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# Environmental Conditions off West Greenland, 1980–85

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**Abstract**

The observations and changes in the hydrographic parameters temperature, salinity and oxygen during the 1980s off West Greenland are described and discussed in the light of a climatic cooling, which occupied the Davis Strait area during the period 1982–84. The analysis which includes time-series data from 1963 has revealed great negative anomalies in the temperature-salinity characteristic due to the atmospheric influence, which has led to changes in the circulation pattern as well as the sea ice distribution in the Davis Strait.

## Introduction

In 1980, recognizing the importance of the physical environment to the living conditions of marine species, the Greenland Fisheries and Environment Research Institute decided to expand research in the field of physical oceanography. The annual research program now consists of three major cruises (Fig. 1), one in April covering the Northwest Atlantic Fisheries Organization (NAFO) standard sections south of the Fylla Bank and two in July and November, each covering the standard sections north of the Fylla Bank. These two cruises also include a number of stations to the west of and in the Disko Bay area. In addition to these three cruises, the Fylla Bank section is worked as frequently as other field activities permit.

During the annual autumn groundfish survey conducted by the Institut für Seefischerei, Hamburg, hydrographic observations along NAFO standard sections off West Greenland are carried out. The time-series of these measurements began in 1963.

This paper summarizes some of the main features of the hydrographic conditions in the West Greenland area during the period 1980–85, when a drastic change

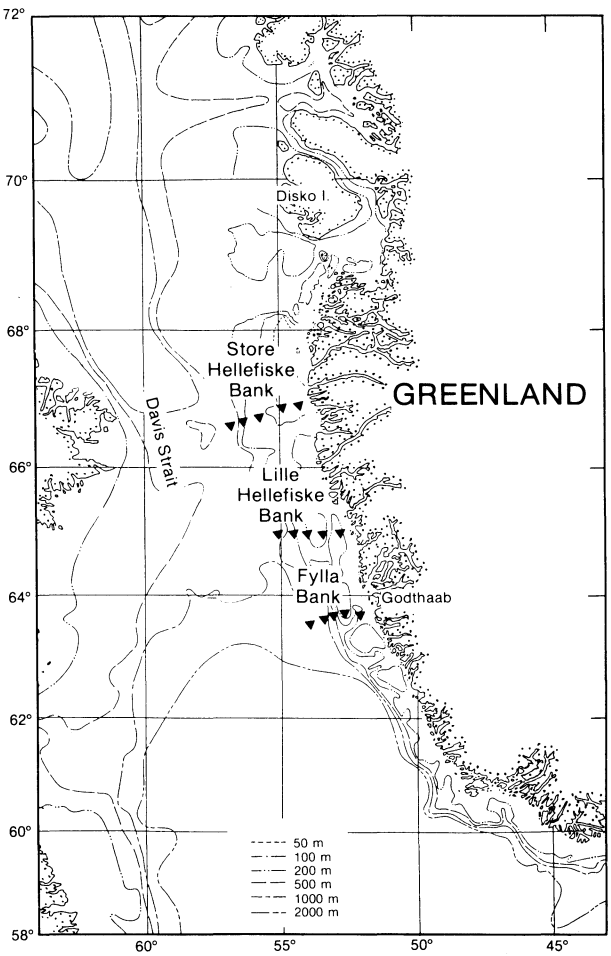


Fig. 1. Map showing major banks of West Greenland where annual cruises were carried out during 1980–85.

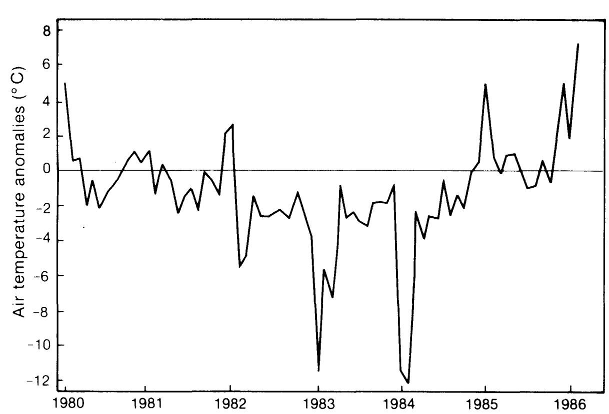


Fig. 2. Air temperature anomalies at the Godthaab station from January 1980 to January 1986.

in climate affected the physical conditions in the entire Davis Strait.

## Climatic Changes

Figure 2 shows the monthly mean air temperature anomalies at the Godthaab meteorological station from January 1980 to January 1986. During 1980 and 1981, the air temperature fluctuated around the normal conditions. The period from February 1982 to November 1984 was characterized by negative temperature anomalies for each month. The winter months of 1983 and 1984 were extremely cold. The reason for these cold conditions was the displacement of an Arctic-Canadian cold airmass to the Davis Strait area. The center of this airmass was located near the city of Egedesminde where the temperature anomalies for the winters of 1983 and 1984 were -12° and -14° C, respectively (Rosenørn *et al.*, 1985). Figure 3 shows the mean air temperature anomalies of January-February, 1983 and depicts the localization of the cold airmass. In 1985 the temperature returned to almost normal conditions, except for the winter months of 1984/85 and 1985/86 when high positive anomalies were observed.

## Hydrographic Changes

### Temperature

The change in climate produced changes in the physical properties of the ocean off West Greenland. The strong cooling, especially during winter, caused negative sea temperature anomalies and an above normal generation of winter ice in the whole Davis Strait area (Fig. 4).

