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Northwest Atlantic Fisheries Organization

Serial No. N4233 **NAFO SCR Doc. 00/11**

SCIENTIFIC COUNCIL MEETING – JUNE 2000

Climatic Conditions Around Greenland - 1999

by

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Abstract

Although the North Atlantic Oscillation index for the winters of 1998/1999 and 1999/2000 was very high, climatic conditions around Greenland remained warm, confirming that during the past two years there was an anomalous NAO pattern over the area.

Warmer than normal conditions were observed around Greenland for most of the year 1999 although mean air temperatures at Nuuk indicate slightly negative anomalies (-0.3K). Based on sea surface temperature (SST) anomaly maps for all months of 1999 it is shown that the arctic water mass components have increased their influence on the surface waters when comparing to the year 1998.

Comparison between the mean stratum weighted temperature index of the entire area under investigation (East and West Greenland), and the results of station 4 of the Fylla Bank Section reveal for the depth layers 0-200m, and 200-400m, i.e. the depth layers of the surveyed strata significant correlation. This points at advective processes which seem to play an important role in this bank system.

The long-term trend of Nuuk air temperature anomalies points at intermediate warming, a feature which was also observed during the 1970s and 1980s.

Introduction

NAFO through its Standing Committee on Fisheries Environment (STACFEN) "provides reviews of environmental conditions and advises the Scientific Council on the effects of the environment on fish stocks and fisheries in the Convention Area" (NAFO, 1998). Whereas the first part of the cited rule of procedure [d) ii)] is followed year after year by NAFO research scientists [see literature cited in Stein (2000)], and based on the systematic sampling of environmental data there is a quite reasonable overview on the environmental conditions in the NAFO Convention Area, part two of the cited rule of procedure - the effects of the environment on fish stocks and fisheries – is more difficult to fulfill.

We should, however, be optimistic and realize what we have achieved: Based on the biological/oceanographic knowledge as acquired in NAFO and it's predecessor ICNAF, there is now, at the end of this century, a data and knowledge base which allows us to correlate biological and environmental data sets. This could lead to answers on "the effects of the environment on fish stocks and fisheries".

As cited 1999 at this same place from Latif (1998), the climate system exhibits considerable natural variability on time scales of the order of decades. Decadal climate variability is an important issue for three reasons:

- A better understanding of the mechanisms generating decadal climate variability might open the possibility to make predictions at decadal time scales.
- The detection of anthropogenic climate change requires information about natural variability to separate the anthropogenic signal from the natural background noise.
- Long-term changes in the climate state might influence short-term climate fluctuations. A better knowledge of the slowly evolving background state can improve the prediction of the faster climate variations substantially.

To follow these three keynotes, continuation of sampling environmental data around Greenland was achieved by the author, and the present paper is the eighths in a series which started with the year 1992, to elucidate relevant climatic issues around Greenland.

Data and Methods

Data on the atmospheric climate of Greenland were sampled by the Danish Meteorological Institute at Nuuk (64°11'N, 51°44.5'W), Egedesminde (68°42.5'N, 52°53'W) and Angmagssalik (65°36'N, 37°40'W). Whereas the first data set was mutually supplied by the Danish Meteorological Institute in Copenhagen and the Seewetteramt, Hamburg, the latter data sets were given by the Seewetteramt, Hamburg. The climatic mean which the air temperature anomaly charts are referenced to is 1961-1990. Ice charts were taken from the INTERNET (http://-www.natice.noaa.gov/pub/East_Arctic/Baffin_Bay/Davis_Strait/; http://www.natice.noaa.gov/pub/East_Arctic/Greenland_Sea/Greenland_Sea_southwest/; http://www.natice.noaa.gov/pub/East_Arctic/Greenland_Sea/Greenland_Sea_South/ (Fig. 6, 7, 8). They originate from NOAA satellite ice observations. Analysis of ice conditions is grouped in sub areas which are denoted in the above given internet links (Baffin Bay/Davis Strait, Greenland Sea southwest, Greenland Sea South).

Sea surface data for the region between Greenland and Labrador were taken from the IGOSS Data Base http://ingrid.ldgo.columbia.edu/SOURCES/.IGOSS .

During cruise WH211 of FRV "Walther Herwig III", CTD profiles were obtained at each fishing position of the surveyed area (Fig. 1). Observations on Standard Oceanographic Stations (**Stein, 1988**) were done at the Cape Desolation Section, the Holsteinsborg Section (Fig. 12), the Little Halibut Bank Section (Fig. 13), and at the Fyllas Bank Section (Fig. 14).

The NAO Index as given in Fig. 17 refers to the mean December, January, February (DJF) Sea Level Pressure (SLP) from the Azores (Ponta Delgada) and from Iceland (Akureyri). The individual SLP's are standardized to 1961-90 base period, and calculated using:

$$\mathrm{NAO_i} = \frac{p_i - \overline{p}}{s}\Big|PD - \frac{p_i - \overline{p}}{s}\Big|A\ .$$

DJF pressures for 1998/99 and 1999/2000 for Ponta Delgada were defined by regression (Stein, 2000).

Results

Air Temperature and Climatic means

Similar to previous years conditions (Stein, 2000), February was the coldest month off West Greenland, and the positive air temperature conditions as observed during December 1998 at the West Greenland sites, were maintained through to January 1998 only at Egedesminde. Nuuk experienced colder than normal conditions both in January, and in February. Air temperature anomalies (in brackets: mean temperature of the month) during February were –2K at Egedesminde (–18°C), and Nuuk (–9.8°C).

The annual air temperature curves referenced to the climatic means at the three observation sites off West and East Greenland, are given in Fig. 2 to 4. Colder than normal conditions were encountered at the West Coast of Greenland during January, February and May. From July onwards, air temperatures were above the climatic mean. Angmagssalik (Fig. 4) experienced climatic conditions, which were near or above the climatic mean throughout the year.

Climatic Variability off West Greenland

After three years with warmer than normal mean annual air temperatures, 1999 is the first year with negative air temperature anomaly (Fig. 5, -0.3K). The decadal presentation of Nuuk mean air temperature anomalies (Fig. 6) reveals much variability during the last year of each decade: whereas the years 1979/1989 indicated considerable positive/negative anomalies, 1999 conditions were about normal. The long-term trend of Nuuk air temperature anomalies (the 13-year running mean as well as the 5-year running mean) is, as emphasised by Stein (1999, 2000) pointing at intermediate warming, a feature which was also observed during the 1970s and 1980s (Fig. 5).

