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A Review of the Hydrographic Conditions off West Greenland in 1980-85

by

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Abstract.

The observations and changes in the hydrographical parameters temperature, salinity and oxygen during the 1980'es off West Greenland are described and discussed in the light of a climatic cooling, which occupied the Davis Strait area in the period 1982 - 1984.

1. Introduction.

Recognizing the importance of the physical environment to the living conditions for marine species, the Greenland Fisheries and Environment Research Institute in 1980 decided to expand the research in the field of physical oceanography.

The annual research program now contains three major cruises, one in April covering the NAFO standard sections south of the Fylla Bank and two in July and November respectively covering the standard sections north of the Fylla Bank as well as 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 out as frequently as allowed by other field activities of the Institute.

The purpose of this paper is to summarize some of the main features in the hydrographical conditions in the West Greenland area during the first half of the present decade.

The period in question has been dominated by a drastical change in climate, which has affected the physical conditions in the whole Davis Strait.

2. Climatic changes.

To illustrate the climatic changes in the West Greenland area in the 1980´es Fig. 1 shows the anomaly of the monthly mean air temperatures at the Godthåb meteorological station from January 1980 to Januray 1986. It is seen that during 1980 and 1981 the air temperature fluctuated around the normal condition. The period from February 1982 to November 1984 was characterized by negative temperature anomalies for each month, and especially the winter months in 1983 and 1984 were extremely cold. The reason for these cold conditions was the displacement of an Artic-Canadian cold airmass to the Davis Strait area. The center of this airmass was located near the city of Egedesminde where the temperature anomaly during the winters 1983 and 1984 was minus 12 degrees and minus 14 degrees, respectively. (Fig. 2) (Rosenoern et al, 1985).

In 1985 the temperature in the atmosphere returned to almost normal conditions, except for the winter months 1984 - 1985 and 1985 - 1986 where high positive anomalies were observed.

3. Temperatures.

The temperature of the surface layer of the ocean generally is affected by two processes:

a) Interaction with the atmosphere.
b) Gain and loss of heat due to advective and vertical convective processes.

Fig. 3 shows that in the West Greenland area the surface - layer temperature for most of the years is correlated with the atmospheric temperature i.e. the cold atmospheric conditions during the period 1982 - 1984 are 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 development in the temperature given as 3-year running means at four depth intervals (0-50, 50-150, 150-400, 400-600m) at three stations just west of the fishing banks along the coast are shown in Fig. 4-6.

It is seen that the tendency in the variations along the coast follows the same pattern more or less, especially at the greater depths, where the temperature is not affected by direct interaction with the atmosphere i.e. advective processes are dominant below the surface layer.

It is also noted that at all three stations the temperature decreases during the cold climatic period at the beginning of the 1980´es. Especially it is remarkable that also the deeper layers show decreasing temperatures. Possible explanations for this will be discussed below.

As mentioned above continious hydrographical observations in the Disko Bay were initiated in 1980, and some characteristic properties can be established, see also Sloth and Buch (1984).

During the summer and autumn period the surface temperatures are generally higher in the bay than outside in the West Greenland coastal current, and maximum temperatures are found in an area south-east of the city of Godhavn, (Fig. 7,8). The effect of the climatic cooling are clearly seen on these figures.

Vertically, the temperature distribution reveals three layers. A surface layer with temperatures up to 10 degrees Celsius during the summer, an intermediate layer most generally with temperatures below 0.5 degrees Celsius and a bottom layer with temperatures increasing to approximately 2-3.5 degrees Celsius.

4. Salinity.

The 1980´es has also revealed great variations in the salinity distribution. In Fig. 9 and 10 is shown the surface salinity distribution from July 1980 and 1982, i.e. from a year before and a year during the above mentioned cold period.

The distribution pattern as well as the absolute values have changed considerably in the period between the two years.

In 1980 only a minor area near the coast showed salinities below 32‰ and the majority of the southwestern part of the investigated area were occupied by water with salinity above 33.75‰ .

In 1982 the maximum values were in the interval 33.25‰ - 33.5‰ observed 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‰ .

Fig. 11-13 show time series of the salinity in four depth intervals at three stations just west of the fishing banks. They all show a decrease in salinity during the cold period, and the decrease is found at all depths, most markedly, of course, in the surface layer.

In the surface layer the variations are greatest at the northwestern station in agreement with the horizontal distribution shown in Fig. 9 and 10. In the other three depth intervals the greatest fluctuations are found to the south and to the north.

5. Oxygen.

In 1982 observations of oxygen and nutrients became a permanent part of the standard hydrographical research program, but only results of the oxygen observations will be discussed briefly in this paper.

A typical vertical profile of the oxygen distribution in the waters off West Greenland is shown in Fig. 14. The concentrations are above 6 ml/l at all depths or a degree of saturation above 80%.

One of the purposes of introducing the oxygen observations in the hydrographical observation program was the idea that oxygen may be used as an parameter to identify different watermasses, which for the West Greenland area is pimarily a question of distinguishing between water from the East Greenland current and that from the Irminger Current.

Preliminary results of this work has been obtained by taking oxygen observations 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. 15.

This provisional analysis indicates that the oxygen content in the East Greenland water is between 7.5 and 8 ml/l, while the Irminger water shows concentrations of 6.5 - 7 ml/l. Although the material is still limited this is so well defined a demarcation between the two watermasses in their oxygen content that it gives reason to believe that oxygen can be used as an independent tracer for watermass classification in the West Greenland area.

6. Discussion.

The change in climate has been the generator of changes in the physical properties of the West Greenland waters.