Figure 5 shows that in the West Greenland area the temperature of the surface layer for most of the years is correlated with the atmospheric temperature: the cold atmospheric conditions during the period 1982–84 are

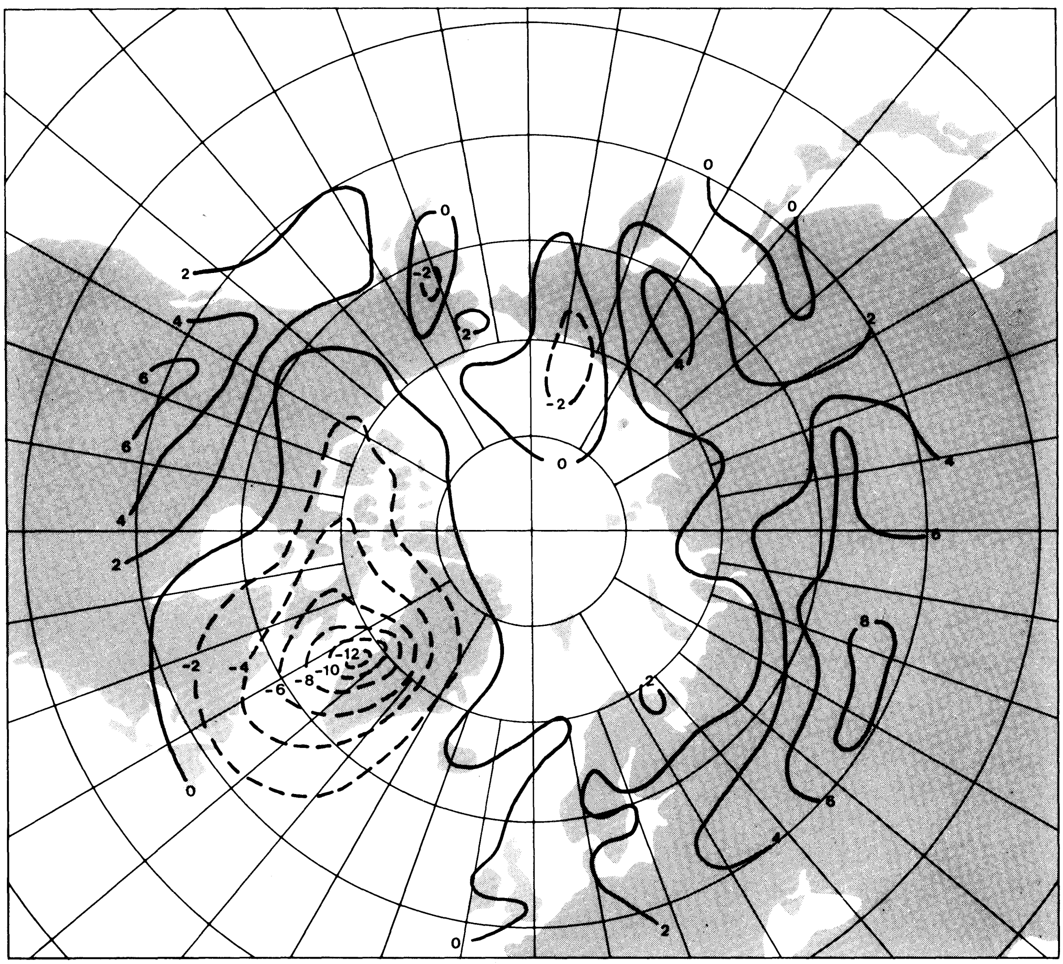

Fig. 3. Anomalies of mean air temperature (° C) of January-February 1983 in the Arctic region.

