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Climatic Conditions Around Greenland - 2000

by

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Abstract

The North Atlantic Oscillation index for the winters of 2000/2001 was negative (-0.89). Air temperature climatic conditions around Greenland continued to be warm.

Warmer than normal conditions were observed around Greenland for most of the year 2000 with mean air temperatures at Nuuk indicating positive anomalies (+0.6K). Based on satellite derived ice charts and sea surface temperature (SST) anomaly maps for all months of 2000 it is shown that the distribution of ice in the southwestern area off West Greenland, and especially in the Julianehaab Bight, is reflected in the sea surface temperature (SST) anomalies. During most of the months in 2000 the surface waters in the southwestern area off West Greenland were colder than normal. At the western boundary of the Labrador Sea SST anomalies indicate considerable warming which exceeded +2.5K during the months of August and September. These conditions are consistent with the NAO index (negative index=mild climate). The long-term trend of Nuuk air temperature anomalies points at intermediate warming, a feature, which was also observed during the 1970s, 1980s and 1990s.

Introduction

There are two annual Greenland surveys, which are ongoing since decades in the waters adjacent to this island: The Danish June survey (Buch, 2001), and the survey performed by Germany in autumn. During September/October 2000 FRV "Walther Herwig III" did oceanographic observations at NAFO Standard Oceanographic Sections Cape Desolation, Frederikshaab Bank, Fyllas Bank and Little Halibut Bank as part of the annual autumn groundfish survey to East and West Greenland waters performed by Germany since 1963. The oceanographic data obtained during these surveys form the basis for interpretation of the oceanic climate on the fishing banks around Greenland and at selected NAFO Standard Oceanographic stations.

Starting in 1993 with a compilation of climatic conditions in the northwestern North Atlantic area (Stein, 1995), this paper is the ninth in a series, which provides an annual overview on environmental conditions around Greenland. Whereas the subsurface oceanographic data originate from FRV "Walther Herwig III" observations, the air temperature data, sea ice data and the sea surface temperature anomalies are taken from sources given under data and methods.

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. 7-11). 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). During 2000 the web presentation of ice conditions changed. Examples are given in Fig. 10, 11.

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

During cruise WH221 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 Frederikshaab Bank Section, the Fyllas Bank Section and the Lille Hellefiske Bank Section (Fig. 14). Salinity readings of the CTD profiles were adjusted to water samples derived by Rosette water sampler. Data analysis and presentation was done using the most recent version of Ocean Data View (5.4). Theta/S sections of Frederikshaab Bank Section, Fyllas Bank Section and Lille Hellefiske Bank Section are displayed in Fig. 16 to 18. Water mass analysis was done using the "patch" option in Ocean Data View for Irminger Water (4°C < Theta < 6°C, 34.95 < S < 35.1) for both the 1999 and the 2000 autumn observations (Fig. 19 to 23). Time series of temperature anomaly at Fyllas Bank station 4 is given in Fig. 24, and the time series of salinity calibration samples is given in Fig. 25.

The NAO Index as given in Fig. 26 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, 1999/2000 and 2000/2001 for Ponta Delgada were defined by regression (Stein, 2000a).

Results

Air Temperature and Climatic means

Similar to previous years conditions (Stein, 2000b), February was the coldest month off West Greenland, and the positive air temperature conditions as observed during December 1999 at the West Greenland sites, were maintained through to January 2000. Nuuk experienced colder than normal conditions both in February, and in March. Air temperature anomalies (in brackets: mean temperature of the month) during February were 0K at Egedesminde (-16°C), and -1.8K Nuuk (-9.6°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. Egedesminde's air temperatures during 2000 were mostly at or above the climatic mean (Fig. 2). Colder than normal conditions were encountered at the west coast of Greenland during February, March and May at Nuuk (Fig. 3). 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, and 1999 with negative air temperature anomaly (Fig. 5, -0.3K), 2000 returned to positive conditions (+0.6K). The decadal presentation of Nuuk mean air temperature anomalies (Fig. 6) reveals much variability during the first year of each decade: whereas the year 1970 was about normal, 1980/1990 indicated considerable positive/negative anomalies, 2000 conditions were similar to

1980. 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, 2000a**)** 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 2000 off West and East Greenland. The southernmost location of the ice edge was found in late March in the region of the Little Halibut Bank (Fig. 7). Least ice cover in the Baffin Bay/Davis Strait area was found from mid-September to the end of October when some coastal ice off northern Baffin Island and Disco Island started to form again. Fig. 10 gives an estimate of the ice conditions in the northern region during the beginning of July. In the southwestern bight of Greenland (Julianehaab) ice formed again during the end of November (Fig. 11). There was ice around Cape Farewell from the beginning of 2000 through to early August. Most ice was found in the Cape region at the end of March (Fig. 8, 9).

Sea Surface Temperature Anomalies

Similar to 1999, colder than normal conditions in sea surface temperatures (SST's) were encountered during most of the year in the Julianehaab Bight where temperatures dropped –2.5K below the norm (Fig. 12, 13). During winter season a patch of warmer than normal water is seen to remain in the centre of the Labrador Sea. As in previous years, during the months of February to May core temperature anomalies of more than +2.5K were found in a warm pool of surface water at about 60°N, 55°W. Starting in June considerable warming was observed at the Canadian side of the Labrador Sea which exceeded +2.5K during the months of August and September (Fig. 13). This was different to 1999 when mostly cooling was observed in the SST's off Labrador and Newfoundland

Subsurface Observations off West Greenland

The major heat input to the water column is derived by advection, i.e. the warm Irminger component of the West Greenland Current. During autumn 1999 Irminger Water was observed as far north as Lille Hellefiske Bank (65° 06'N, c.f. Fig.19). The green spot in the Theta/S diagrams marks the water mass characteristics of Irminger Water (4°C < Theta < 6°C, 34.95 < S < 35.1; Fig. 19). The vertical extension of this warm water during the autumn 2000 observations is marked green in Figs. 20, 21, 22 and 23. ***It should be noted that during 2000 Irminger Water was not observed at the westernmost station of Lille Hellefiske Bank Section. In contrast to previous years only five stations of this section were done.***

Vertical distribution of potential temperature and salinity at the NAFO Standard Oceanographic sections Frederikshaab Bank, Fylla Bank and Lille Hellefiske Bank are given in Fig. 16, 17, 18. They reveal the typical distribution of cold, low saline waters on the banks and warm saline waters at the slope region.

The results from Fylla Bank are given in Fig. 17, 22 and 24. The presence of Irminger Water at the slope region of Fylla Bank is clearly documented for the autumn 2000 observations (Fig. 22). As in previous years, West Greenland waters were warmer than normal (rel. 1963-1990). The surface layer (0-200m) at Fyllas Bank station 4 revealed thermal conditions, which were 1.55K above the long-term mean (mean 1963-1990: 2.68°C; Fig. 24). Mean temperature anomalies of water layers 0-50m/200-300m are +1.50K/+1.04K above the 1963-90 mean value (2.68°C/4.78°C).

At Frederikshaab Bank Irminger Water was found at depths around 500m (Fig. 22).

The deep layer at the Cape Desolation section indicates a slight increase in salinity at the 3000 dbar level (Fig. 25) if compared to the 1999 observations (1999: 34.835; 2000: 34.862). Due to technical problems, there are unfortunately no calibration samples available for depths other than the 3000 dbar level.

The North Atlantic Oscillation (NAO) Index

The NAO index as given for the last and present decade shows mostly positive values (Fig. 26, upper panel). The index for winter 2000/2001 is, however, negative (-0.89)

During the second half of the last century we see that the 1960s were generally low-index years while the 1990s were 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 (Fig. 26 upper panel).

Discussion

Greenland lies within the area, which normally experiences warm conditions when the NAO index is negative. The NAO index for the winter of 2000/2001 was negative (-0.89), and air temperature climatic conditions around Greenland were warm.

From the three air temperature monitoring sites off West and East Greenland, only Nuuk had mean monthly air temperatures, which were below normal during February, March and May. However, except February, mean temperatures of these colder than normal months were near the climatic mean which led to warmer than normal mean annual air temperatures (Fig. 5, +0.6K).

Winter ice conditions were favourable during 2000 off West and East Greenland. Most of the year there was, however, ice around Cape Farewell will was observed there from the beginning of 2000 through to early-August. Ice formed again in the southwestern bight of Greenland (Julianehaab) during the end of November (Fig. 11).

The distribution of ice in the southwestern area off West Greenland, and especially in the Julianehaab Bight, is reflected in the sea surface temperature (SST) anomalies (Fig. 12, 13): During most of the months in 2000 the surface waters in the southwestern area off West Greenland were colder than normal. There is an exception for the month of September when the cold area shrinked to the size of Julianehaab Bight. At the western boundary of the Labrador Sea SST anomalies indicate considerable warming which exceeded +2.5K during the months of August and September (Fig. 13). These conditions are consistent with the NAO index (negative index=mild climate).