Ice Conditions in the Northwest Atlantic

Winter ice conditions were favourable during 1999 off West and East Greenland. The southernmost location of the ice edge was found in early March in the region of the Little Halibut Bank (Fig. 7). Least ice cover in the Baffin Bay/Davis Strait area was found during mid-September when only some coastal ice off northern Baffin Island was present. In the southwestern bight of Greenland (Julianehaab) ice formed again during the end of November (Fig. 8). There was ice around Cape Farewell from the beginning of 1999 through to early-August (Fig. 9).

Sea Surface Temperature Anomalies

Colder than normal conditions in sea surface temperatures (SSTs) were encountered during the first quarter of the year in the Julianehaab Bight where temperatures dropped –2.5K below the norm. There is a gradual cooling taking place in the following months of the year, and during winter season a patch of warmer than normal water is seen to remain in the centre of the Labrador Sea. Examples from February 1998 (Fig. 10), and February of the previous and the following year show nearly identical structures: With core temperature anomalies of more than 2.5K a warm pool of surface water is found at about 60°N, 55°W. The arctic water masses confined to the shelf regions off West Greenland and Labrador, indicate cooling of more than –2.5K. Compared to the previous year 1998, 1999 indicates cooling throughout all months, especially during the second half of the year (Fig. 11).

Subsurface Observations off West Greenland

Investigations performed by FRV "Walther Herwig III" in October/November 1999 at NAFO Standard Oceanographic Sections Fyllas Bank, Little Halibut Bank, and Holsteinsborg indicate that warm, saline water reached the northern parts of the West Greenland bank areas. Along the Holsteinsborg Section water temperatures in the depth layer 300-400m were well above 5°C (Fig. 12). At the Little Halibut Bank Section temperatures above 6°C were measured, a value which is seldom reached at this section (Fig. 13).

The results from Fylla Bank are given in Fig. 14 and 15. Accordingly, mean temperature anomalies of water layers 0-50m, 0-200m, and 200-300m are +1K above the 1963-90 mean value.

Comparison between the mean stratum weighted temperature index of the entire area under investigation (East and West Greenland), and the results of station 4 of the Fylla Bank Section (Fig. 16) reveal for the depth layers 0-200m, and 200-400m, i.e. the depth layers of the surveyed strata (Fig. 1), significant correlation:

0-200m	/ Temperature-Index	$r^2 = 0.82$	($p \ll 0.001$)
200-400m	/ Temperature-Index	$r^2 = 0.78$	($p \ll 0.001$).

The North Atlantic Oscillation (NAO) Index

The NAO index as given for the present decade of the 1990s shows mostly positive values (Fig. 17, upper panel).

During the second half of the present century we see that the 1960s were generally low-index years while the 1990s are high index years. There was a major exception to this pattern occurring between the winter preceding 1995 and the winter preceding 1996, when the index flipped from being one of its most positive values to its most negative value this century (Anon., 2000).

Discussion

Greenland lies within the area which normally experiences cold conditions when the NAO index is positive. However, although the NAO index for the winters of 1998/1999 and 1999/2000 was very high (Fig. 17), climatic conditions around Greenland remained warm, confirming that during 1998 and 1999 there was an anomalous NAO pattern over the area.

Mean monthly air temperatures at Nuuk were below normal during January, February, May and June which led to slightly lower than normal mean annual air temperatures (Fig. 5, -0.3K).

Winter ice conditions were favourable during 1999 off West and East Greenland.

Changes in the ocean climate in the waters to the west of Greenland generally followed those of air temperature. The exceptionally high temperatures in 1998 (see Figs. 14, 15 in Stein, 2000), cooled a little during 1999 (Figs. 10, 11), but the year was still one of the warmest years since observations began in autumn 1963.

Subsurface ocean climatic conditions were warmer than normal along the West Greenland Standard Sections. The so-called Irminger Water layer (200m-300m depth layer) revealed highest temperature anomalies at Fylla Bank station 4 when comparing to the changes encountered at 0-50m or 0-200m. The warm water of Irminger Water origin could be traced as far north as the Holsteinsborg section (Fig. 12).

Comparison between the mean stratum weighted temperature index of the entire area under investigation (East and West Greenland), and the results of station 4 of the Fylla Bank Section indicates that both methods, the observation at a standard station, and the area integrated temperature index give similar results on the climatic situation in the near-bottom water layer of the bank system East and West Greenland. This points at advective processes which seem to play an important role in this bank system.

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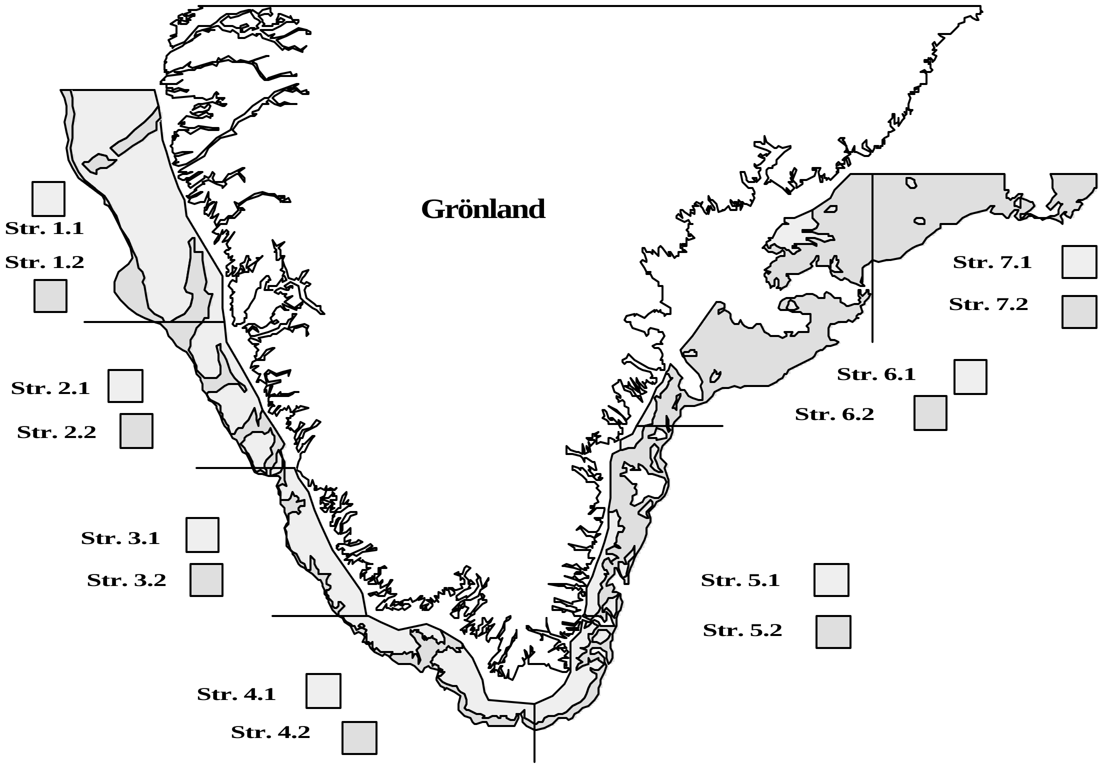