First of all the strong cooling, especially during winter, has caused negative temperature anomalies and an above-normal generation of winter ice in the whole Davis Strait area, Fig. 16.

Generation of ice means disengagement of salt, which 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.

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

The changed distribution of temperature and salinity naturally will 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 evalute and describe the changes in the circulation in details 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 400-600m in July as described latest by Buch (1984), who also showed that there is good correlation between temperature and salinity variations. (Fig. 17). This figure shows especially two years diverging from the Irminger water characteristics, viz. 1976 and 1984. The 1976 divergence can be attributed to the so-called "1970´ies anomaly", which was observed at various places throughout the North Atlantic (Ellett, 1980; Malmberg and Svansson, 1982; Dickson and Blindheim, 1984). The latter authors 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 hydrographical conditions in the West Greenland area / Davis Strait prevented a normal inflow of Irminger water, or that the hydrographical conditions in the Irminger Sea itself were abnormal, which again would be a reflection of drastic changes in the whole North Atlantic circulation system, which to the authors knowledge have not been observed.

Knowing the meteorological anomalies in the Davis Strait described above and their effect on the marine environment, the first explanation seems the most likely one.

References.

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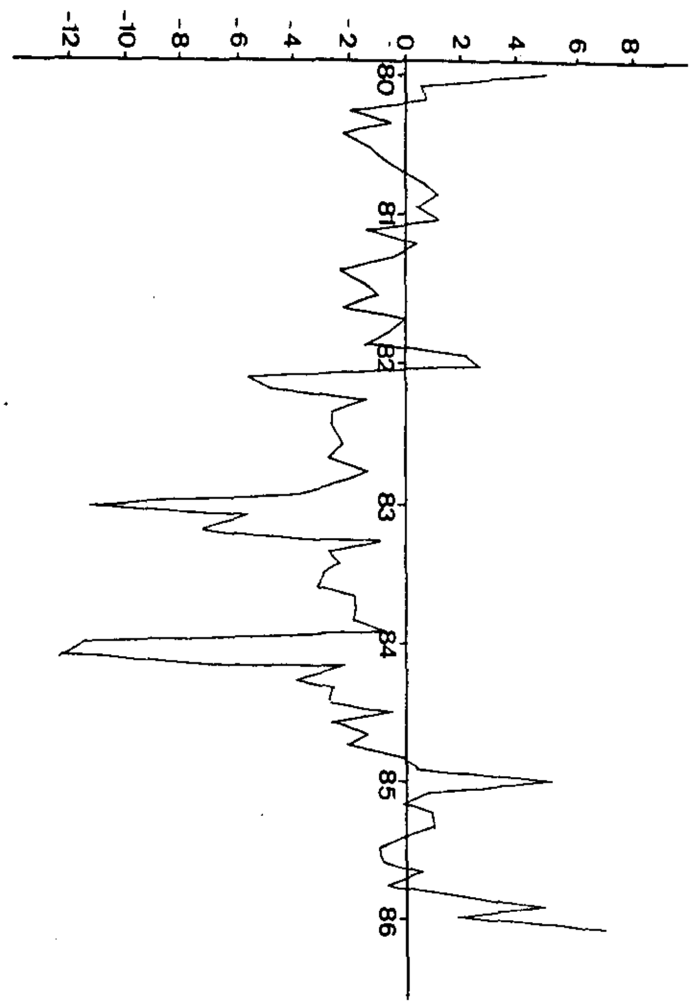

Fig. 1. Air temperature anomalies at the Godthåb station in the period 1980-86.

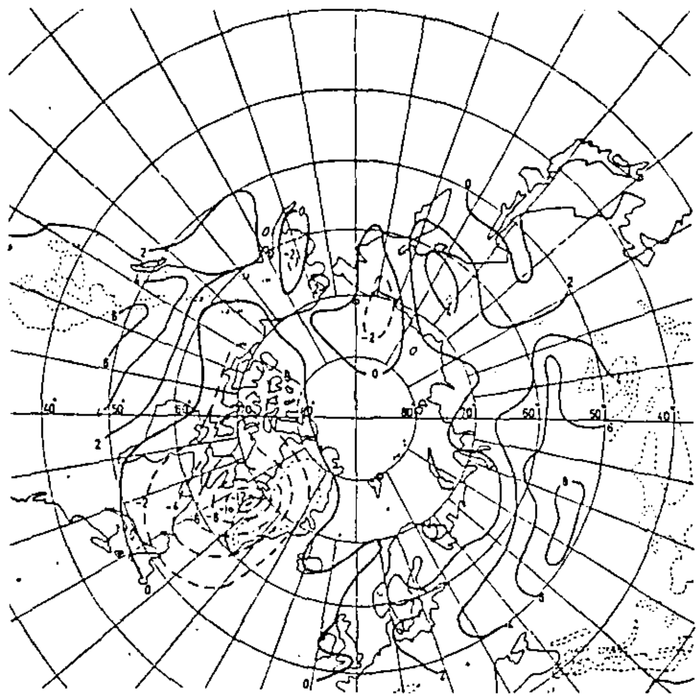

Fig. 2.

Anomalies of the mean air temperature of January-February 1983 in the arctic region.