Subsurface ocean climatic conditions during October were warmer than normal at Fylla Bank. The surface layer (0-200m) at Fyllas Bank station 4 revealed thermal conditions, which were 1.55K above the long-term mean (mean 1963-1990: 2.68°C; Fig. 24). The year 2000 thermal conditions in the upper 200m at Fylla Bank station 4 are among the warmest ever observed since 1963. They are similar to the conditions experienced during the autumn of 1996 and 1998.

It should be noted here that the SST anomalies for October (Fig. 13, middle right panel) do not show warming in the range as the sub-surface observations indicate (0-50 m: +1.50K). The SST map shows a 0K isotherme at 64°N which is the approximate latitude of Fylla Bank station 4 (see Fig. 14).

Warm saline water of Irminger Current origin was not found at Lille Hellefiske Bank during October 2000. This water mass was found off-slope of the sections Frederikshaab Bank and Fylla Bank.

References

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1995. Climatic Conditions Around Greenland – 1992. NAFO Sci. Coun. Studies. *NAFO Sci. Coun. Studies*, **22**: 33-41.

2000a. Climatic Conditions Around Greenland – 1998. NAFO Sci. Coun. Studies. *NAFO Sci. Coun. Studies*, **33**: 1-10.

2000b. Climatic Conditions Around Greenland – 1999. *NAFO SCR Doc*., No. 00/11, 15 p.

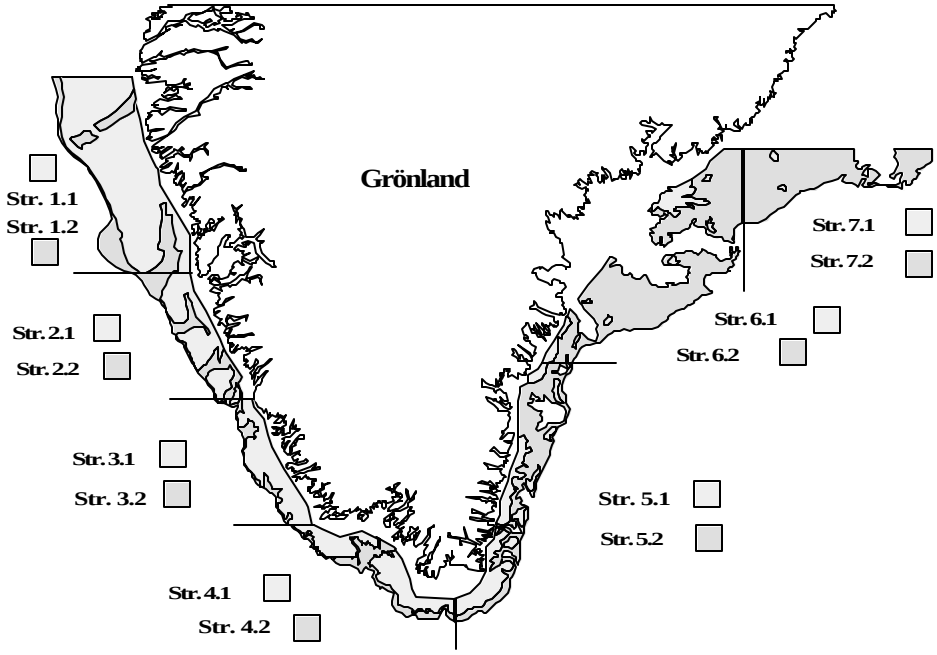

Fig. 1. Area of investigation during WH 221 (15 September-27 October 2000), and individual survey strata; strata 0-200 m: 1.1, 2.1, 3.1, 4.1, 5.1, 6.1 and 7.1, and 200-400 m: 1.2,2.2,3.2,4.2, 5.2, 6.2 and 7.2 around Greenland.

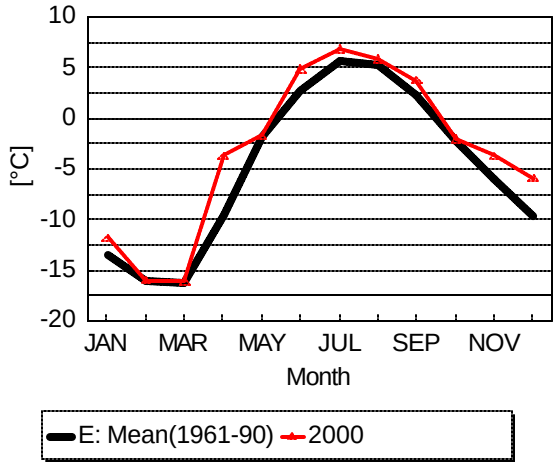

Fig. 2. Monthly mean air temperature at Egedesminde during 2000 and climatic mean (1961-1990).

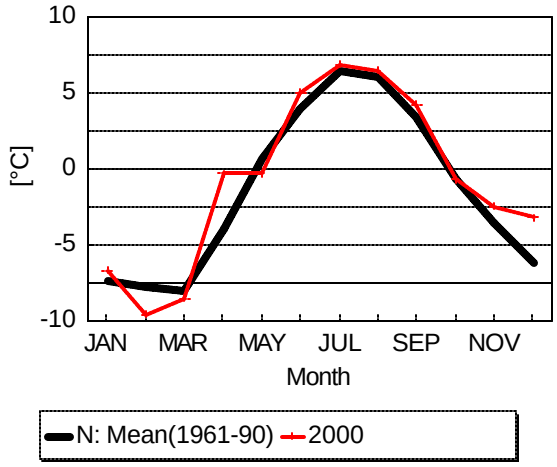

Fig. 3. Monthly mean air temperature at Nuuk during 2000 and climatic mean (1961-1990).

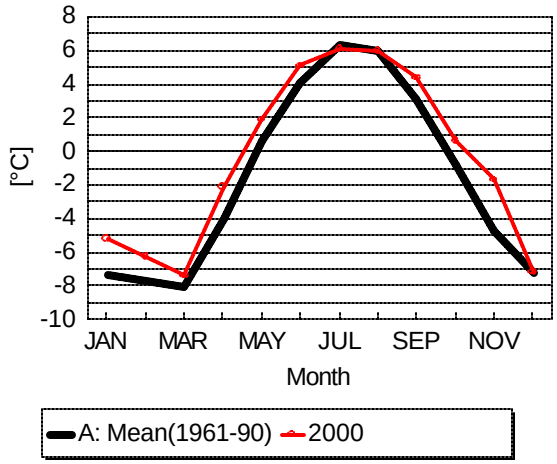

Fig. 4. Monthly mean air temperature at Angmagssalik during 2000 and climatic mean (1961-1990).

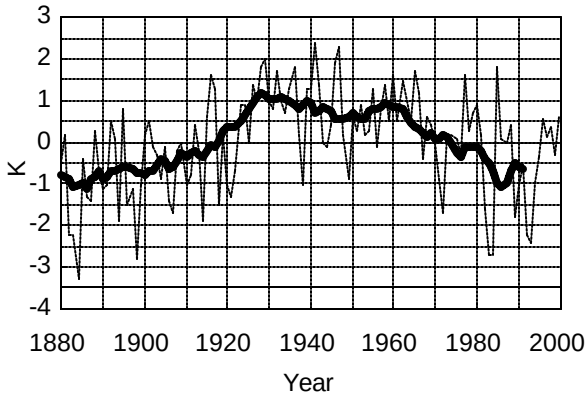

Fig.5. Time series of annual mean air temperature anomalies at Nuuk (1880-1999, rel. 1876-2000), and 13-year running mean.

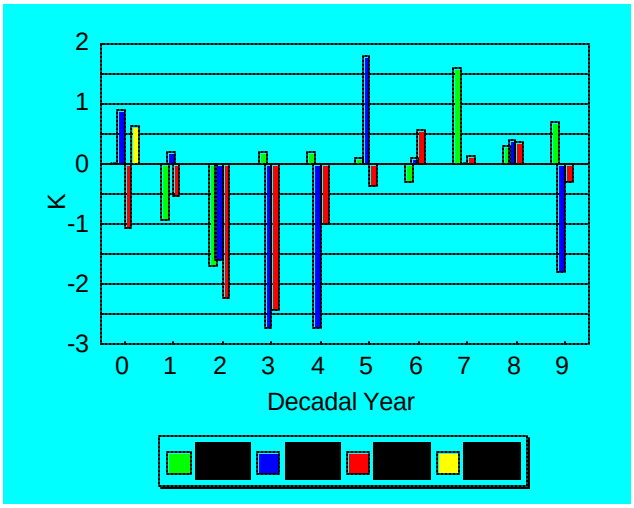

Fig. 6. Composite of decadal air temperature anomalies at Nuuk given relative to the climatic mean of 1961-90 for the decades of the 1970s, 1980s, 1990s and 2000s