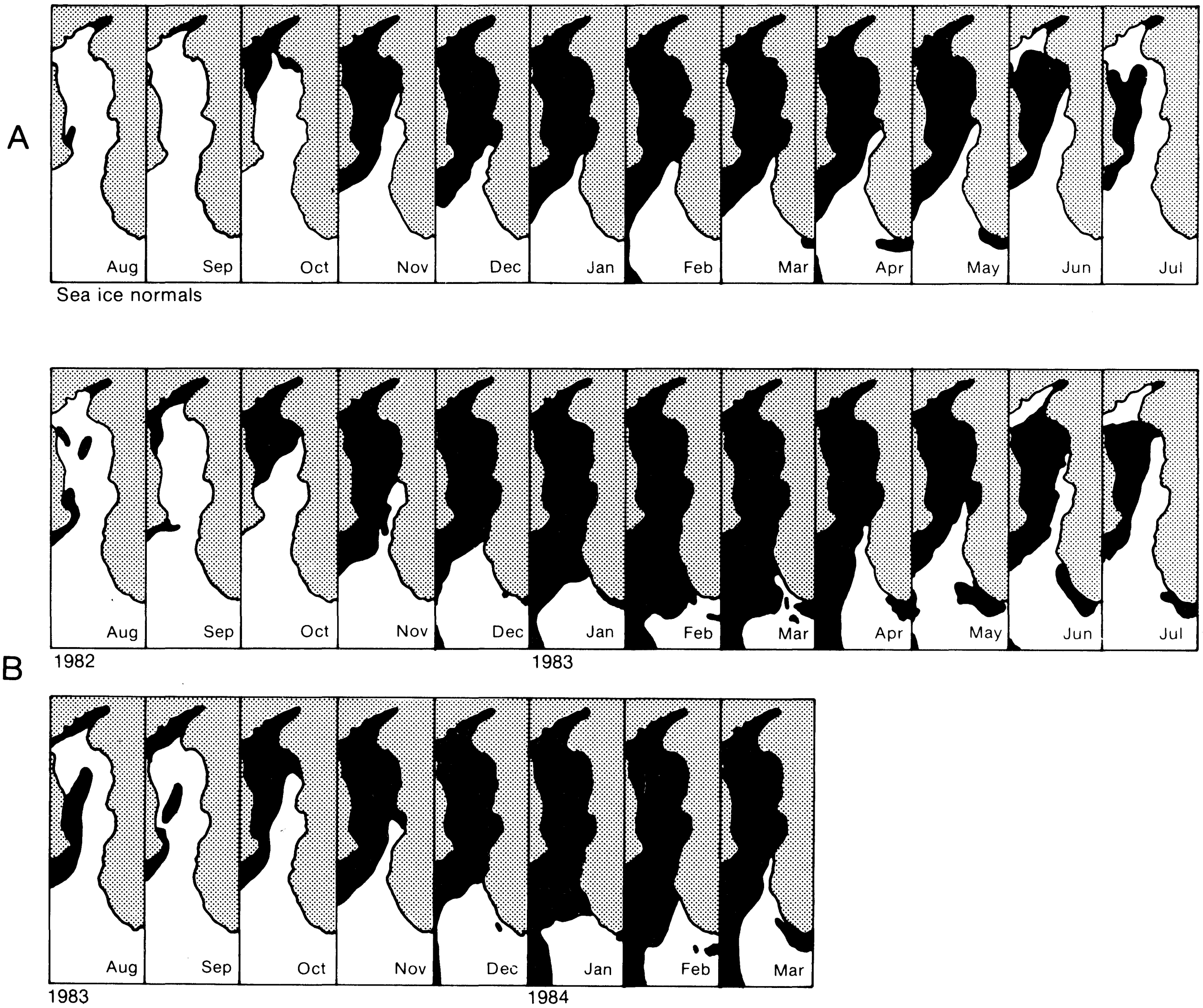


Fig. 4. Sea ice distribution in the Davis Strait. (**A**) normal distribution through the course of a year, (**B**) distribution during the period August 1982 to March 1984.

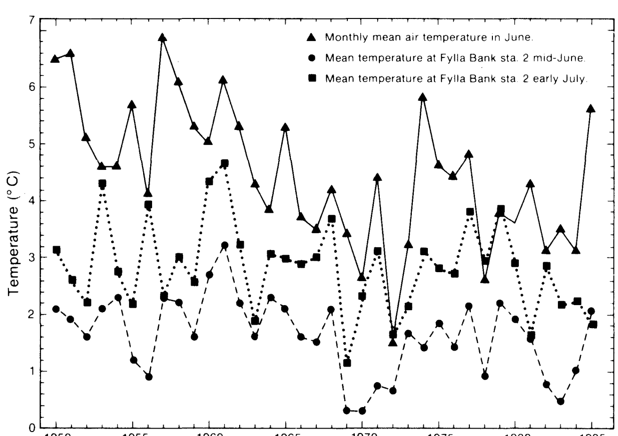


Fig. 5. Air and sea temperatures near Godthaab in June and July for the period 1950–85.

reflected in the sea temperatures. Besides the cold atmospheric conditions, 1982 was also characterized by a greater than normal inflow of cold Arctic water from the East Greenland current. The cold conditions in July 1981 and 1985 are due to the influence of East Greenland waters.

Changes in temperature in early July given as 3-year running means at four depth intervals (0–50, 50–150, 150–400, 400–600 m) at three stations just west of three fishing banks (Fylla, Lille Hellefiske and Store Hellefiske) along the coast, are shown in Fig. 6. The variations along the coast tend to follow more or less the same pattern, especially at the greater depths where advective processes are dominant and the temperature is less affected by direct interaction with the atmosphere. At all three stations the temperature