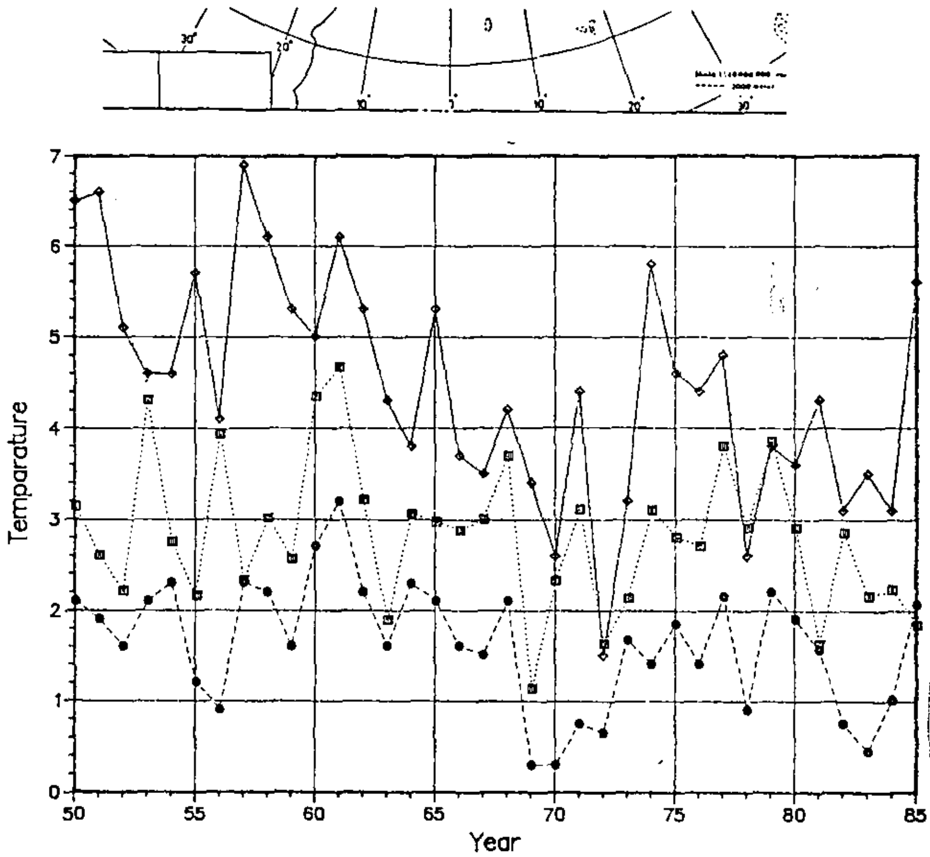

Fig. 3. Air and sea temperatures near Godthåb in June and July for the period 1950-85.

◇ Monthly mean air temperature in June.

● Mean temperature at Fylla Bank st. 2 medio June.

⊡ Mean temperature at Fylla Bank st. 2 primo July.

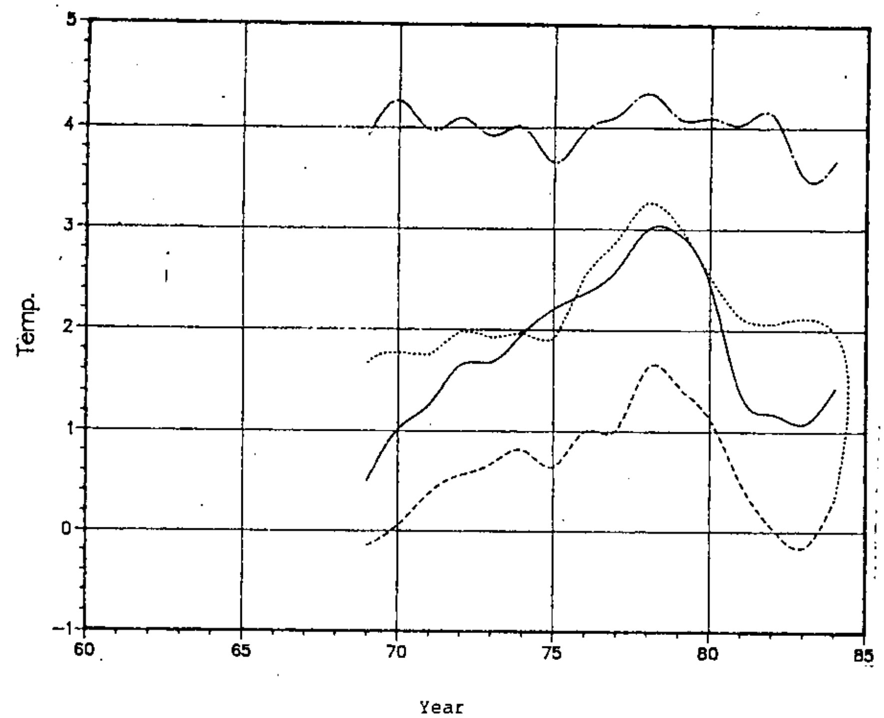

Fig. 4. 3 year running mean of temperatures in 4 depth intervals on Fylla Bank, St. 4 at the beginning of July, 1969 - 1984.

