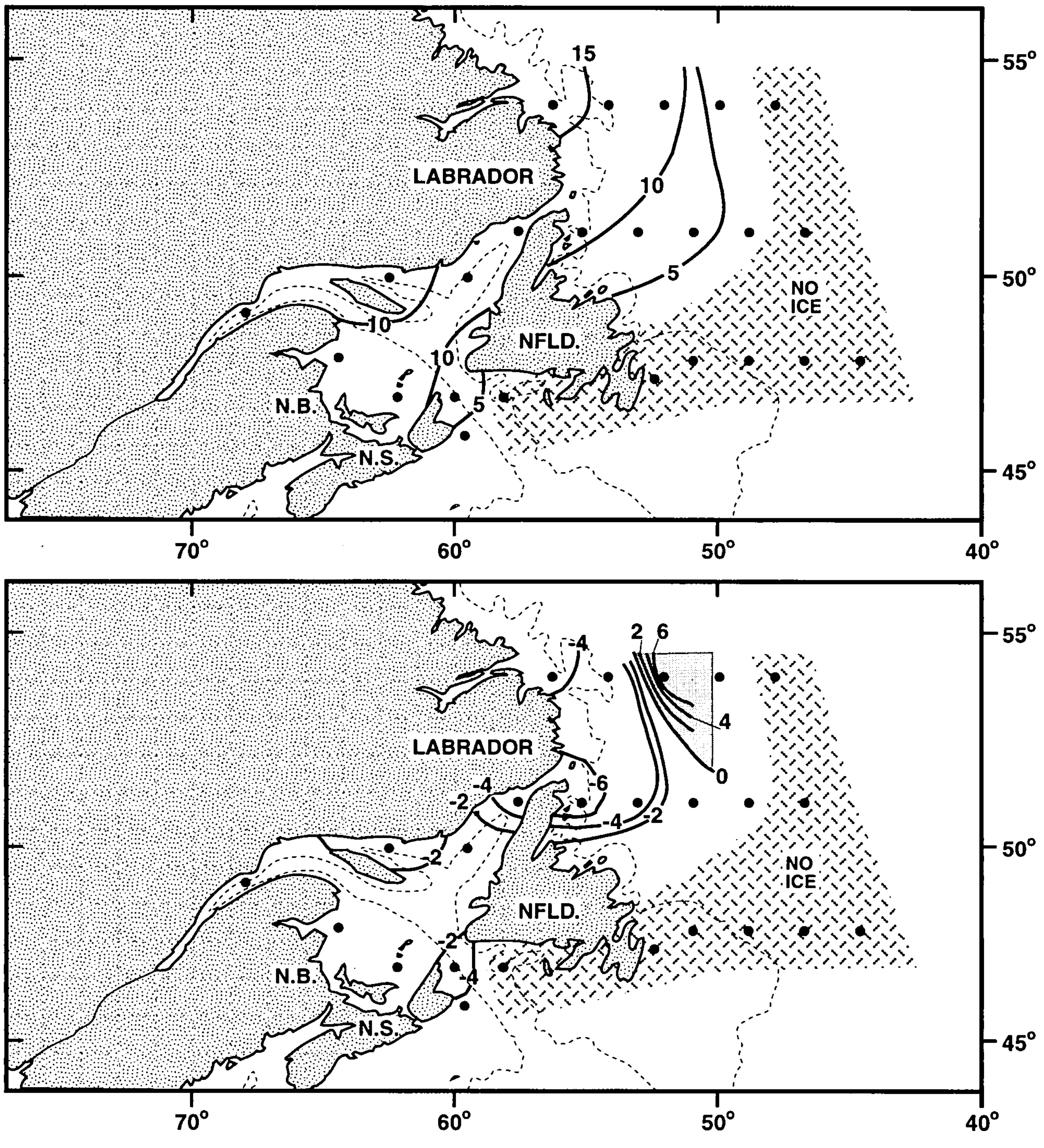

Fig. 11. The duration of ice in 1996 (top) and its anomaly, in weeks, relative to the long-term mean (bottom). Positive anomalies indicate a duration longer than the mean.