Fig. 1. Area of investigation during WH 211 (10 October – 8 November 1999), and individual survey strata; strata 0-200m: 1.1, 2.1, 3.1, 4.1, 5.1, 6.1 and 7.1, and 200-400m: 1.2,2.2,3.2,4.2, 5.2, 6.2 and 7.2 around Greenland.

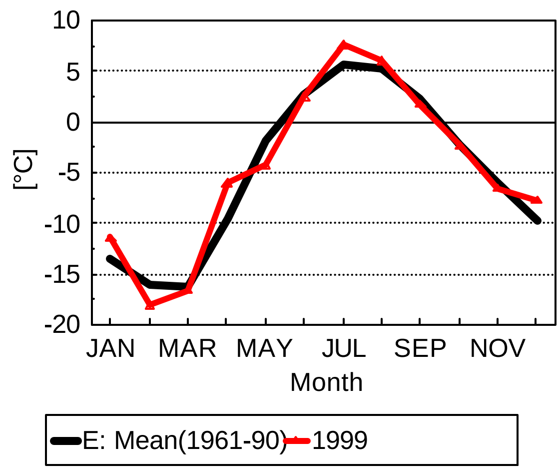

Fig. 2. Monthly mean air temperature at Egedesminde during 1999 and climatic mean (1961-1990).

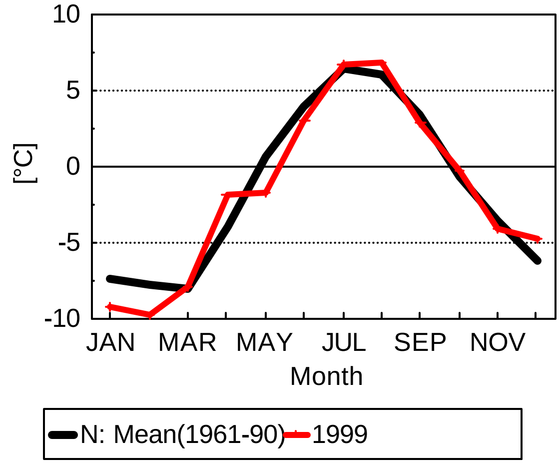

Fig. 3. Monthly mean air temperature at Nuuk during 1999 and climatic mean (1961-1990).

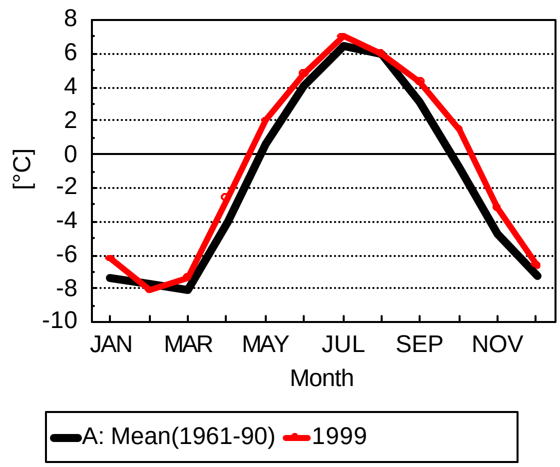

Fig. 4. Monthly mean air temperature at Angmagssalik during 1999 and climatic mean (1961-1990).

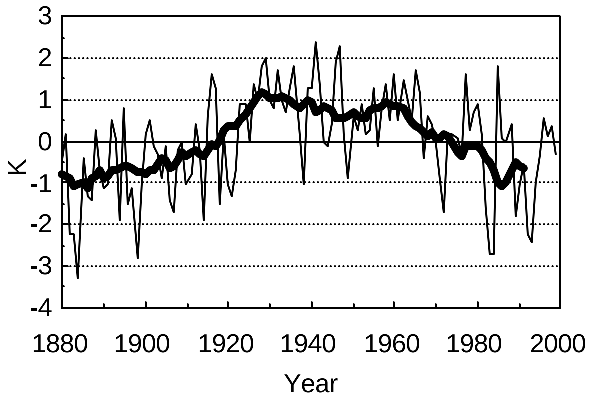

Fig. 5. Time series of annual mean air temperature anomalies at Nuuk (1880-1999, rel. 1876-1999), and 13 year running mean.