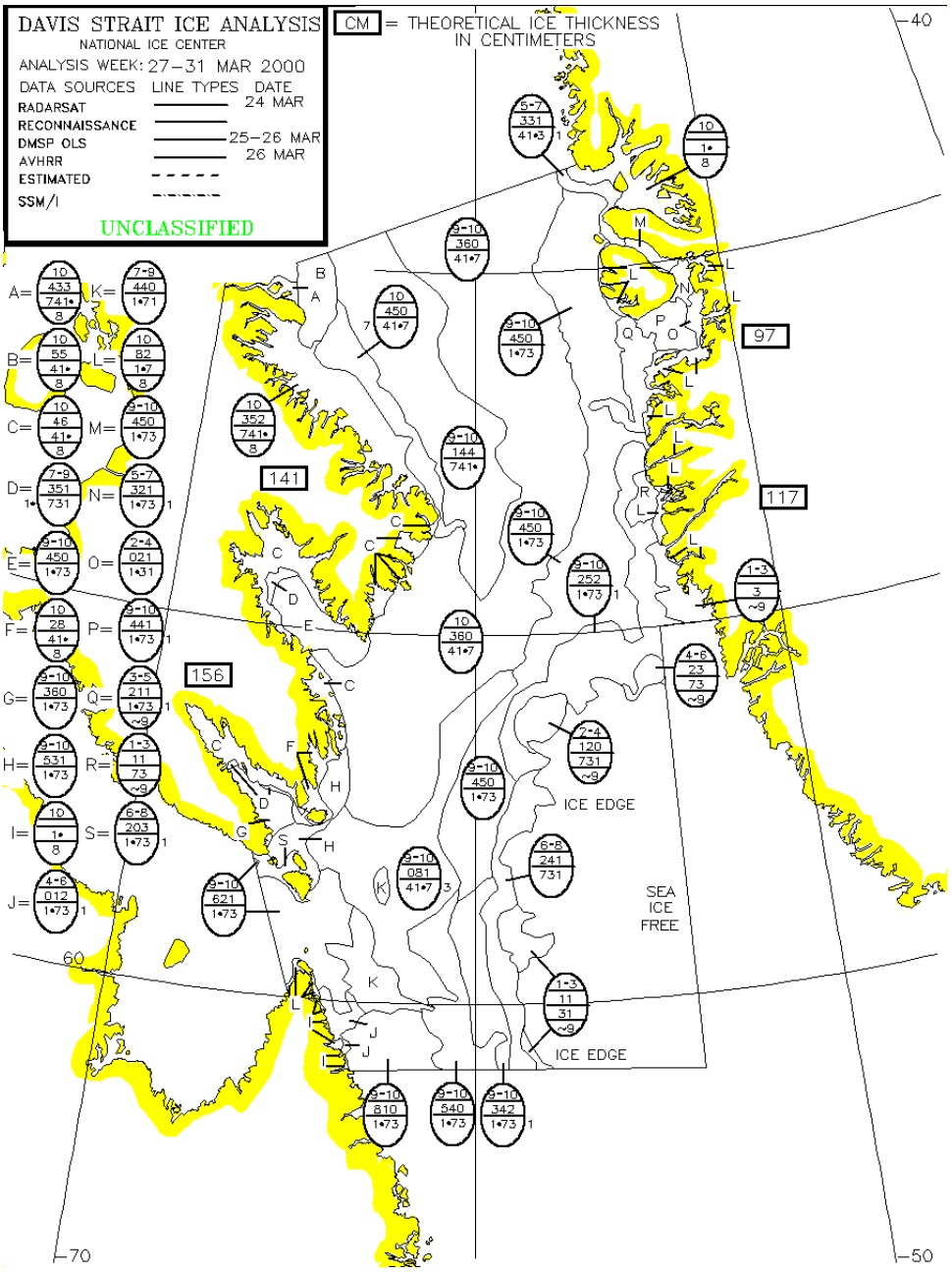

Fig. 7. Ice cover and ice edge during 27-31 March 2000 (Davis Strait).

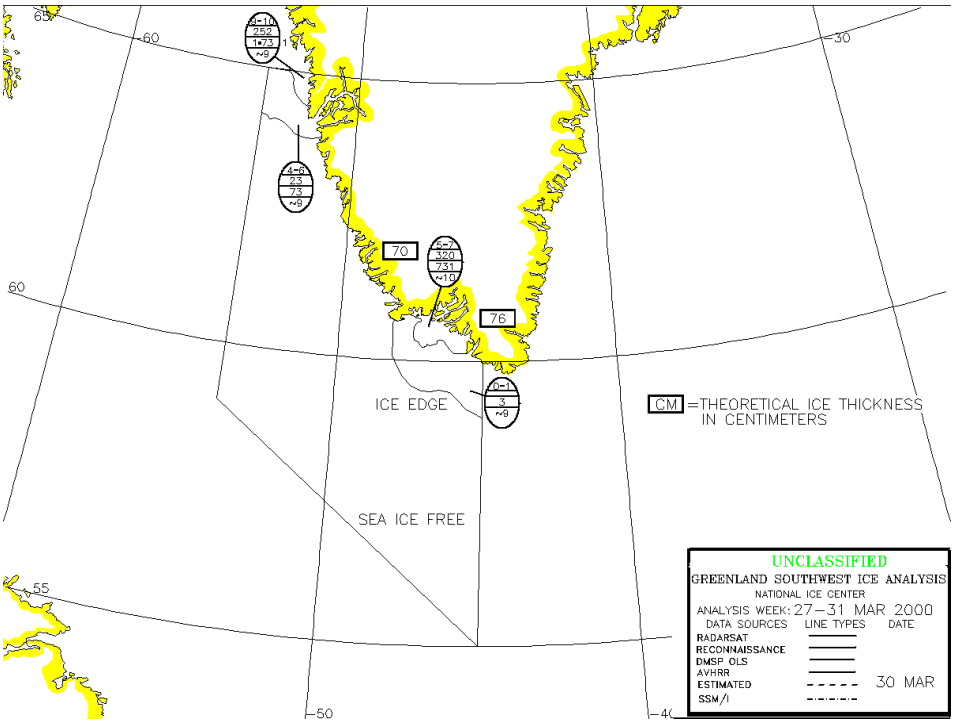

Fig. 8. Ice cover and ice edge during 27-31 March 2000 (Greenland Southwest).

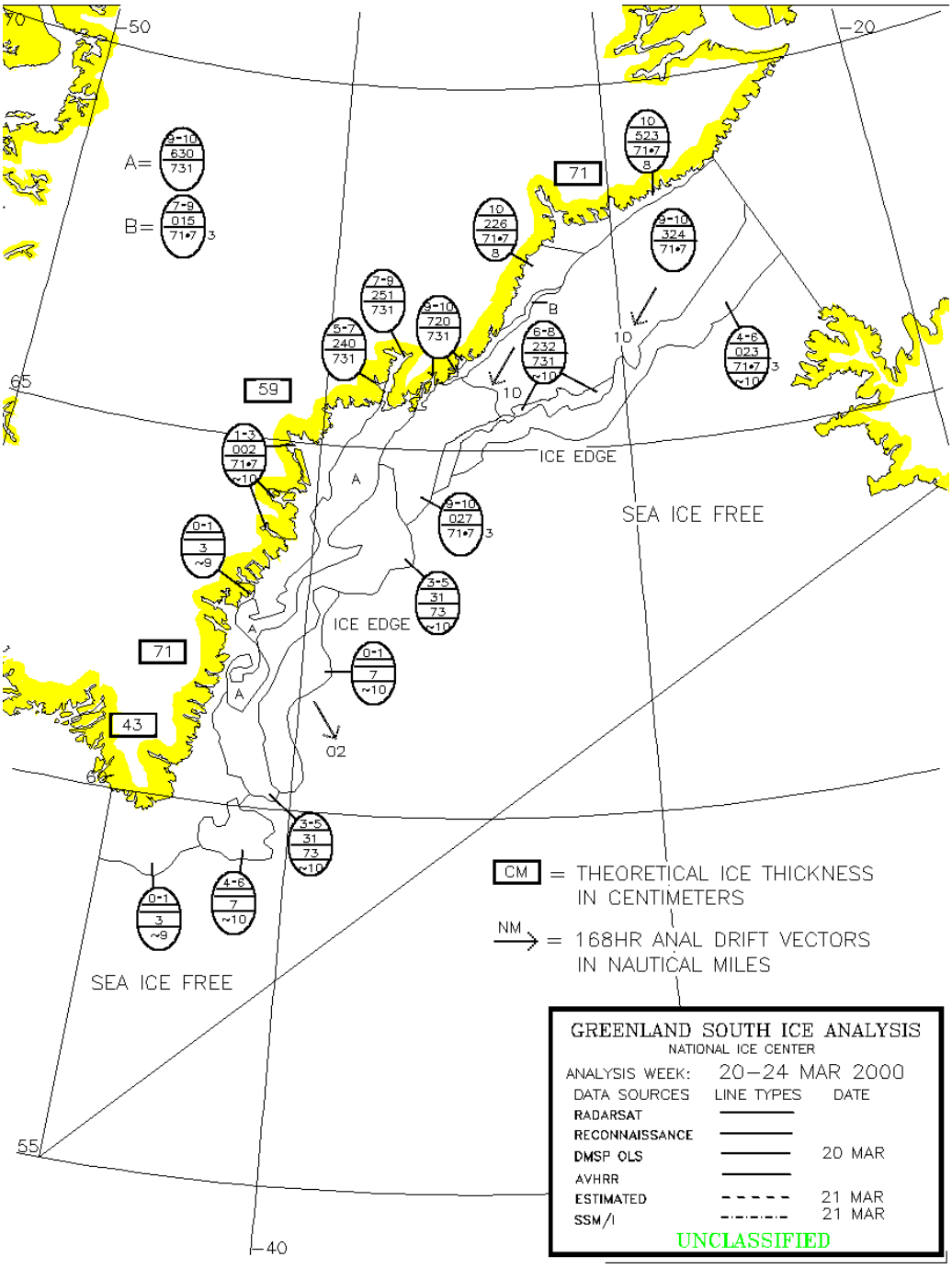

Fig. 9. Ice cover and ice edge during 20-24 March 2000 (Greenland South).