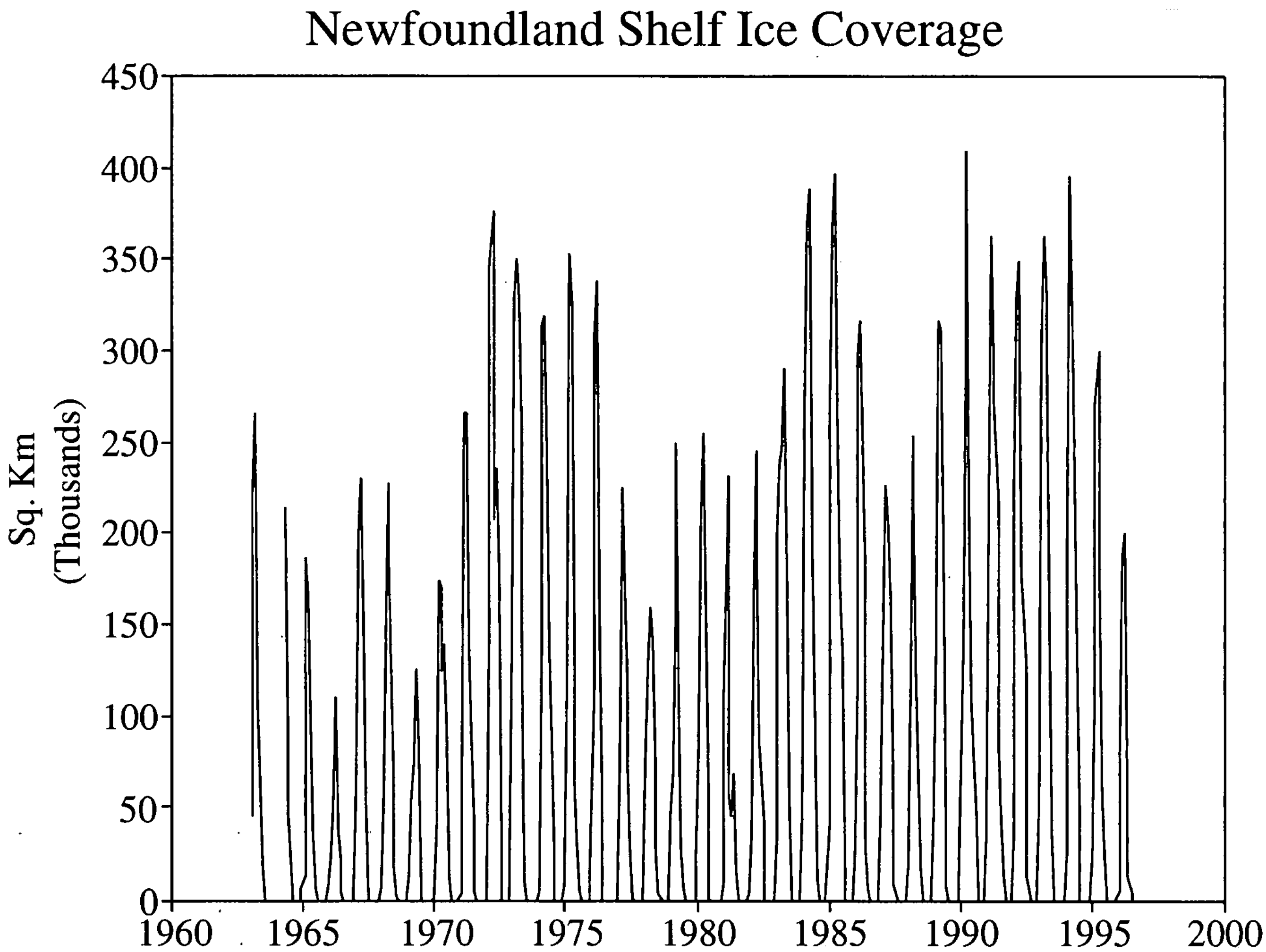

Fig. 12. Time series of the monthly mean ice area off Newfoundland and Labrador (between 45°N-55°N).