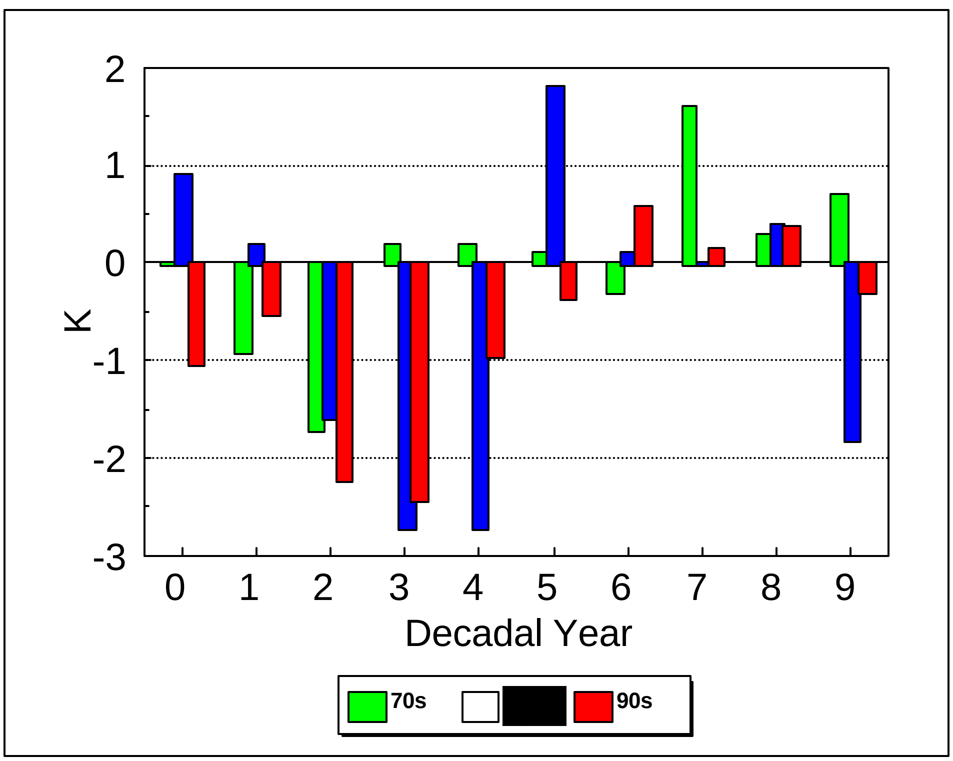

Fig. 6. Composite of decadal air temperature anomalies at Nuuk given relative to the climatic mean of 1961-90 for the decades of the 1970s, 1980s and 1990s.