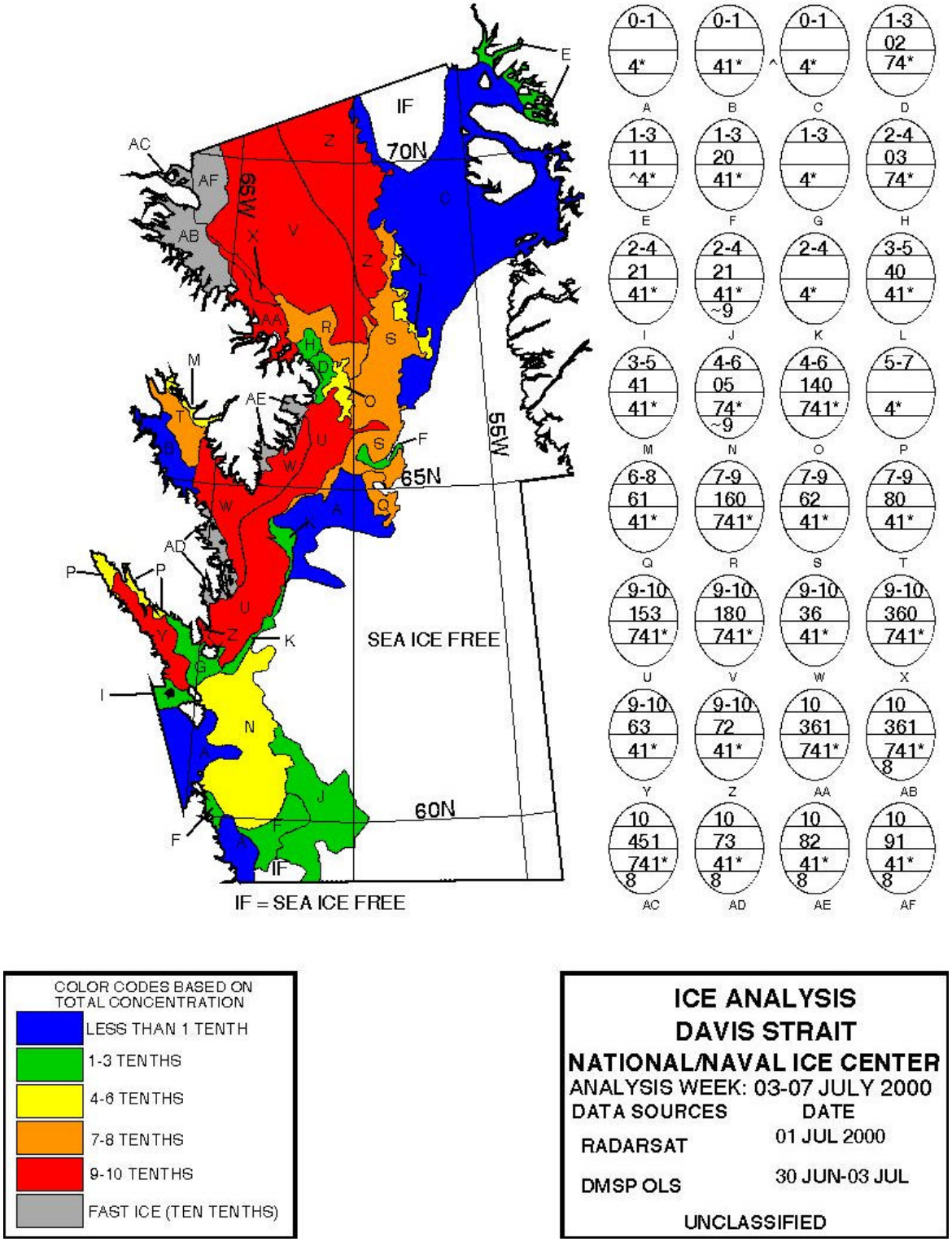

Fig. 10. Ice cover and ice edge during 03-07 July 2000 (Davis Strait).

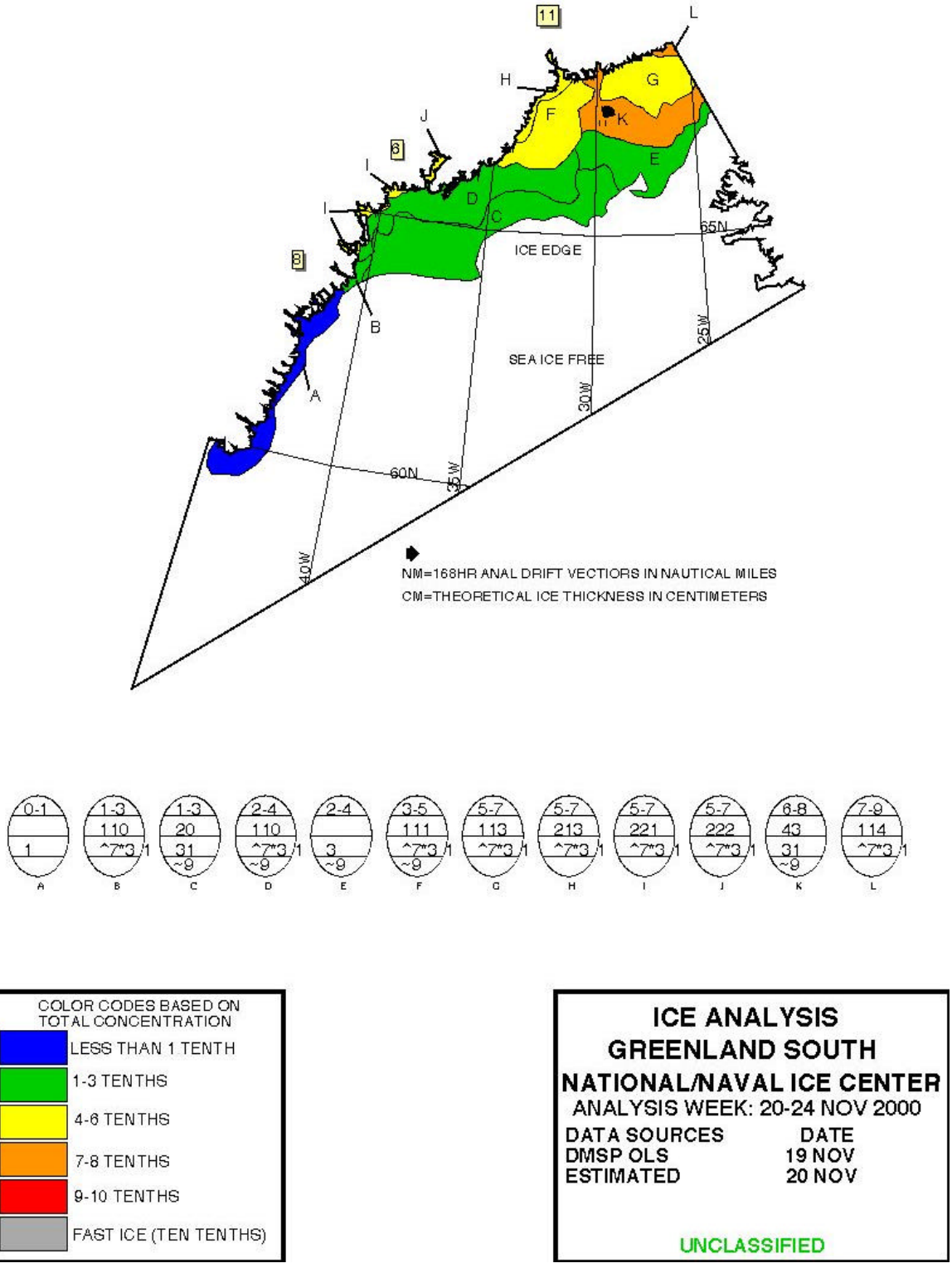

Fig. 11. Ice cover and ice edge during 20-24 November 2000 (Greenland South).