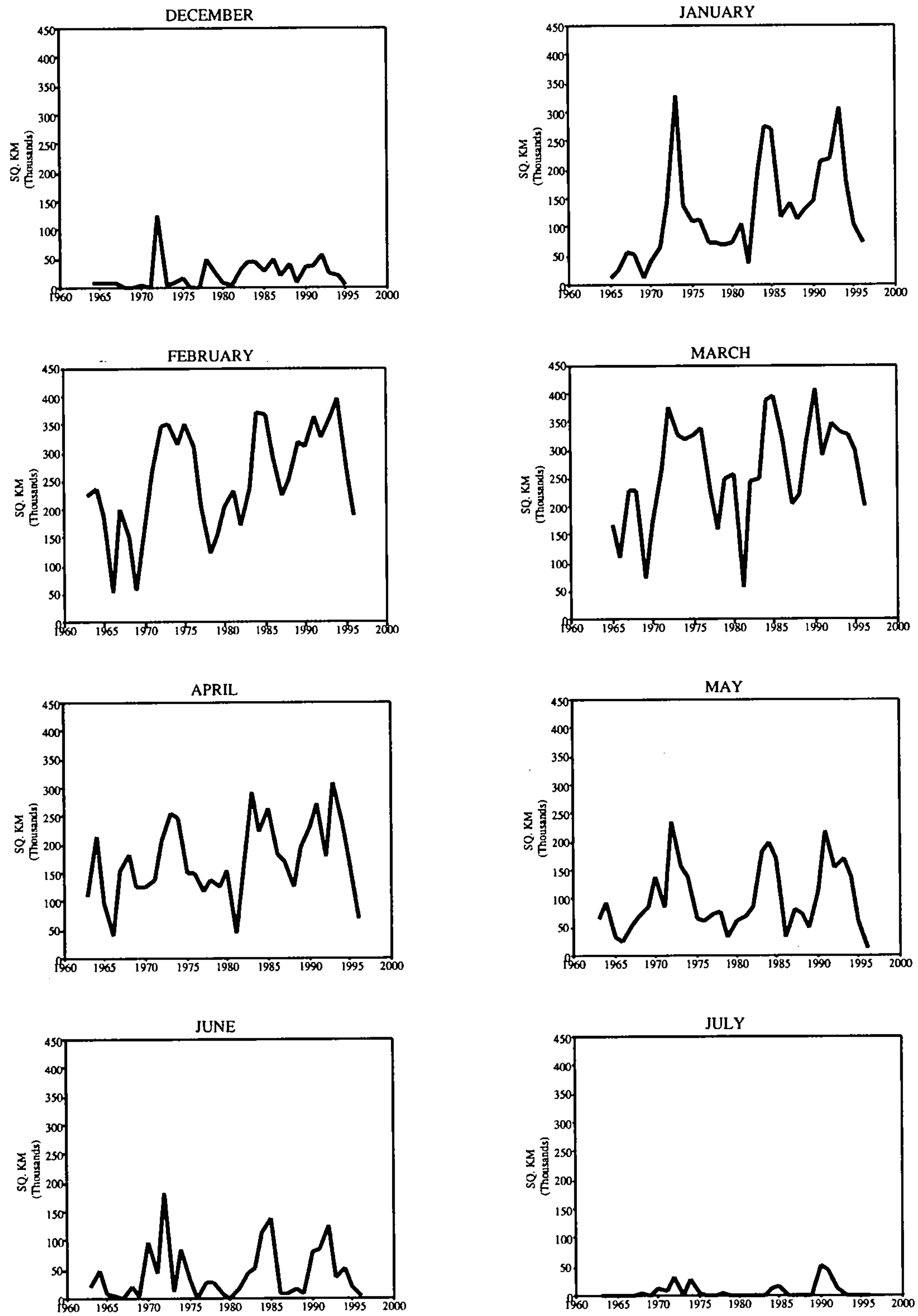

Fig. 13. The time series of ice area off Newfoundland and Labrador, by month.