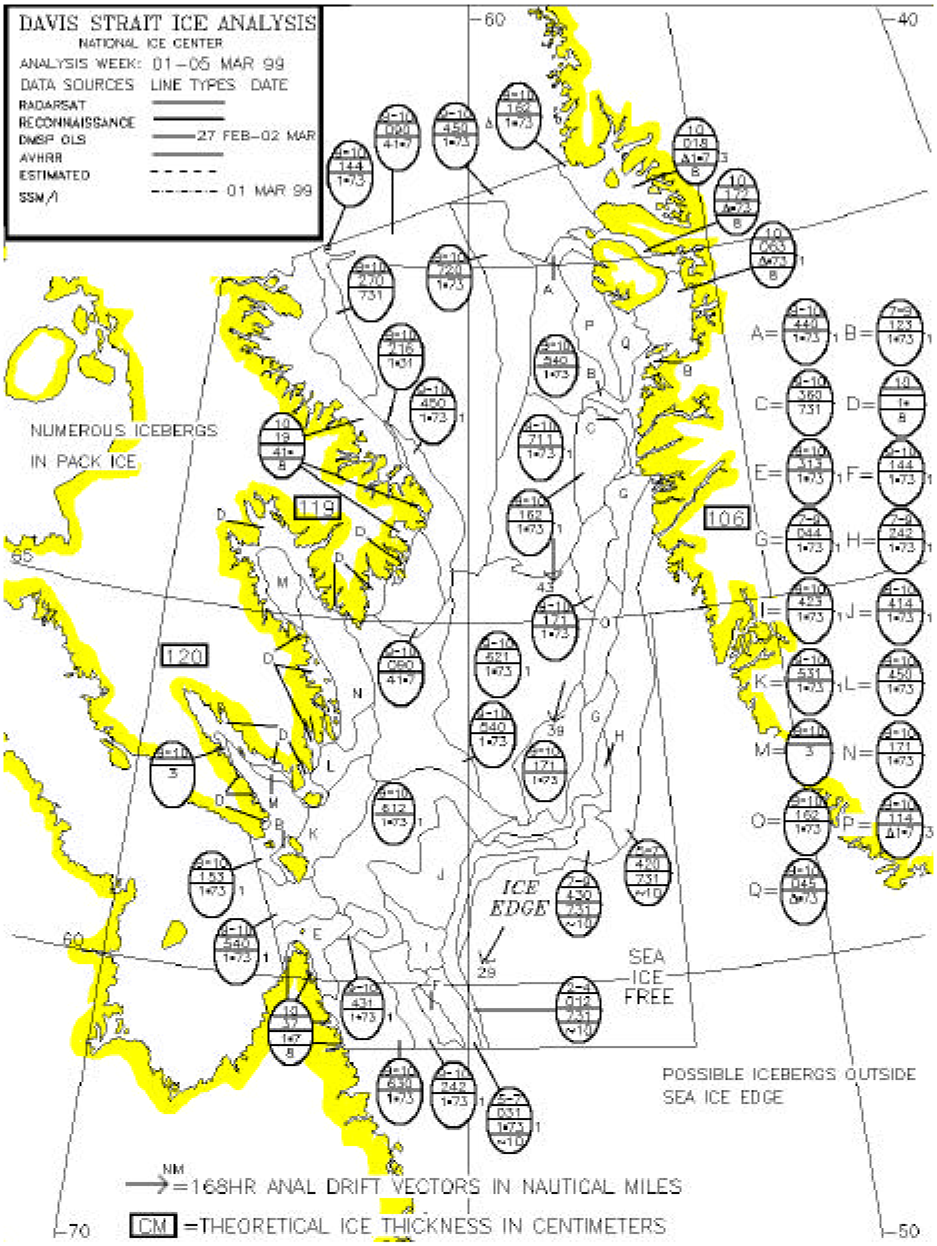

Fig. 7. Ice cover and ice edge during 01-05 March 1999

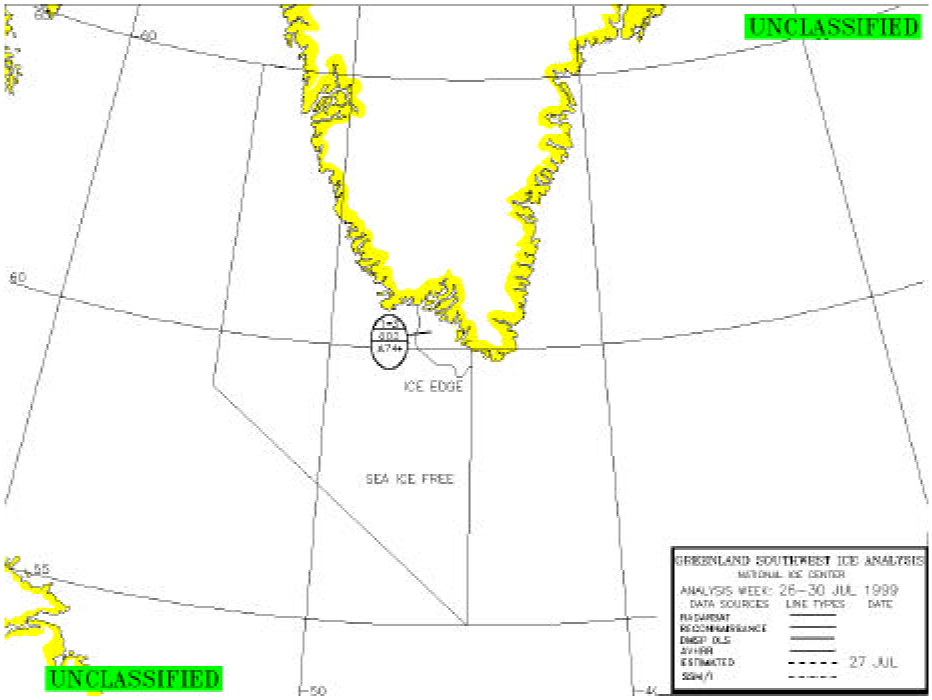

Fig. 8. Ice cover and ice edge during 26-30 July 1999.

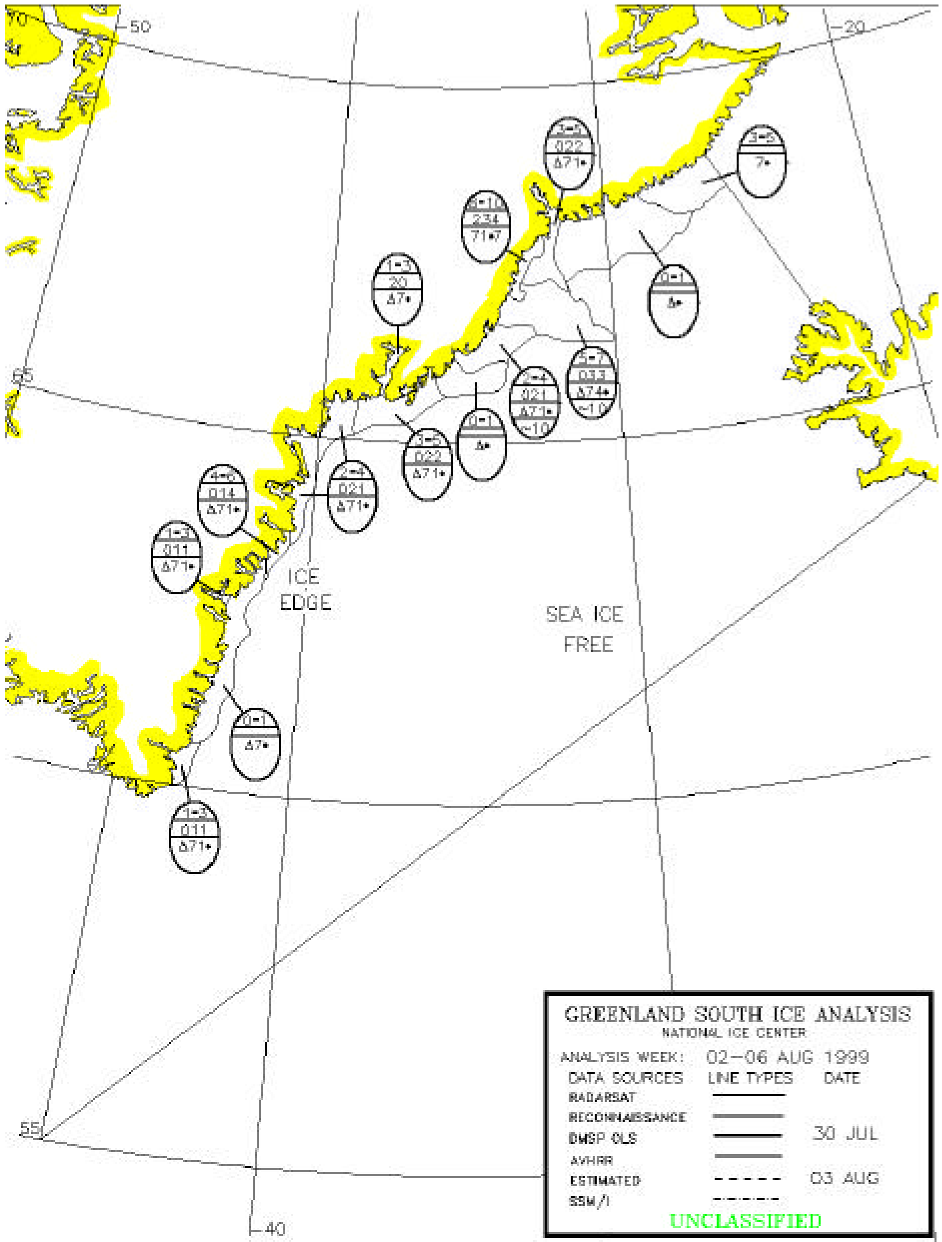

Fig. 9. Ice cover and ice edge during 02-06 August 1999.