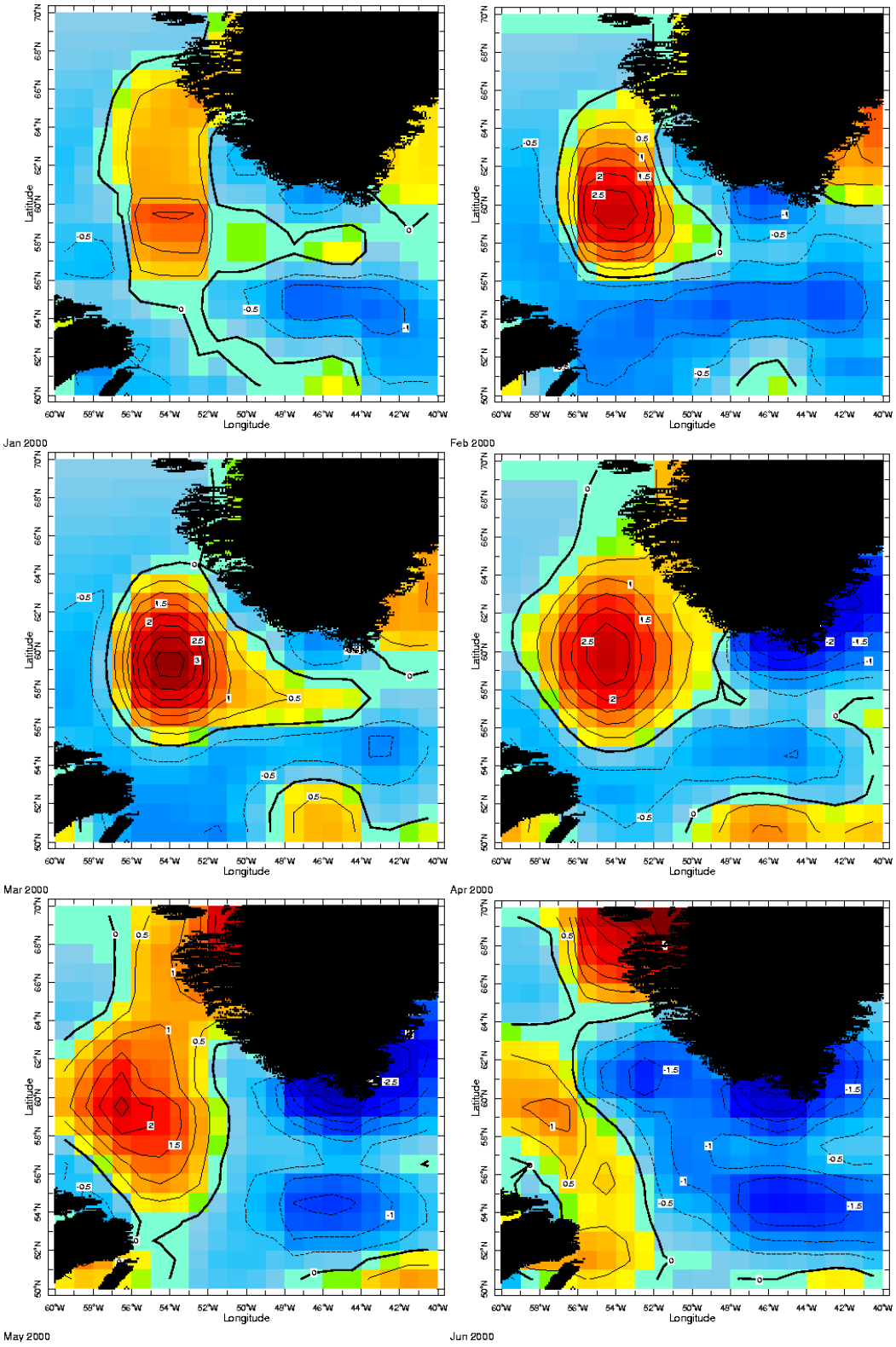

Fig. 12. Sea-surface Temperature Anomalies during January-June 2000.

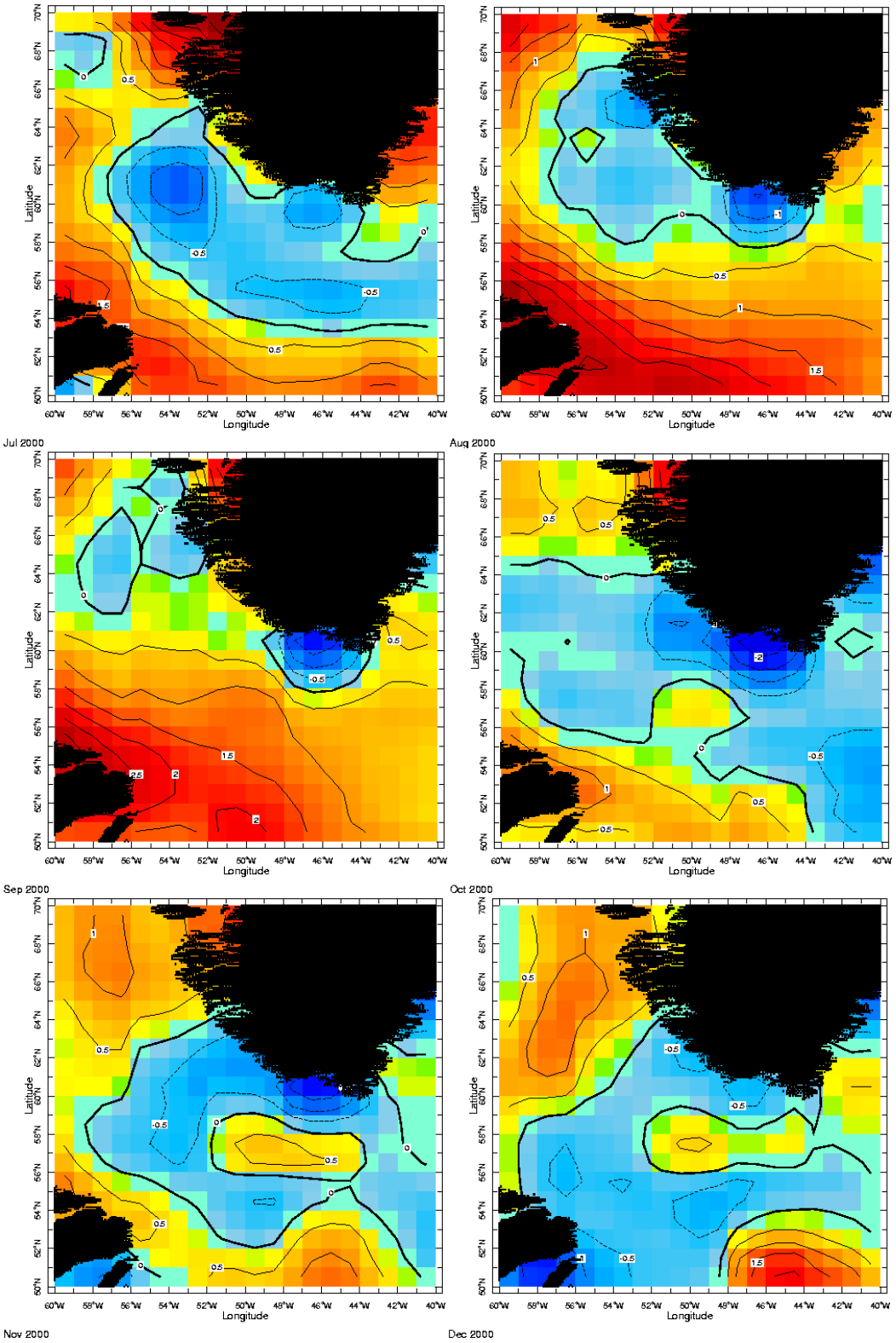

Fig. 13. Sea-surface Temperature Anomalies during July-December 2000.

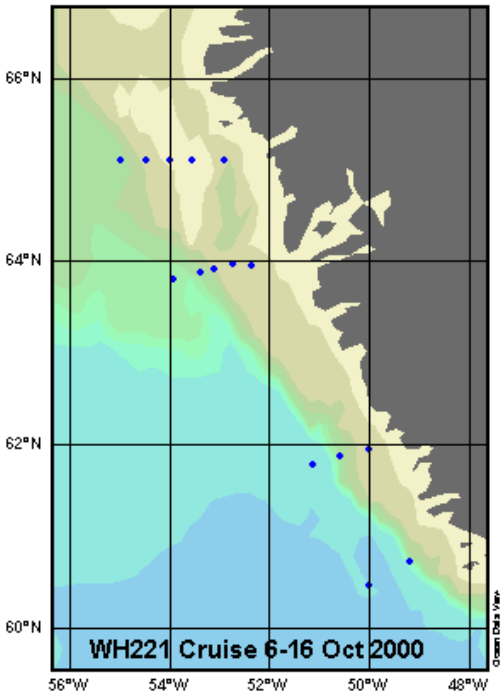

Fig. 14. Positions of sampled NAFO Standard Stations and Sections (6-16 October 2000).