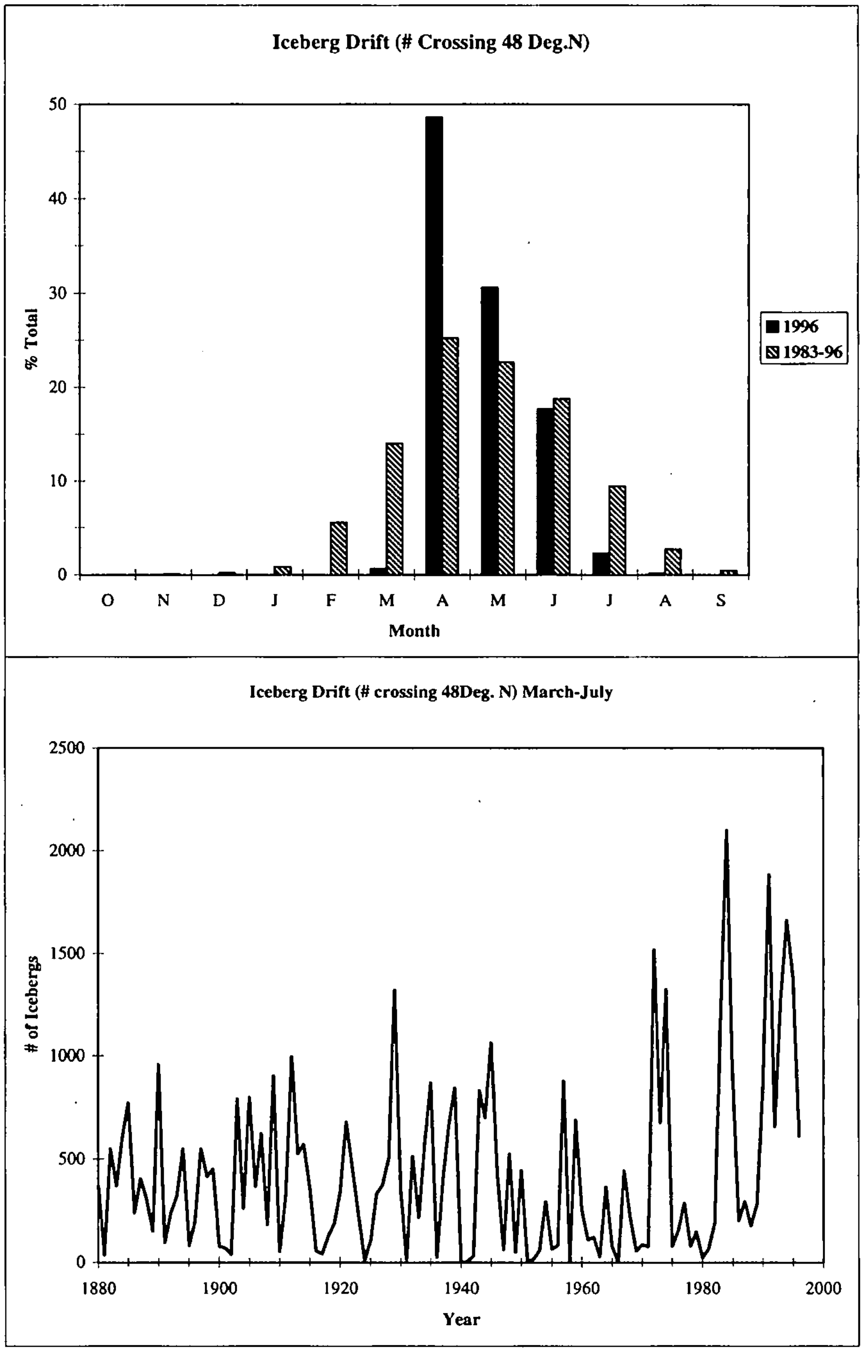

Fig. 14. The number of icebergs crossing south of 48°N during the iceberg season 1995/96 expressed as a percent of the total by month compared to the mean during 1983-96, the years SLAR has been used (top) and the time series of total number of icebergs observed during March to July (bottom).