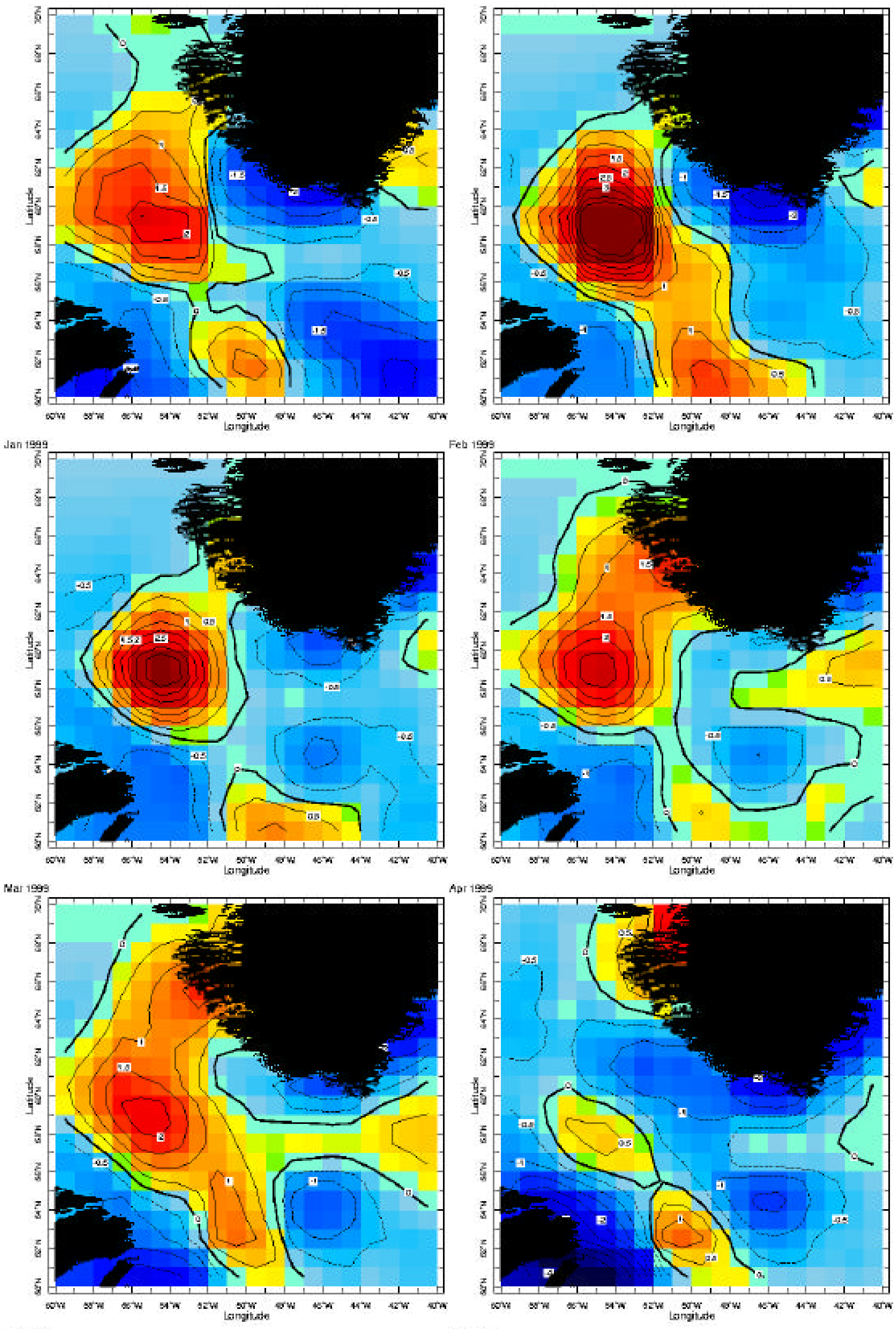

Fig. 10. Sea Surface Temperature Anomalies during January-June 1999.

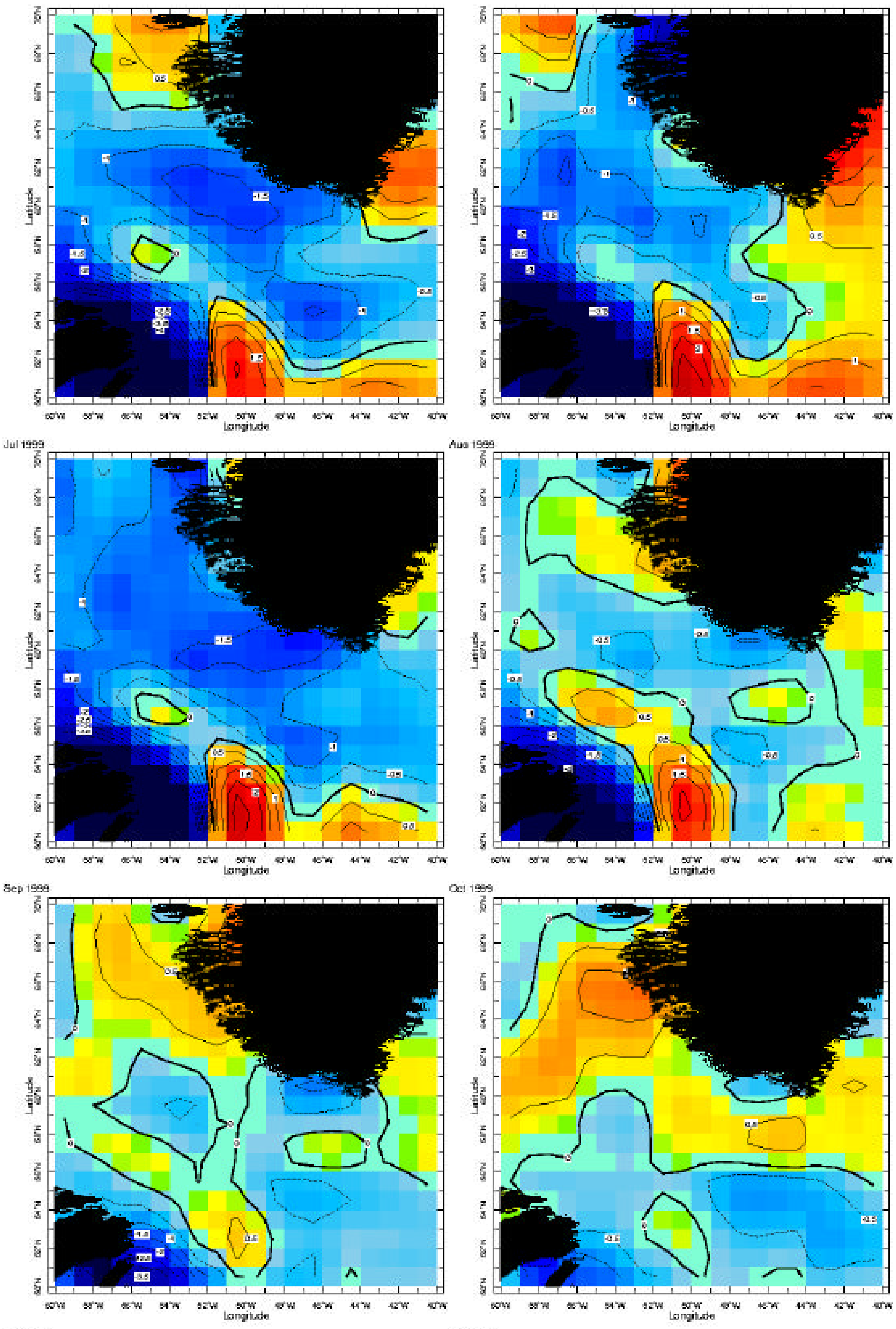

Fig. 11. Sea Surface Temperature Anomalies during July-December 1999.