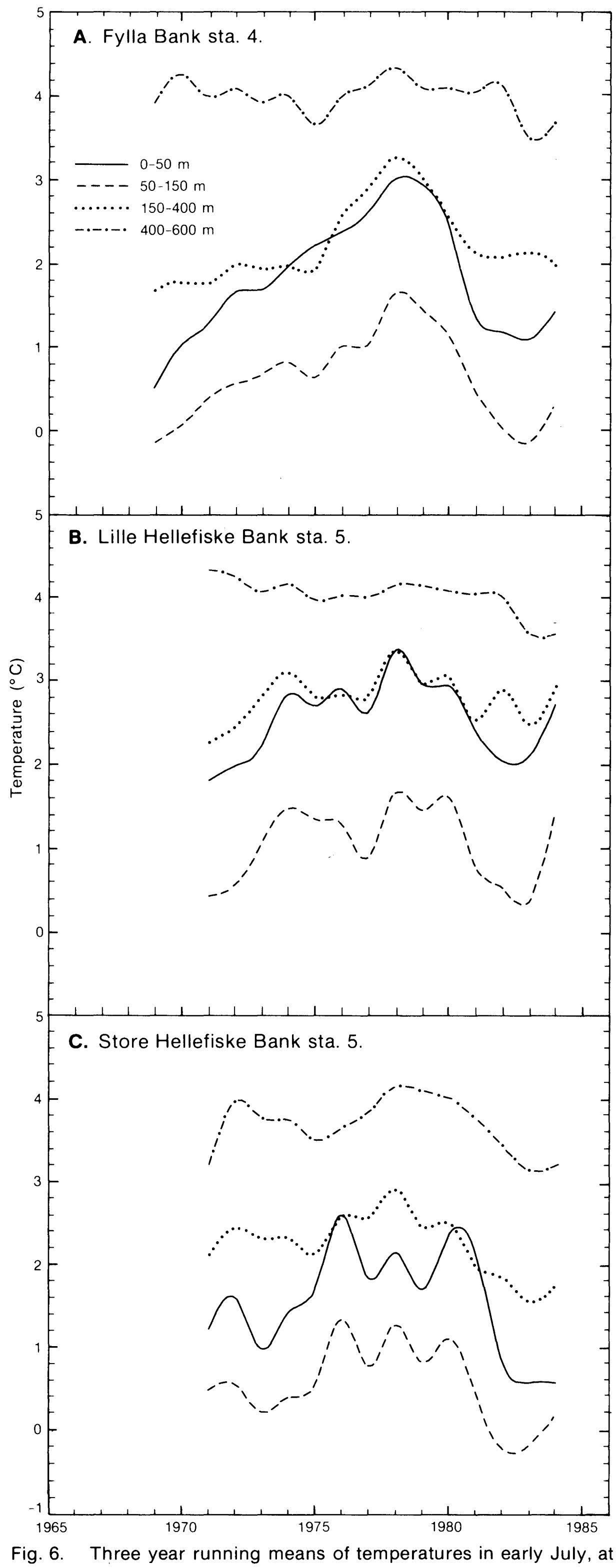


Fig. 6. Three year running means of temperatures in early July, at 4-depth intervals.

decreased during the cold climatic period at the beginning of the 1980s. It is remarkable that the deeper layers also show decreasing temperatures, possible explanations for this will be discussed below. From the continuous hydrographic observations in Disko Bay which were initiated in 1980, some characteristic properties can be established (see also Sloth and Buch, MS 1984). During the summer and autumn, the surface temperatures are generally higher in the Bay than outisde in the West Greenland coastal current, and maximum temperatures are found in an area southeast of the city of Godthaab (Fig. 7). Figure 7A depicts the pattern in July 1980 and Fig. 7B shows the effect of the climatic cooling in July 1983.

## Salinity

The hydrographic observations of the early 1980s have also revealed great variations in the salinity distribution. In Fig. 8 the surface salinity distribution from July 1980 and July 1982 are shown, i.e. from a year before and a year during the cold period. The distribution pattern as well as the absolute values are markedly different in the 2 years.

In 1980 only a small area near the coast showed salinities below 32‰ and most of the southwestern part of the investigated area was occupied by water with salinity above 33.75‰. In 1982 the maximum values were between (33.25–33.5‰) in a relatively small area near the coast. In all other areas the observed salinities were below 33.25‰ decreasing towards the west and northwest with a minimum below 29‰.

Figure 9 shows time series of the salinity in four depth intervals at three stations just west of the three fishing banks observed in early July. They all show a decrease in salinity during the cold period, and the decrease is found at all depths, although most pronounced in the surface layer. In this layer, the variations are greatest at the northernmost station in agreement with the horizontal distribution shown in Fig. 9. In the other three depth intervals the greatest fluctuations are found in the south (Fylla Bank) and in the north (Store Hellefiske Bank).

## Oxygen

A typical vertical profile of oxygen distribution in the waters off West Greenland is shown in Fig. 10. The concentrations are above 6 ml/l at all depths or a degree of saturation above 80%.

Oxygen observations were made with the intention of using them to identify different water masses, which

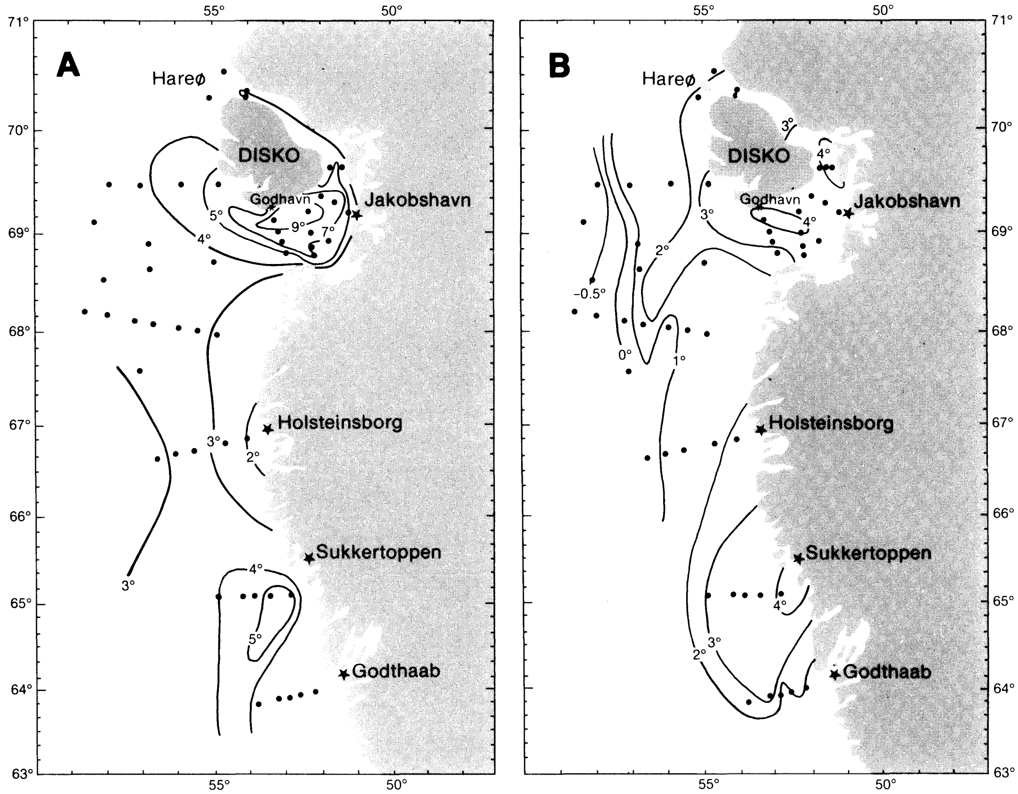


Fig. 7. Sea surface temperature (°C) patterns: (**A**) in July 1980, (**B**) in July 1983.