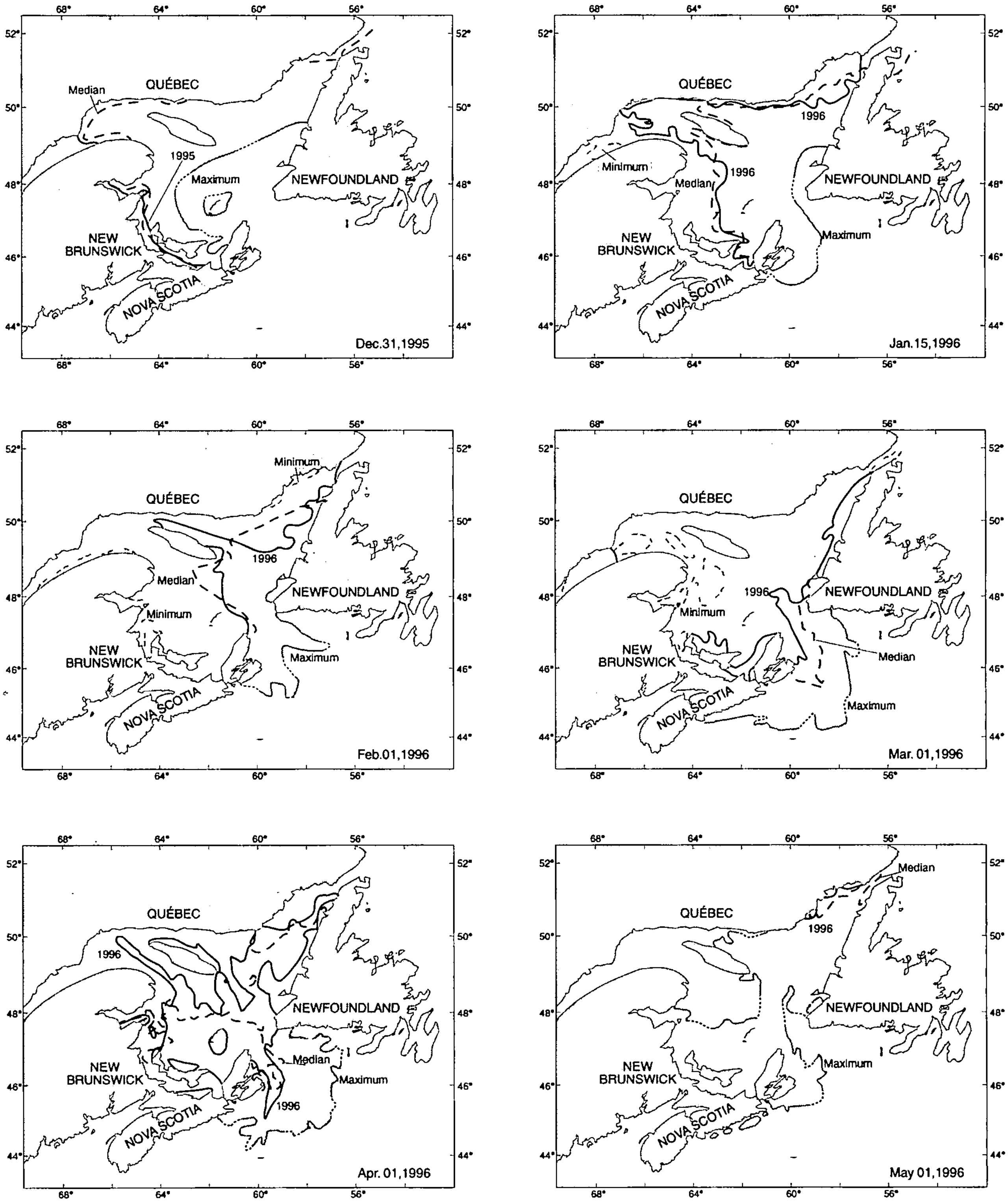

Fig. 15. The location of the ice edge together with the historical (1962-1987) median and maximum positions in the Gulf of St. Lawrence between December 1995 and May 1996.