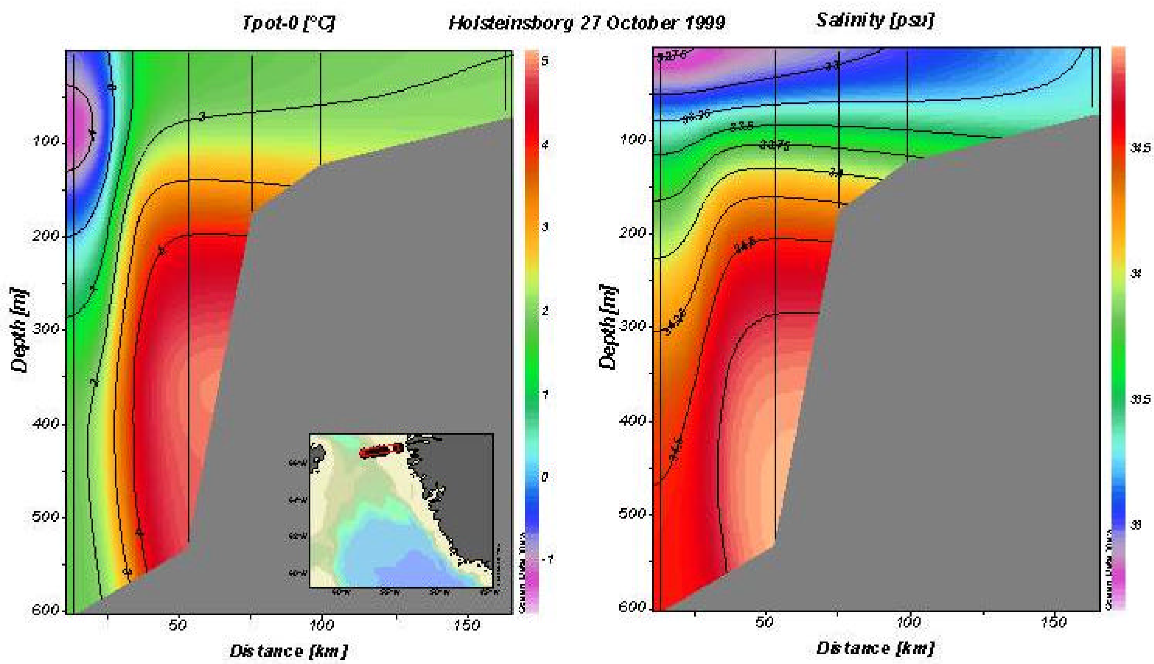

Fig. 12. Potential temperature and salinity along Holsteinsborg Section (27 October 1999).

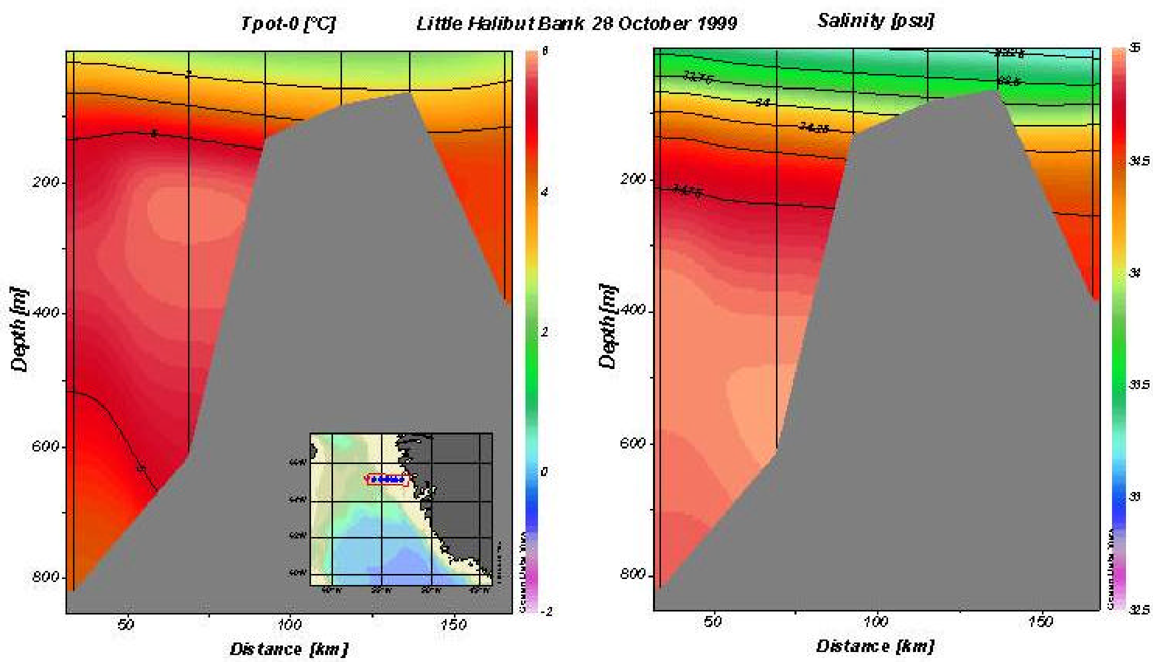

Fig. 13. Potential temperature and salinity along Little Halibut Bank Section (28 October 1999).