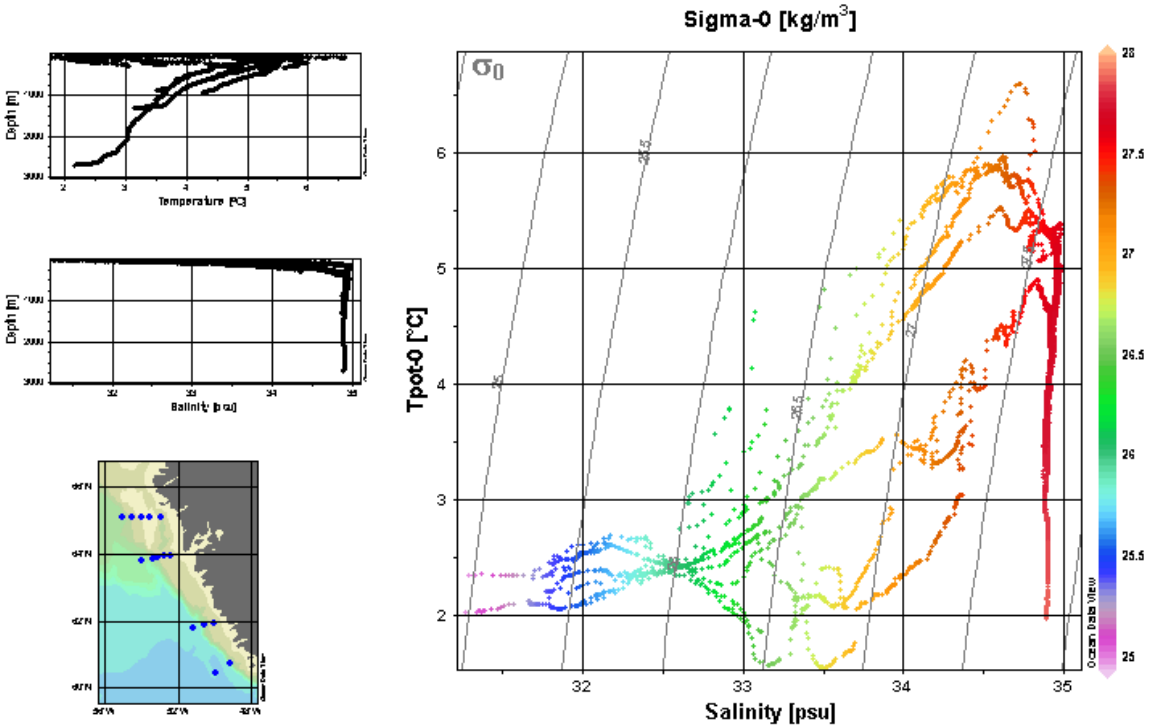

Fig. 15. Theta/S diagram of station profiles indicated in Fig. 14.

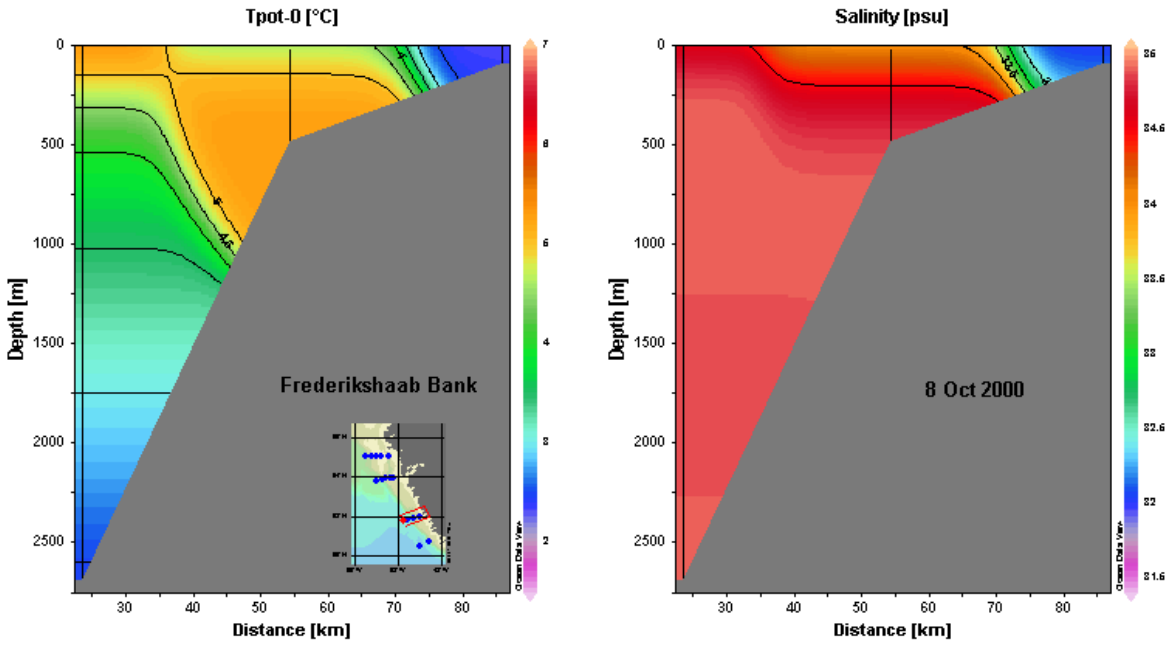

Fig. 16. Potential temperature and salinity along Frederikshaab Bank Section (8 October 2000).

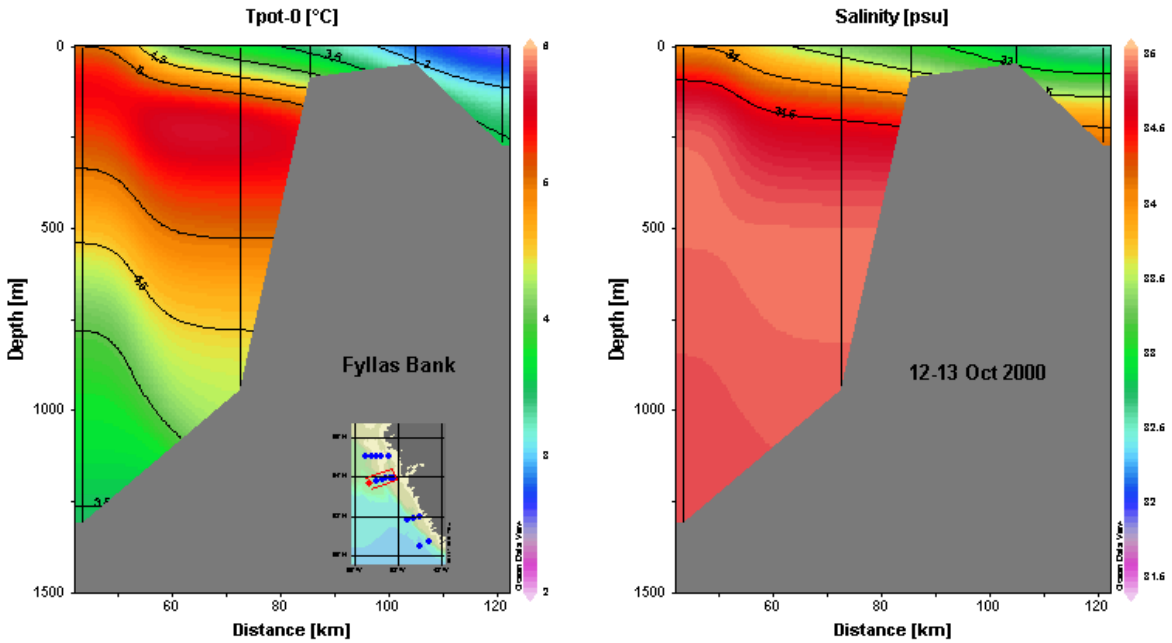

Fig. 17. Potential temperature and salinity along Fylla Bank Section (12-13 October 2000).

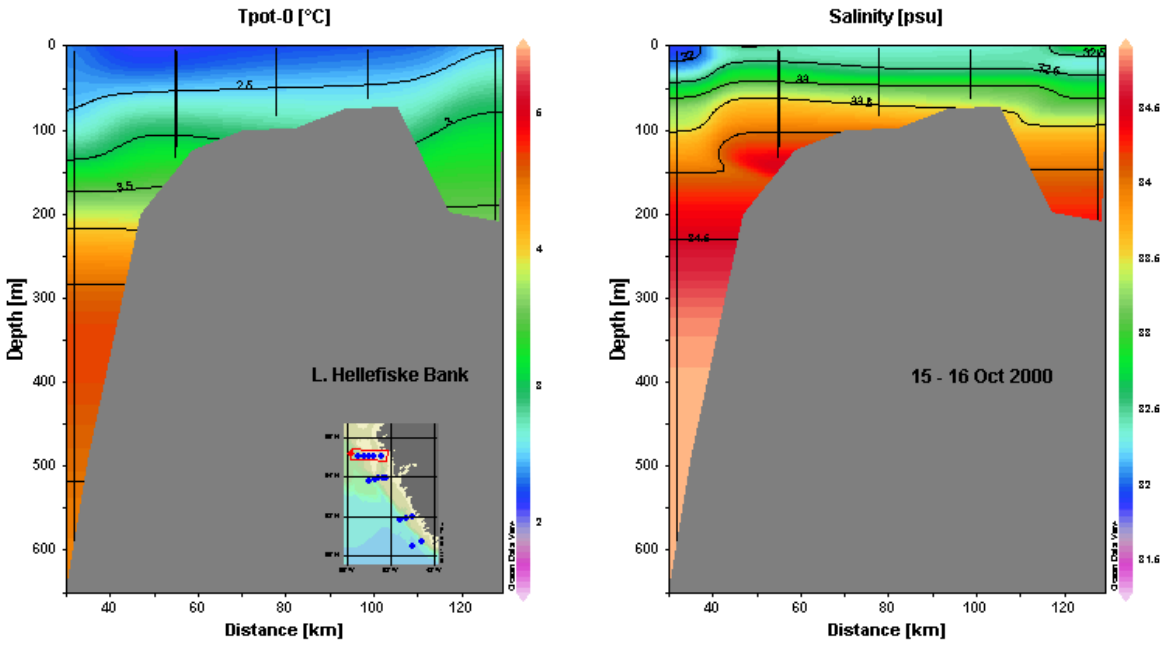

Fig. 18. Potential temperature and salinity along L. Hellefiske Bank Section (15-16 October 2000).