————	0 - 50 m
---------	50 - 150 m
....	150 - 400 m
-·-·-·-·-	400 - 600 m

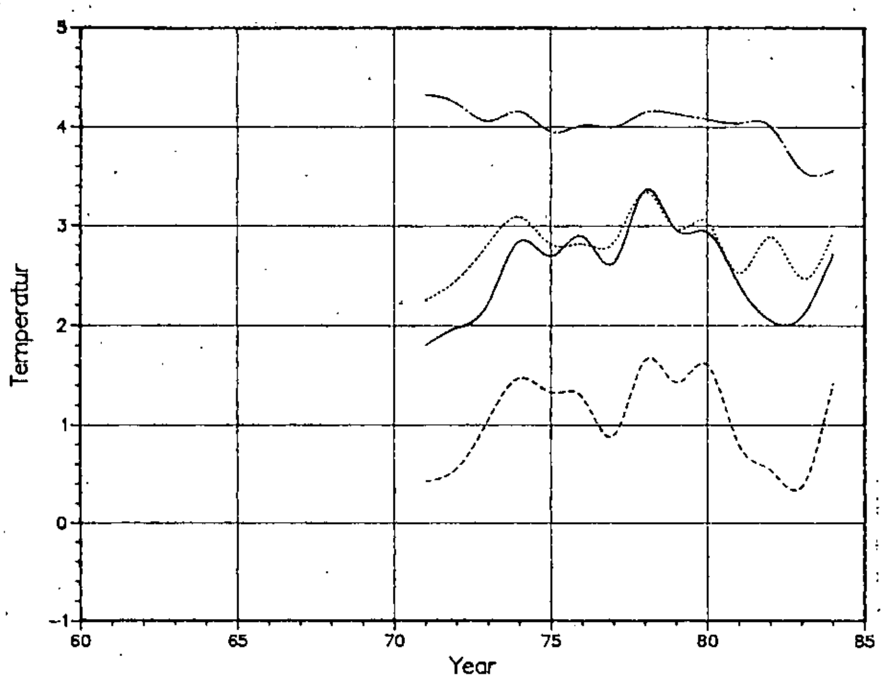

Fig. 5. 3 year running mean of temperatures in 4 depth intervals on Lille Hellefisk Bank, St. 5 at the beginning of July, 1971 - 1984.

————	0 - 50 m
---------	50 - 150 m
....	150 - 400 m
-·-·-·-·-	400 - 600 m

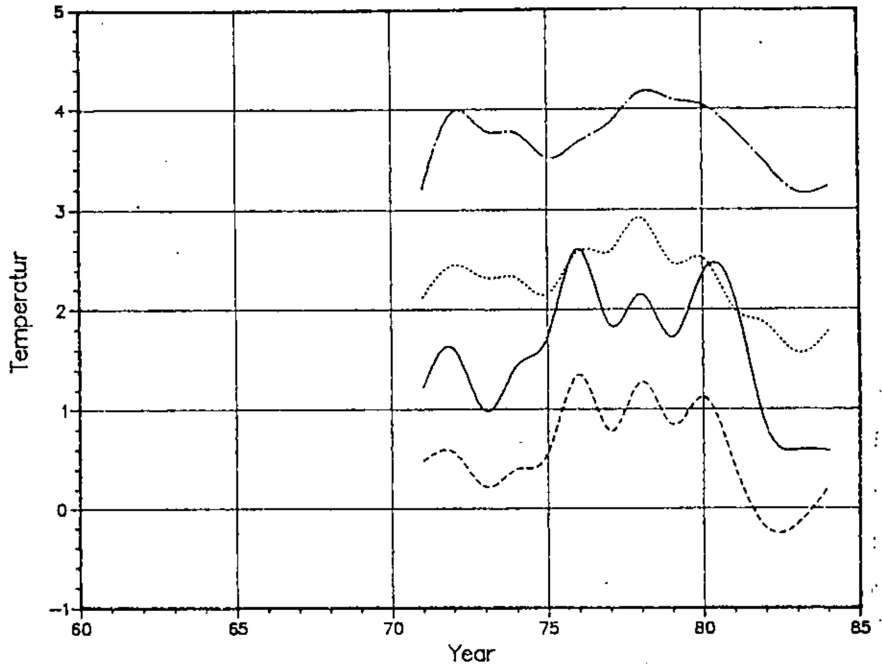

Fig. 6. 3 year running mean of temperatures in 4 depth intervals on Store Hellefisk Bank, St. 5 at the beginning of July, 1971 - 1984.

———————— 0 - 50 m
---------- 50 - 150 m
.... 150 - 400 m
-·-·-·-·-· 400 - 600 m

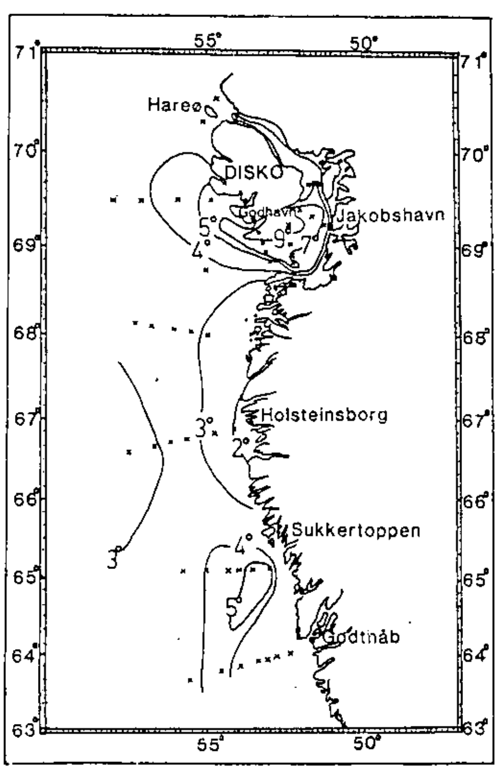

Fig. 7.

Surface temperatures, July 1980.