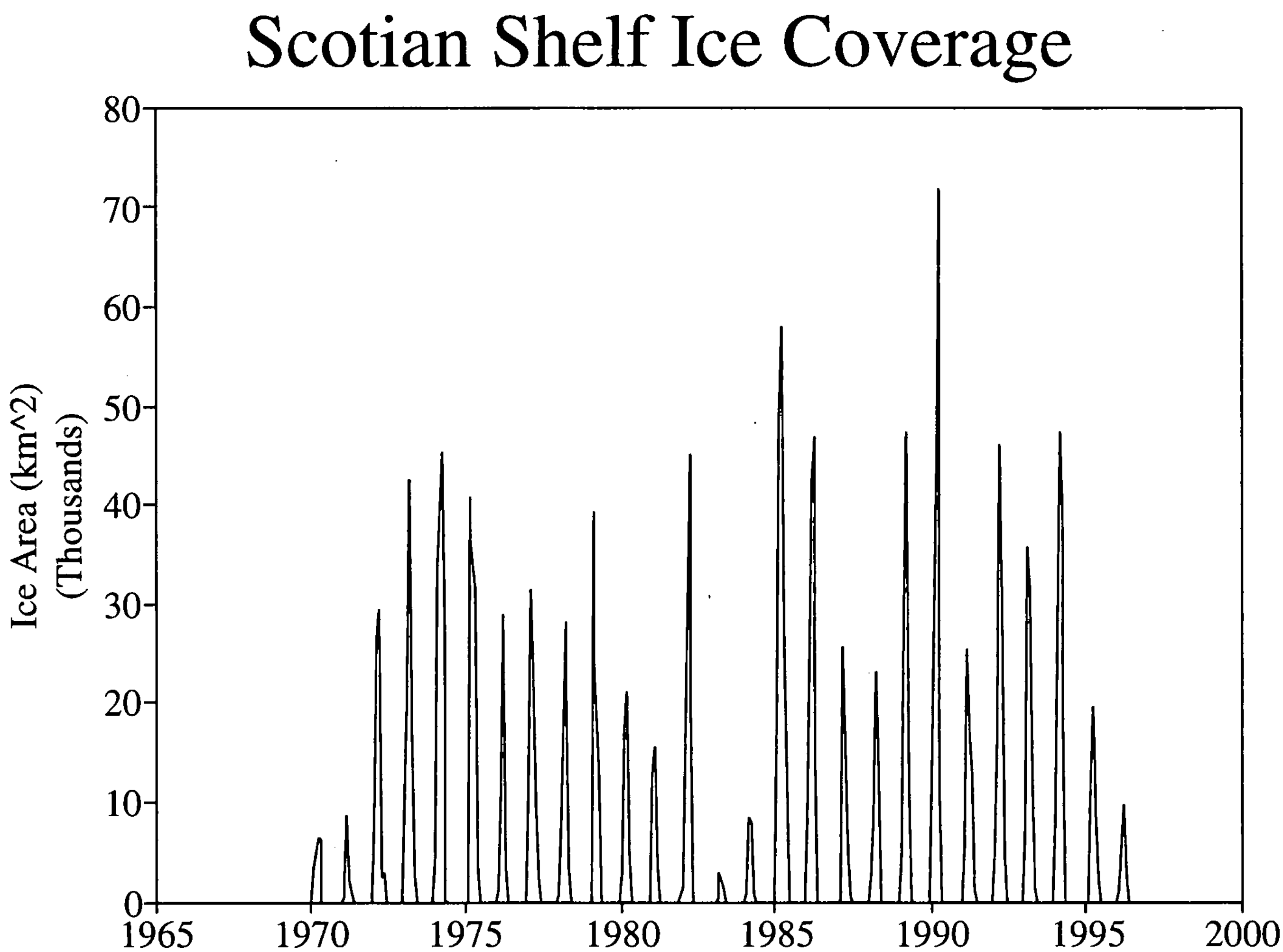

Fig. 16. Time series of the monthly mean ice area seaward of Cabot Strait.