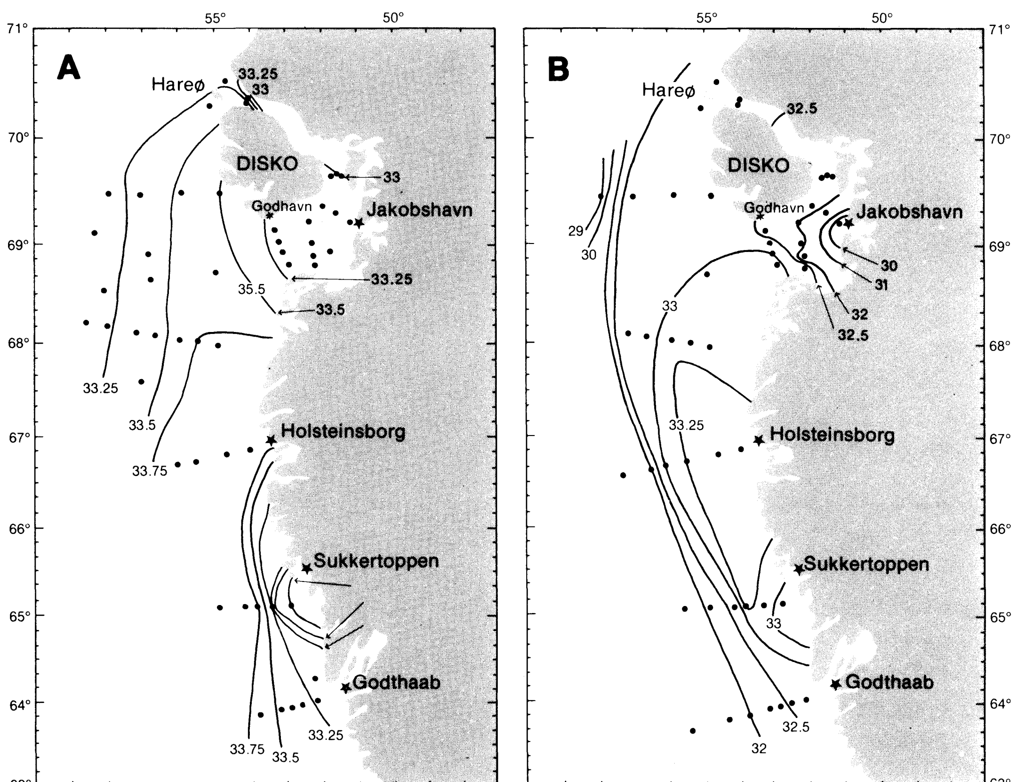


Fig. 8. Sea surface salinity (‰) patterns: (**A**) in July 1980, (**B**) in July 1982.

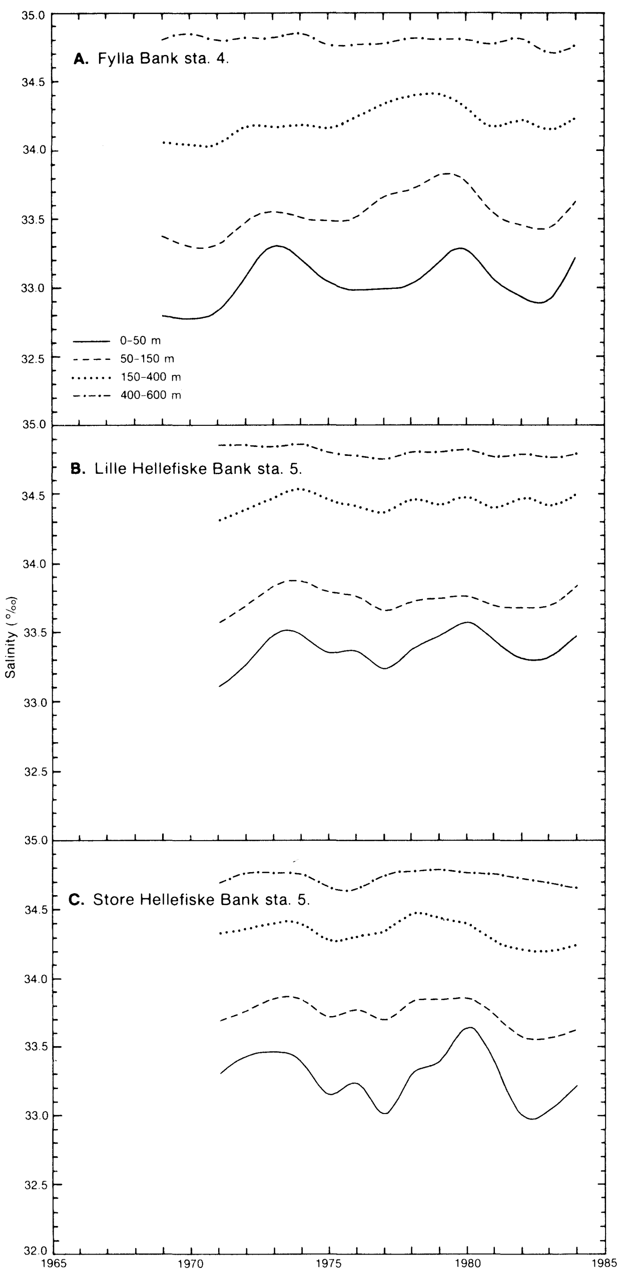


Fig. 9. Three-year running means of salinities in early July, at 4-depth intervals.