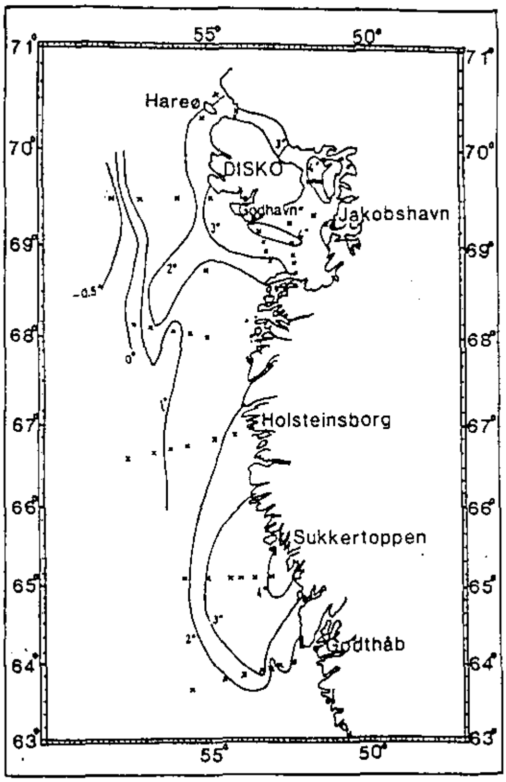

Fig. 8.

Surface temperatures, July 1983.

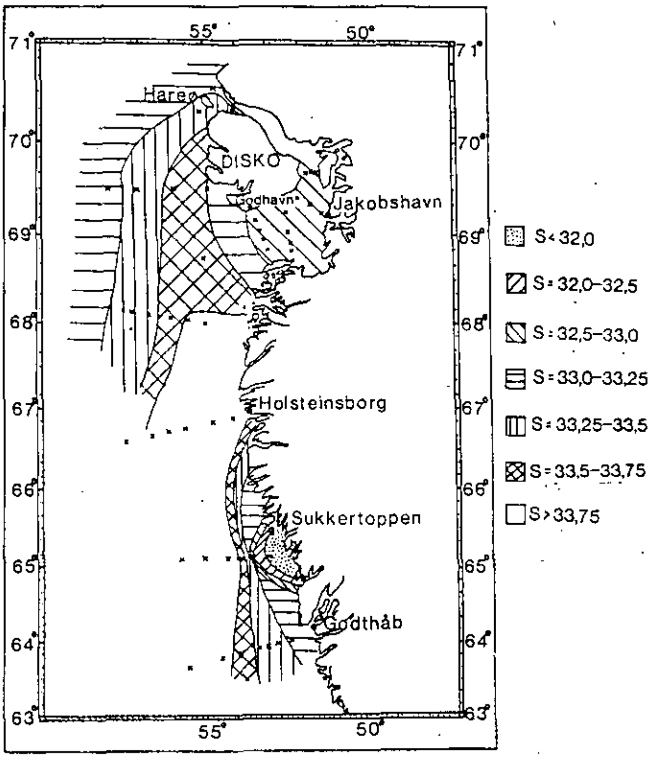

Fig. 9.

Surface salinity, July 1980.

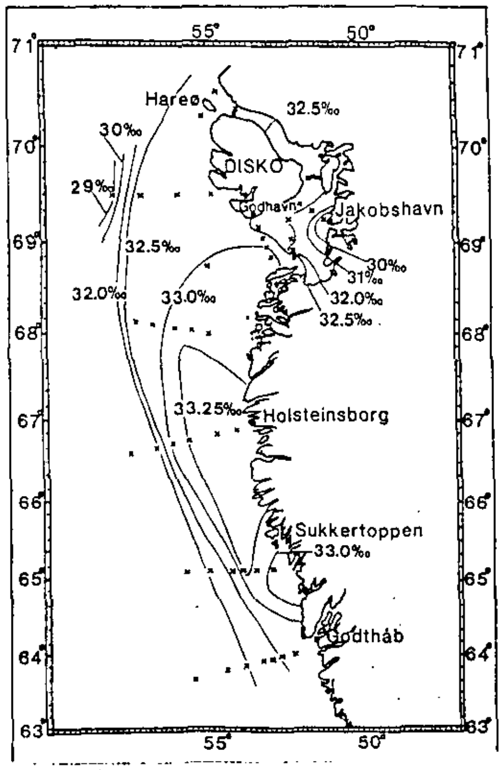

Fig. 10.

Surface salinity, July 1982.

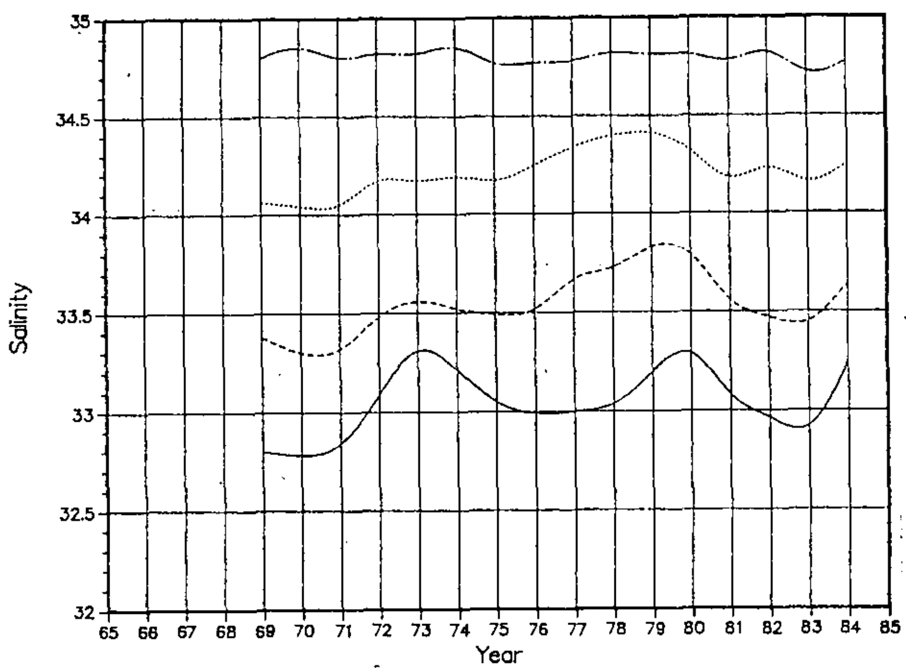

Fig. 11. 3 year running mean of salinities in 4 depth intervals on Fylla Bank, St. 4 at the beginning of July, 1969 - 1984.