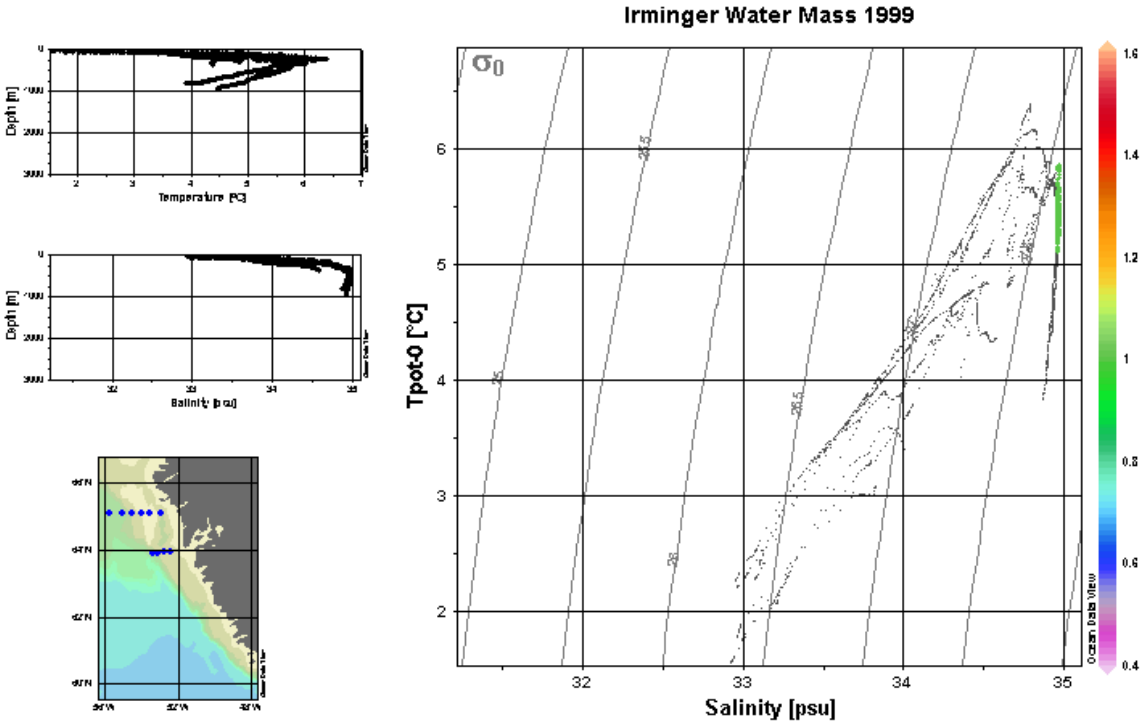

Fig. 19. Theta/S diagram with patch of Irminger Water mass (green area: 4°C < Theta < 6°C, 34.95 < S < 35.1) for 1999 autumn.

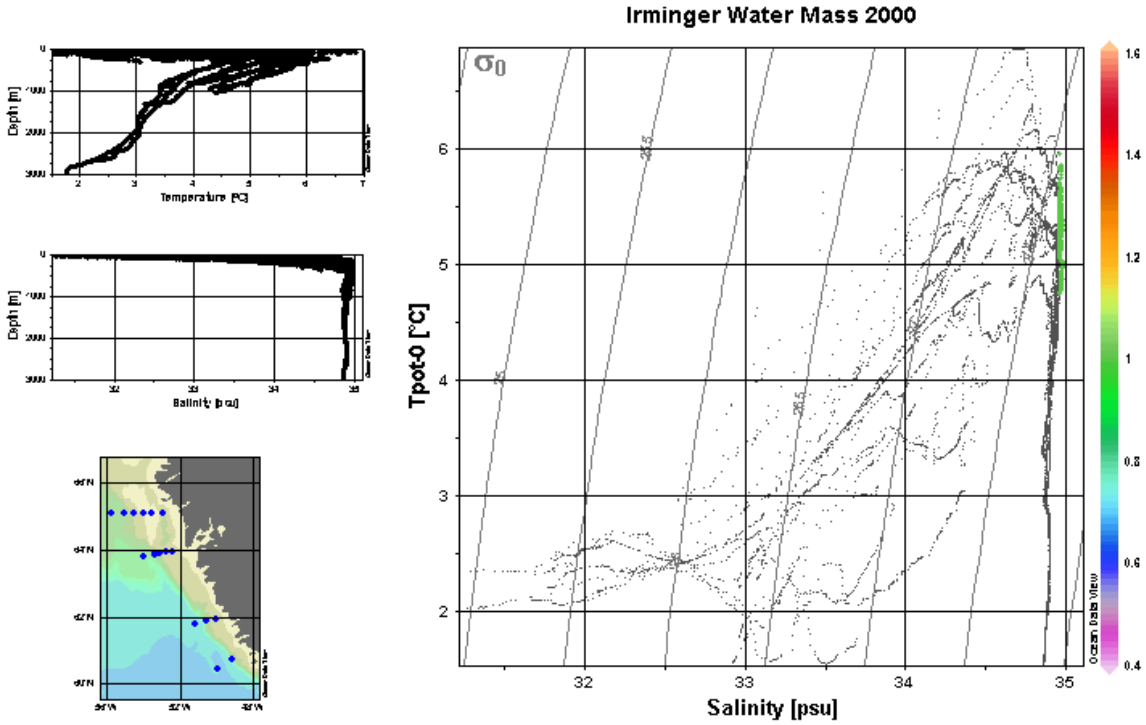

Fig. 20. Theta/S diagram with patch of Irminger Water mass (green area: 4°C < Theta < 6°C, 34.95 < S < 35.1) for 2000 autumn.

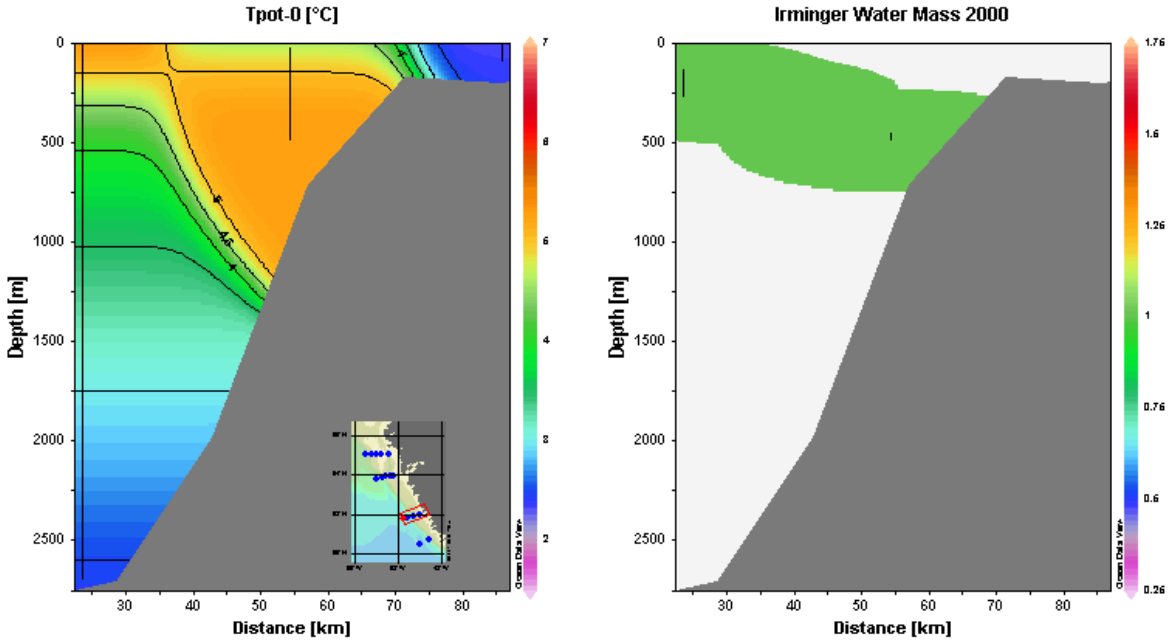

Fig. 21. Potential temperature and Irminger Water mass along Frederikshaab Bank Section (8 October 2000).