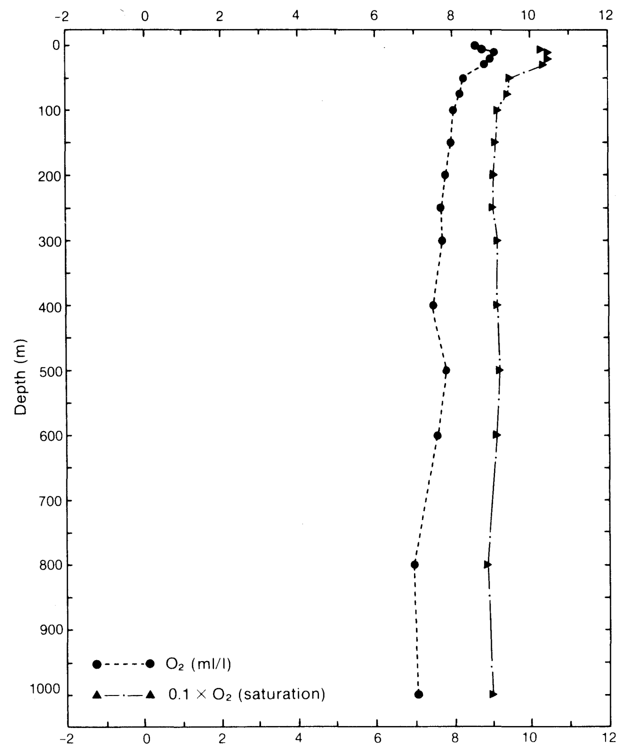


Fig. 10. Vertical profile of oxygen content at Station 4 off Fylla Bank in July 1983.

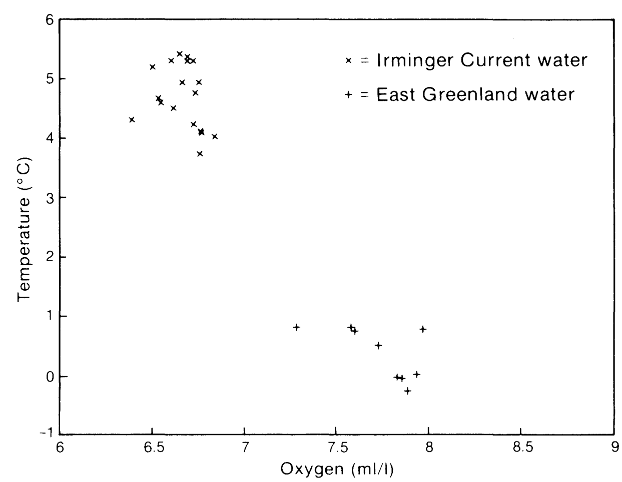


Fig. 11. Oxygen content *versus* temperature observed at stations in West Greenland area.

for the West Greenland area is primarily a question of distinguishing between water from the East Greenland Current and water from the Irminger Current. Oxygen observations taken from different stations and depths where the temperature and salinity clearly indicated that the water originated either from the East Greenland or from the Irminger Current (Fig. 11), show that the oxygen content in the East Greenland water is mostly between 7.5 and 8 ml/l, while the Irminger water generally shows concentrations of 6.5–7 ml/l. Although the information base is still limited, the demarcation between the two water masses is so well defined that it gives reason to believe that oxygen can be used as an independent tracer for water mass classification in the West Greenland area.

## Discussion

Generation of sea ice results in the release of salt into the water. Salt concentration together with the cooling of the water are the driving factors in the process of vertical convection. It seems reasonable to believe that this process is at least partly responsible for the negative temperature anomalies observed at great depths (Fig. 6).

The positive anomaly of ice distribution will, when ice is melting, cause a change in the distribution and the absolute values of salinity, which was also observed (Fig. 8).

A change in distribution of temperature and salinity will naturally affect the density conditions in the area and thereby the circulation pattern, which is another factor to be considered when exploring the anomalies in temperature and salinity at greater depths. Data to evaluate and describe the changes in circulation in detail are not available, but some tendencies can be presented.

In the West Greenland area the Irminger Sea Current component is found just west of the fishing banks at a depth of 400-600 m in July as described most recently by Buch (1984), who also showed that there is good correlation between temperature and salinity variations. Figure. 12 shows the 2 years 1976 and 1984 diverging considerably from the Irminger water characteristics. The 1976 divergence can be attributed to the so-called "1970s anomaly", which was observed at various places throughout the North Atlantic (Ellett, MS 1980; Malmberg and Svansson, MS 1982; Dickson and Blindheim, MS 1984). Dickson and Blindheim (MS 1984) also reported a change in the distribution and migration pattern of cod in the Barents Sea due to the anomaly in the environment.

The 1984 anomaly is much stronger than the one observed in 1976. A possible explanation for this anomaly may be either that the hydrographic conditions in the West Greenland/Davis Strait area prevented a normal inflow of Irminger water, or that the hydrographic conditions in the Irminger Sea itself were abnormal. This however would imply a drastic change in the whole North Atlantic circulation system, which to the authors knowledge has not been observed.