————	0 - 50 m
- - - - - -	50 - 150 m
....	150 - 400 m
-·-·-·-·-	400 - 600 m

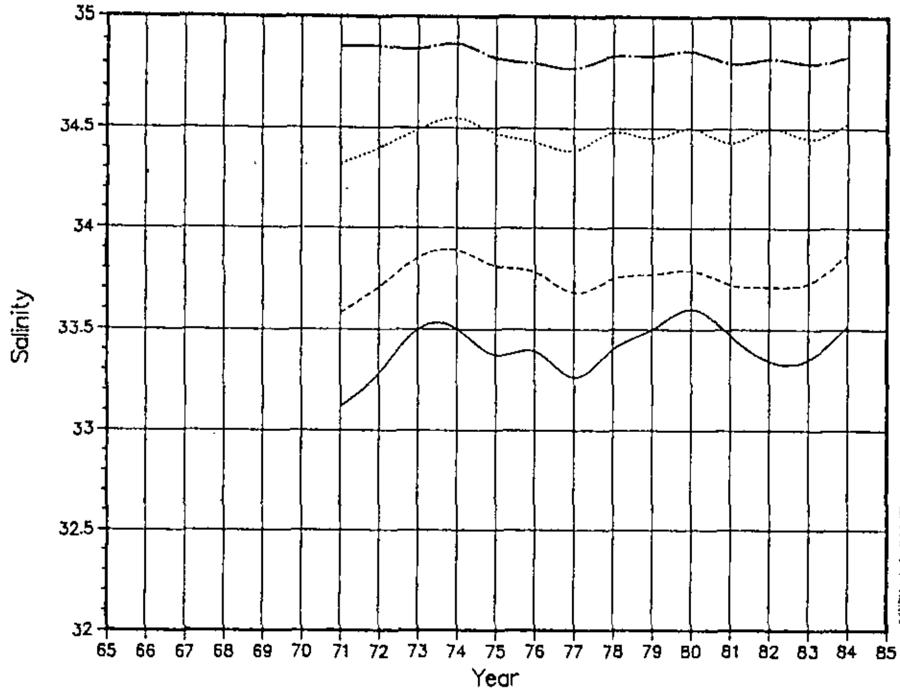

Fig. 12. 3 year running mean of salinities in 4 depth intervals on Lille Hellefisk Bank, St. 5 at the beginning of July, 1971 - 1984.

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————————   0 -  50 m
---------  50 - 150 m
.......... 150 - 400 m
-·-·-·-·-  400 - 600 m
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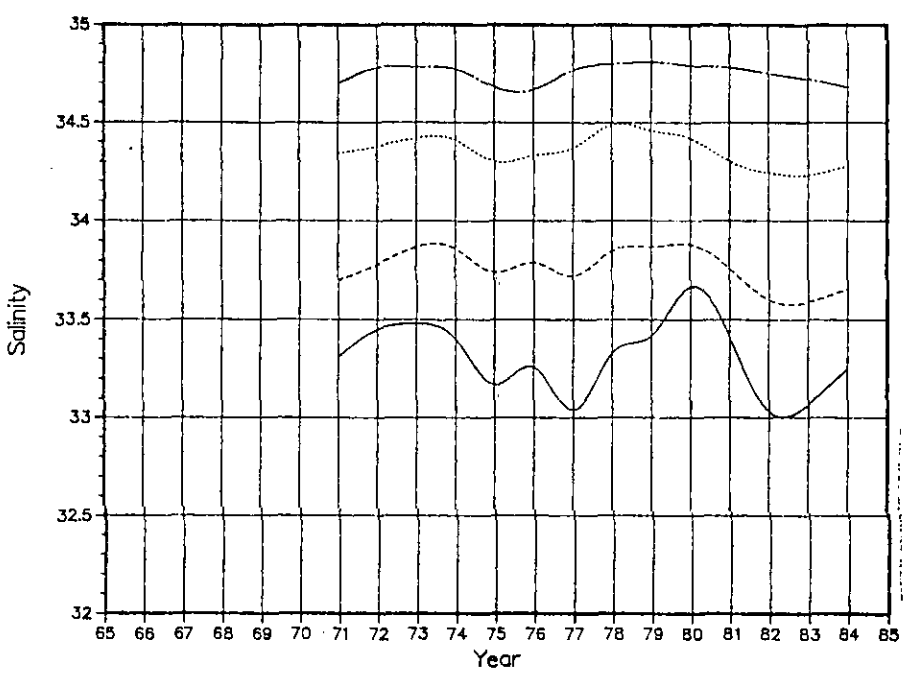

Fig. 13. 3 year running mean of salinities in 4 depth intervals on Store Hellefisk Bank, St. 5 at the beginning of July, 1971 - 1984.