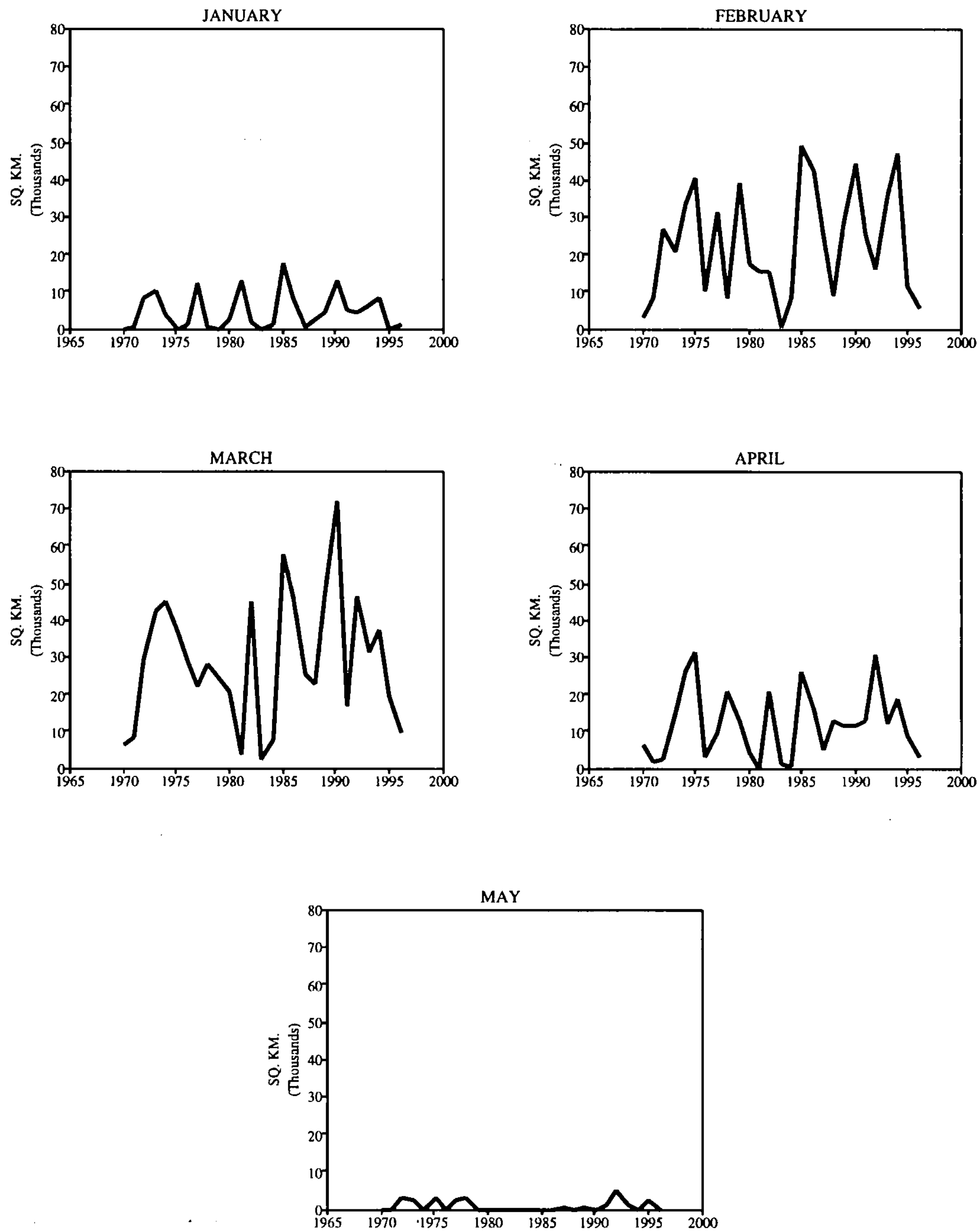

Fig. 17. The time series of ice area seaward of Cabot Strait, by month.