The November data from the Fylla Bank Station 4 (Stein and Buch, 1985) reveal a slightly different situation with regards to the early 1980s. The mean T-S diagram in Fig. 13 might be considered as preliminary information on the distribution of water masses at this station. However, it shows a straight line extending from the low salinity surface water to the more saline Irminger water mass (dotted line at 3.5° C, 34.75‰). The layer of interest in the context of this study is between the 400-600 m where the temperature and salinity maxima occur. Below 600 m to a depth of 800 m, the Irminger water mass is quite uniform with respect to salinity. Within the deep water layer, the year-to-year changes are very low (Fig. 14). They amount to less than 10% for temperature and less than 0.6% for salinity. Whereas seasonal processes play an important role

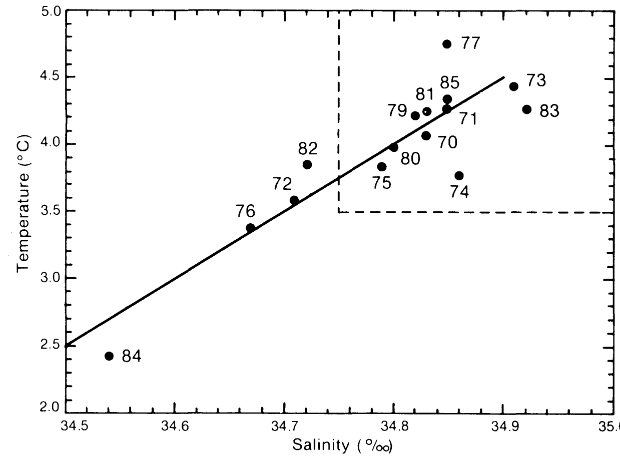


Fig. 12. T-S diagram for the 400-600 m depth interval in the West Greenland area in early July since 1970. The T-S characteristics of the Irminger Water component are shown inside the dotted rectangle.

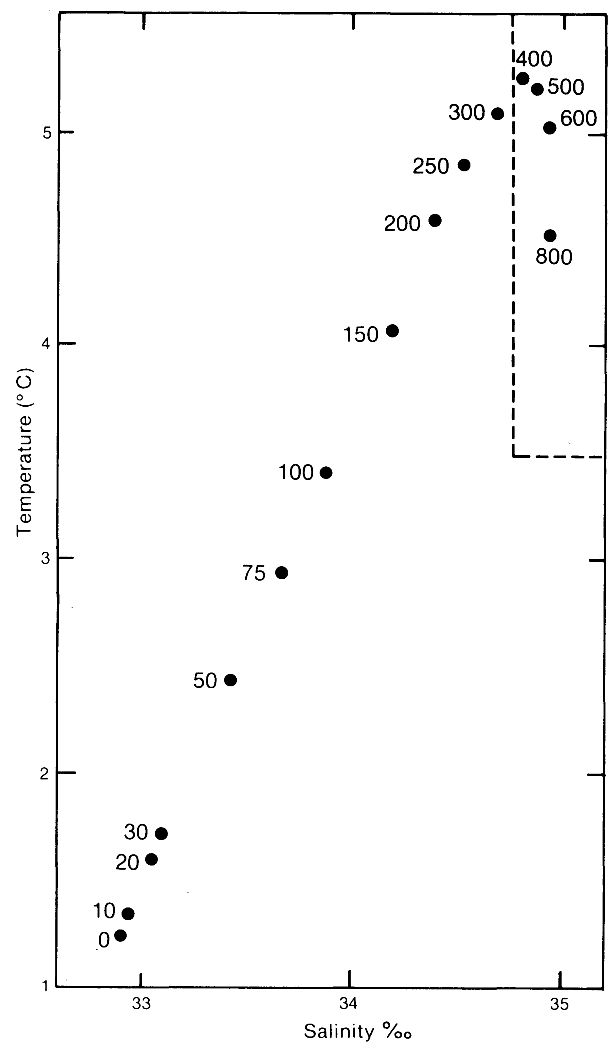


Fig. 13. Mean T-S diagram (November 1963-85) from surface to 800 m depths at station 4 off Fylla Bank. The T-S characteristics of the Irminger Water component are shown inside the dotted rectangle.