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————————   0 -  50 m
---------  50 - 150 m
.......... 150 - 400 m
-·-·-·-·-  400 - 600 m
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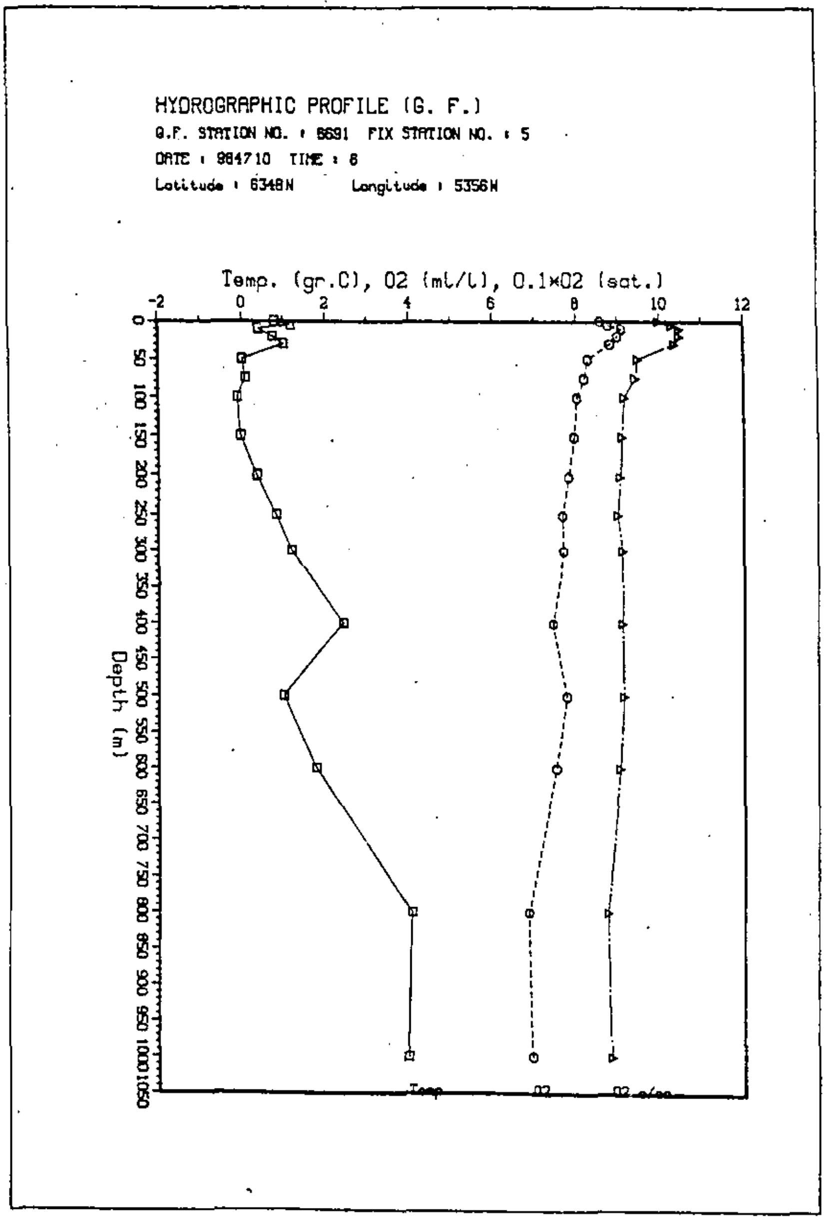

Fig. 14. Vertical profile of temperature and oxygencontent at Fylla Bank, St. 4, July 1983.

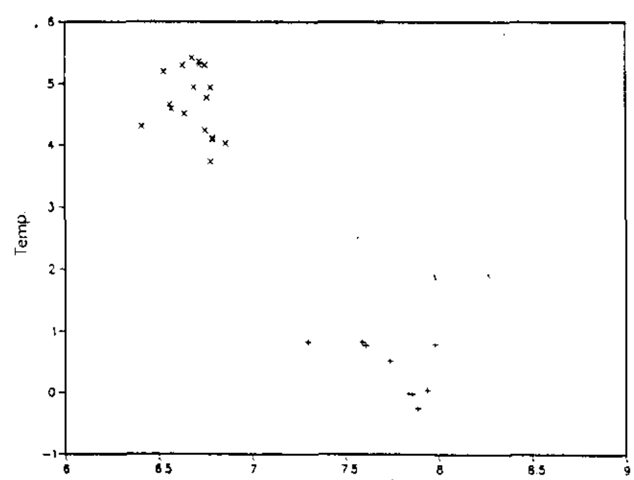

Fig. 15. Oxygen versus temperature from the West Greenland area.