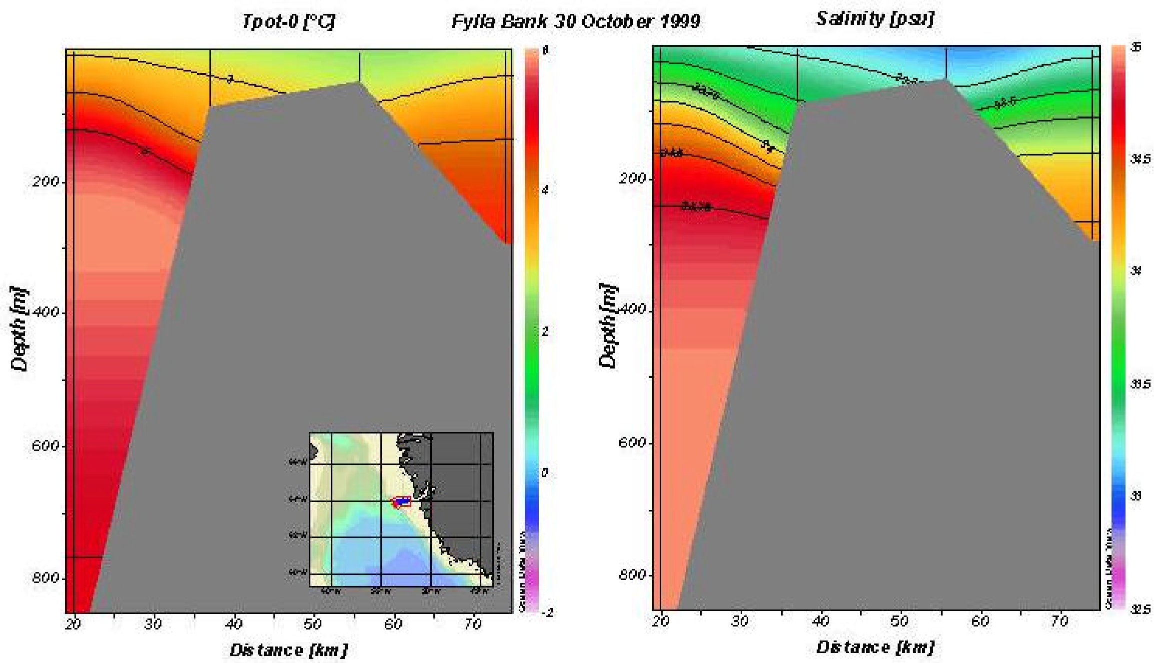

Fig. 14. Potential temperature and salinity along Fylla Bank Section (30 October 1999).

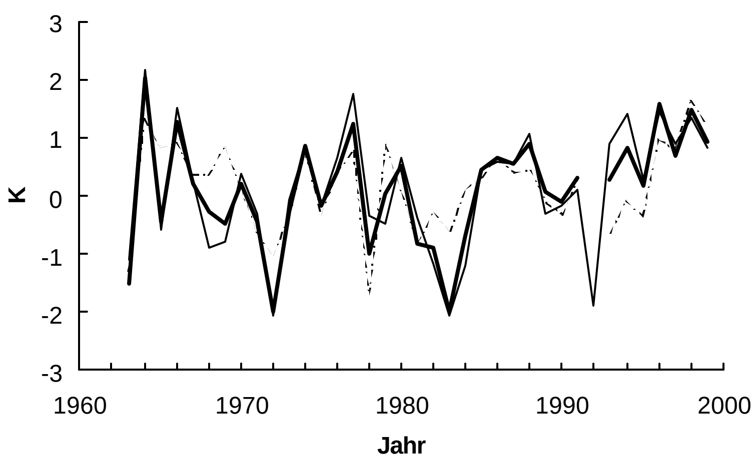

Fig. 15. Mean temperature anomalies of water layers at station 4 of the Fylla Bank Section (0-50m: thin; 0-200m: bold; 200-300m: dashed).

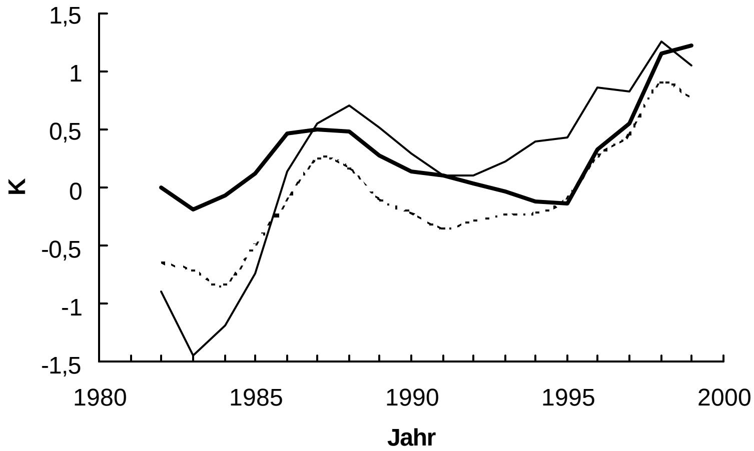

Fig. 16. Mean temperature anomaly of water layers 0-200m (thin), 200-400m (bold) at station 4 of Fylla Bank Section, and stratum weighted mean temperature index (dotted) of entire research area as given in Fig. 1.

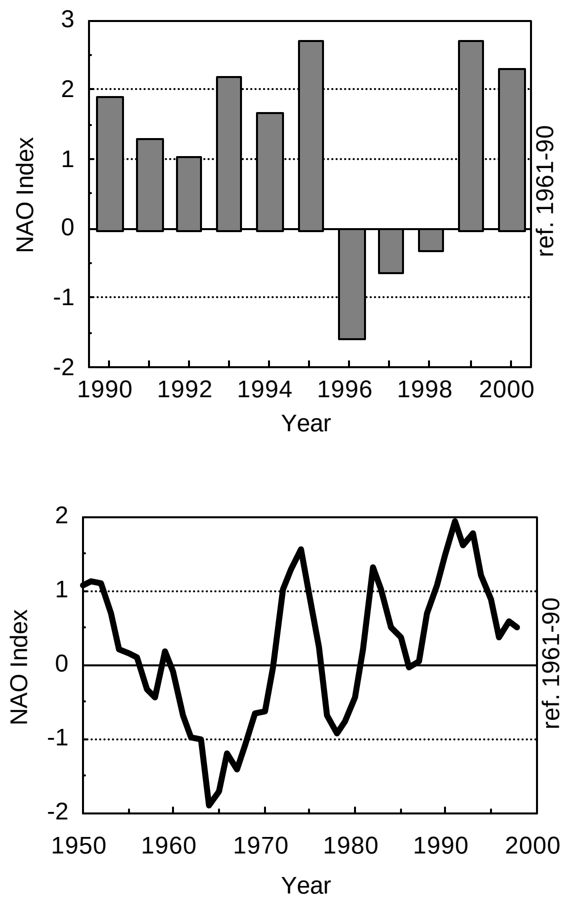

Fig. 17. The winter (DJF) NAO index in terms of the present decade (upper figure) and the second half of the present century (lower figure, a 5 year running mean has been applied).