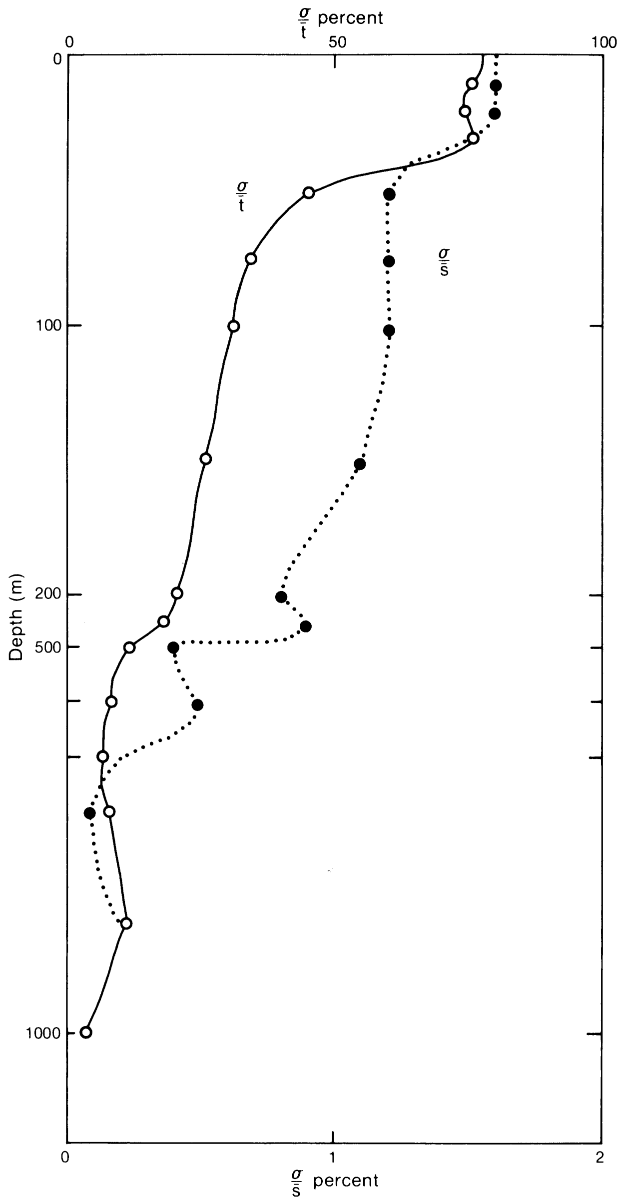


Fig. 14. Vertical profile of ratios of variance ($\sigma$) to mean temperature ($\bar{t}$) and of variance ($\sigma$) to mean salinity ($\bar{s}$) at station 4 off Fylla Bank.

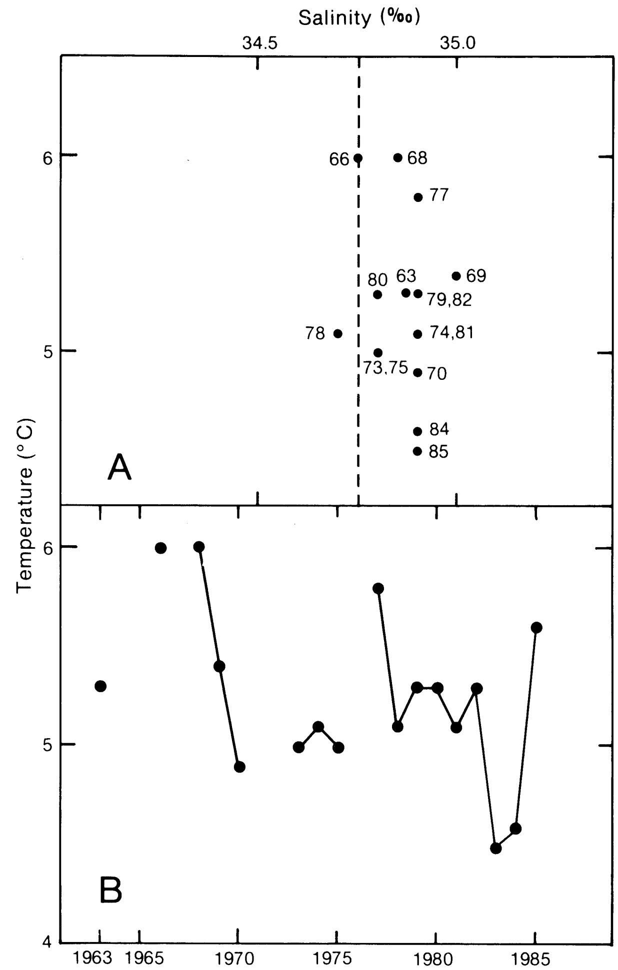


Fig. 15. (**A**) T-S diagram, and (**B**) mean temperature at the 400-600 m depth interval, at station 4 off Fylla Bank in November during the period 1963-85.

in the upper 200 m, the deep water layers are sensitive to advective and, to a certain degree, convective processes.

Figure 15 in contrast to Fig. 12, reveals a completely different mean T-S diagram for the November conditions off Fylla Bank. When considering the November conditions off West Greenland, it must be borne in mind that the Irminger component at this time is at its maximum influence on the distribution of heat and salt in the West Greenland Current system (Buch, 1982). This has an effect on the haline structure in the core layer of this current component. As is evident in Fig.15 salinities higher than 34.75‰ prevailed for those years in the period 1963-85 where data are available except 1978. There was no dramatic salinity anomaly within the 400-600 m water layer, as observed in the July data. There was, however, a remarkable decline in temperature in 1983 and 1984 (lower part of Fig. 15 and T-S dots 83 and 84). The November data of both years reveal temperatures 0.5° to 0.8°C below normal at the standard depths 400, 500 and 600 m (Fig. 16). The fact that salinity did not change in the 400-600 m layer leads to the assumption that the November data indicate deep convection cooling, starting in the surface layer between 1980 and 1981 (Stein, MS 1986). Whereas a warming of the upper layer was observed in 1984 autumn data, the core layer of the Irminger component started warming after 1984.

The decrease in the anomaly from summer to autumn in 1984, together with the fact that the warming

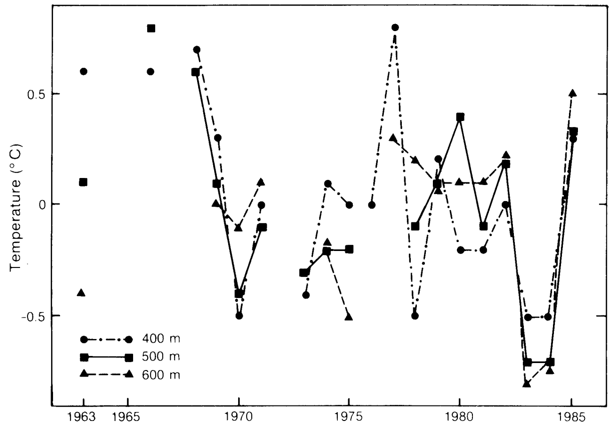


Fig. 16. Temperature anomalies at 400, 500 and 600 m depths at Station 4 off Fylla Bank in November during 1963–85.

in the upper 200 m started 1 year before it was observed in the deeper layer, indicates that local hydrographical anomalies generated by the abnormal meteorological condition over the Davis Strait, are responsible for the anomalous situation observed in the deep water layers off Fylla Bank during the summer of 1984.

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