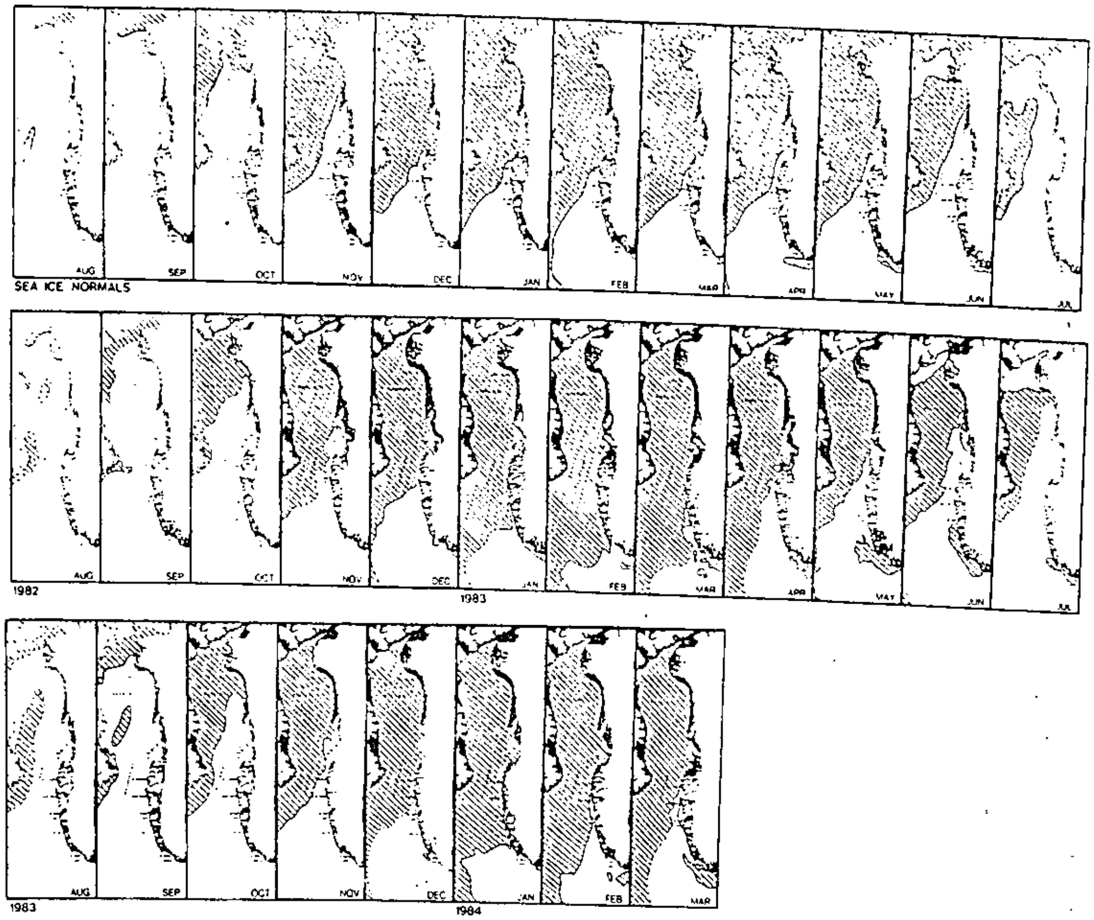

Fig. 16 Sea ice distribution in the Davis Strait.
Upper row: normal distribution.
Middle and lower row: distribution in the period August 1982 to March 1984.

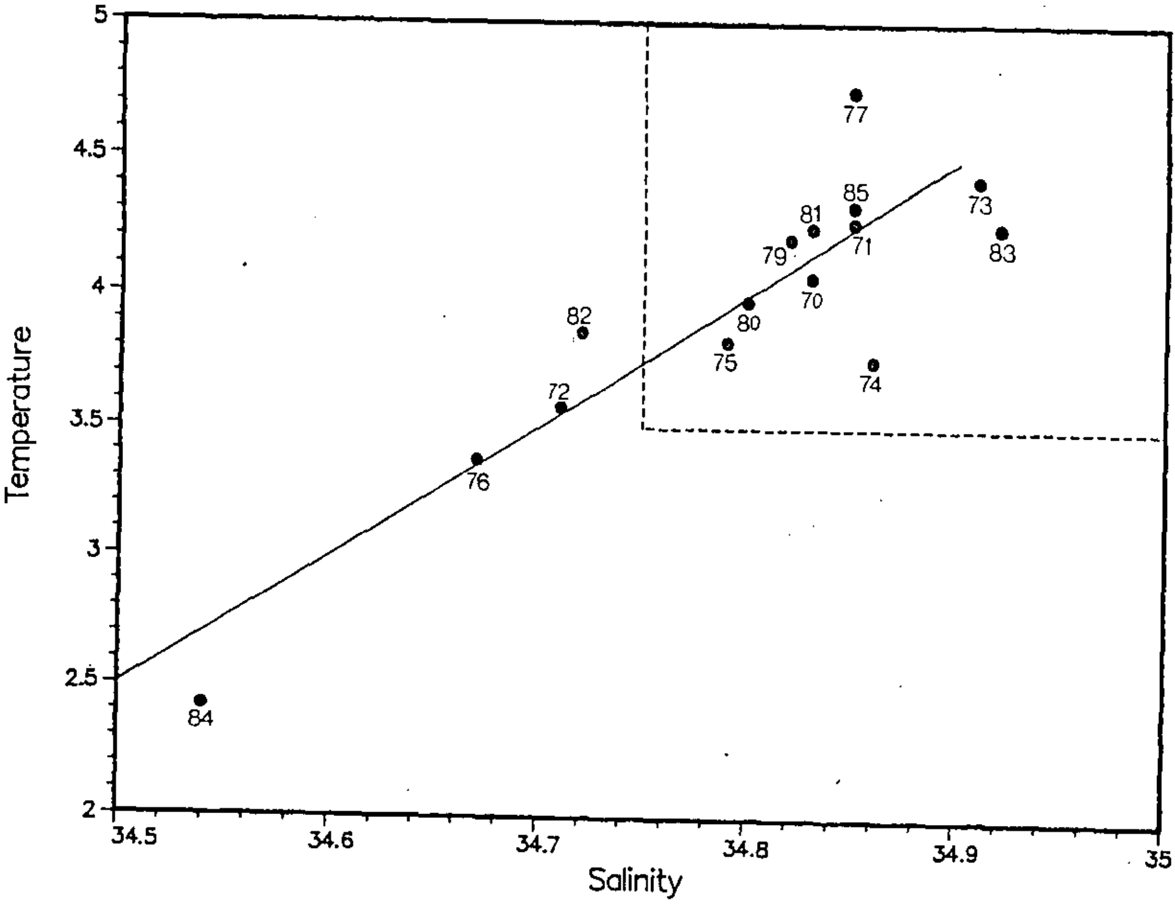

Fig. 17 Temperature - salinity diagram for the 400-600 m water column at the beginning of July since 1970. The T-S characteristics of the Irminger Water component are shown inside the rectangular.