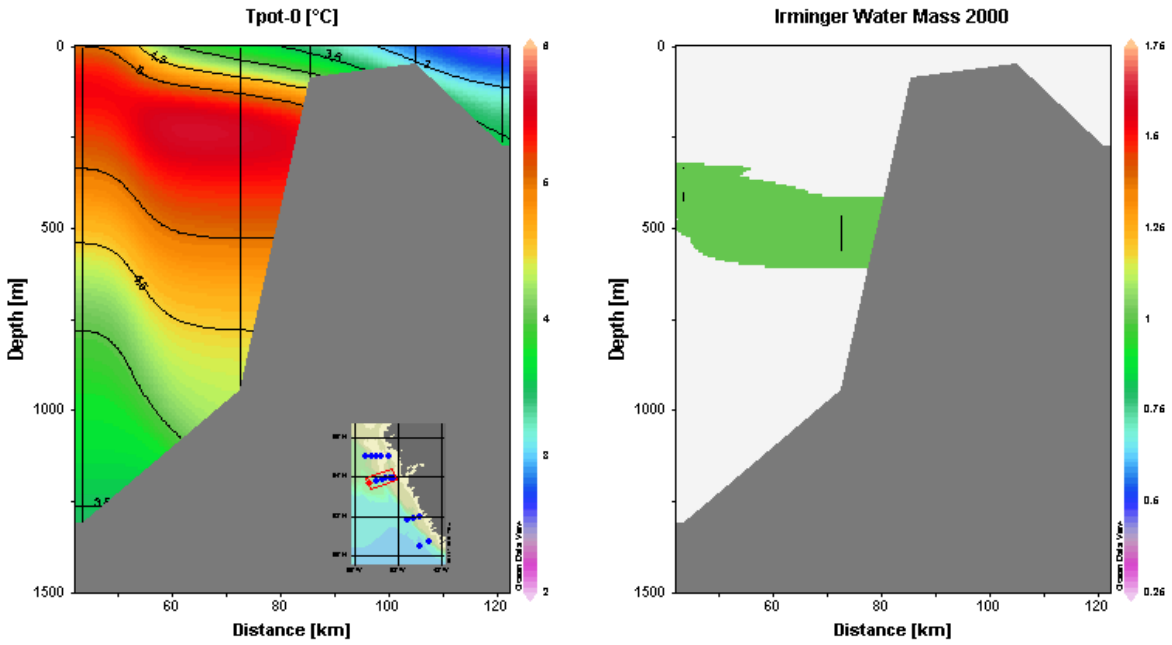

Fig. 22. Potential temperature and Irminger Water mass along Fyllas Bank Section (12-13 October 2000).

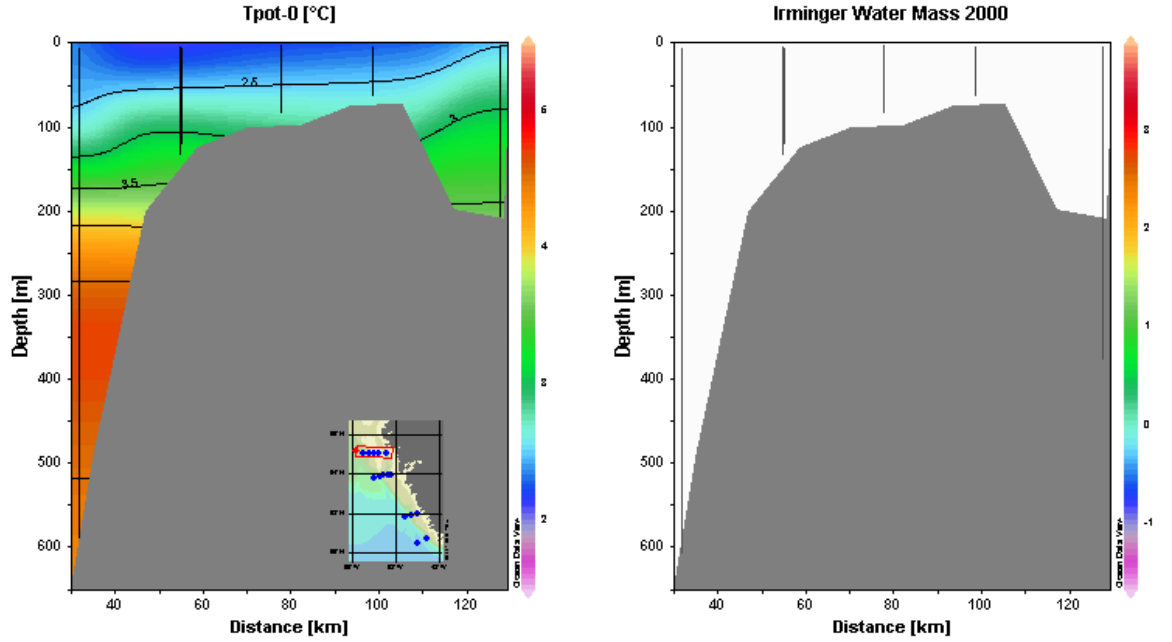

Fig. 23. Potential temperature and Irminger Water mass along Lille Hellefiske Bank Section (15-16 October 2000).

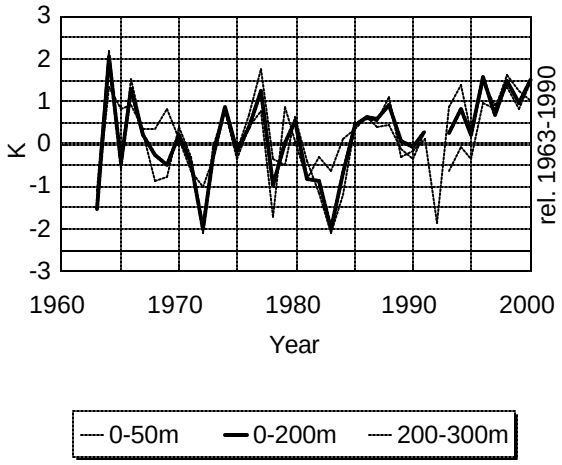

Fig. 24. Mean temperature anomalies of water layers at station 4 of the Fyllas Bank Section (0-50m: thin; 0-200 m: bold; 200-300 m: dashed).

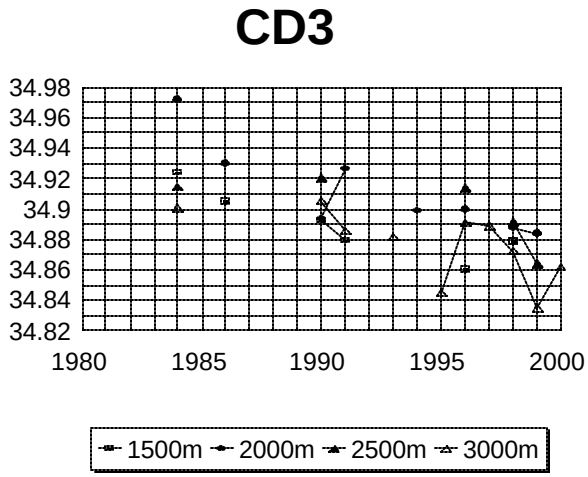

Fig. 25. Salinity of calibration samples at Cape Desolation Section station 3 (60°28'N, 50° 00'W).

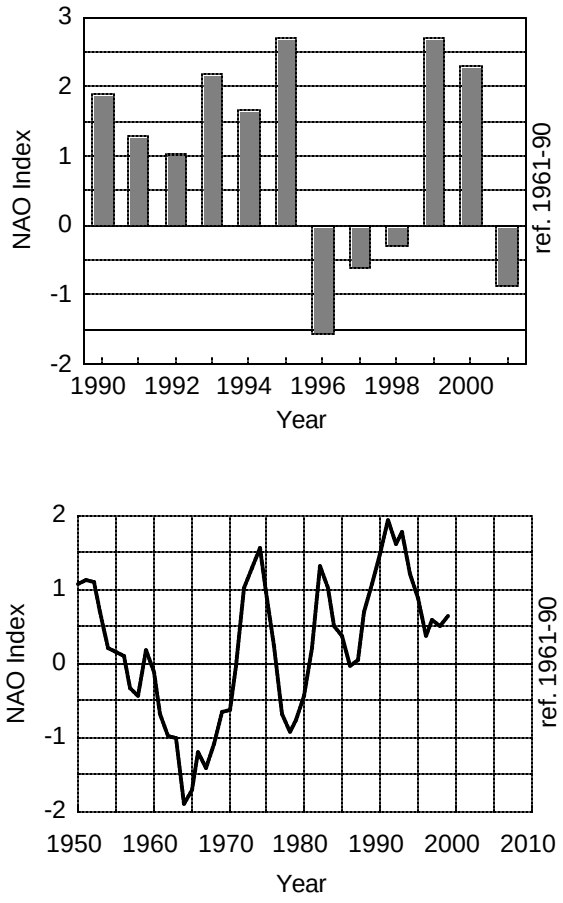

Fig. 26. The winter (DJF) NAO index in terms of the last and present decade (upper figure) and the second half of the last century (lower figure, a 5-year running mean has been applied).