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Oceanographic Investigations off Greenland 1998

by

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1. Abstract

The oceanographic conditions at the West Greenland standard sections were monitored during the period 24 June-8 July 1998.

Extraordinary warm conditions in the surface layer was observed – 1998 was one of the warmest years recorded within the recent 50 years.

A high inflow of warm high saline water originating from the North Atlantic Current was high in 1998.

2. Introduction

Extreme climatic conditions has been experienced at many localities all over the world in 1997 and 1998. Many of the extreme signals can be related to the strong El Nino event in 1997, which is clearly reflected as high positive temperature anomalies in the Pacific Ocean off Peru in South America, Fig. 1.

Figure 1 does reveal positive temperature anomalies in some parts of the North Atlantic especially in the Irminger Sea and the southern part of the Davis Strait. The Davis Strait observations confirms the measurements performed by the author on behalf the Greenland Institute of Natural Resources in late June 1997, which also showed temperature's slightly higher than normal as far north as the Frederikshaab Section (62^{o}N).

In 1998 the ocean surface temperature conditions were markedly different, Fig.2.

The El Nino signal in the Pacific Ocean has almost disappeared, while the positive temperature signal in the North Atlantic has strengthened especially in the Irminger Sea and Davis Strait.

The present report focuses on results from the oceanographic measurements performed in late June early July 1998 on the NAFO standard sections off West Greenland. These measurements reveal - as can be seen below - some of the highest temperatures in the surface layer ever recorded since the Greenland Fisheries Research Institute (now the Greenland Institute of Natural Resources) started regular oceanographic observations in the area in 1950.

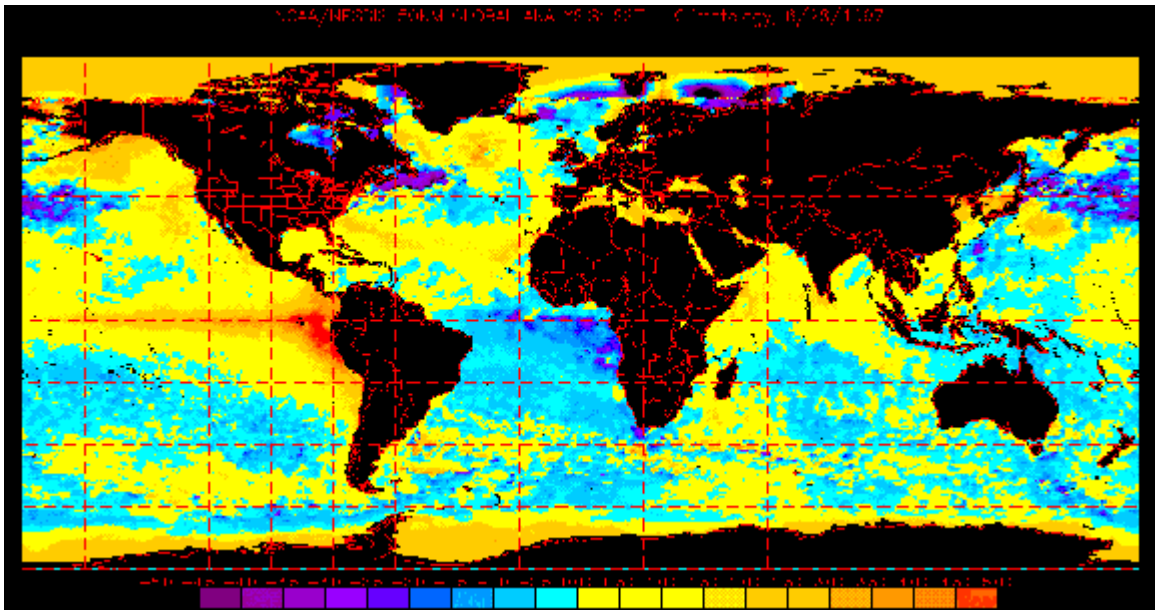


Fig. 1. Ocean surface temperature anomalies June 28, 1997 observed from satellite.

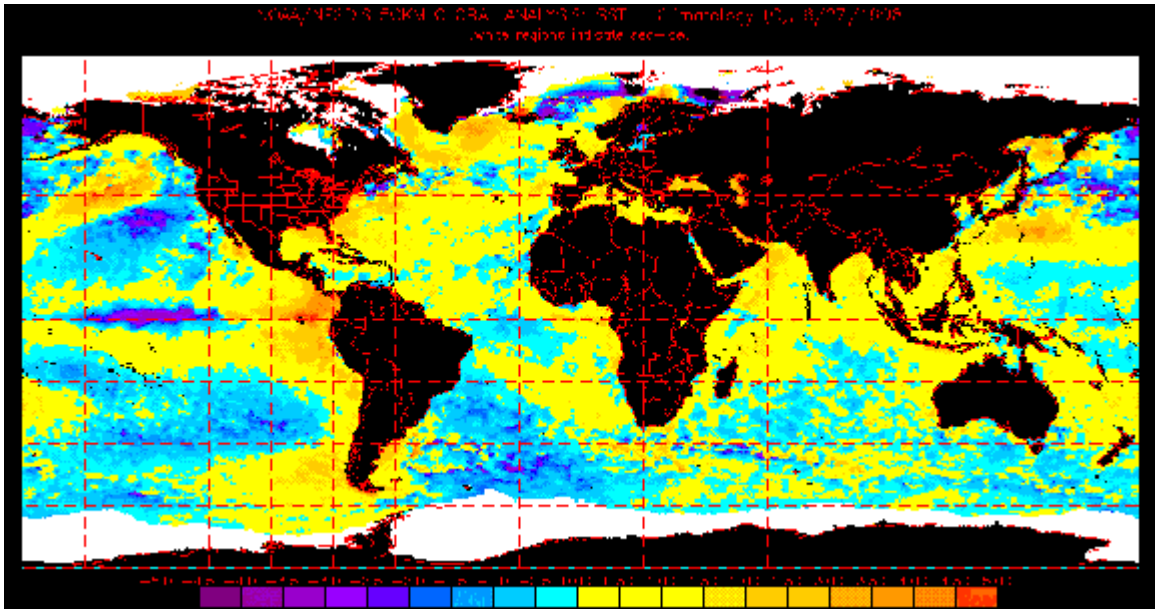


Fig.2. Ocean surface temperature anomalies June 27, 1998 observed from satellite

3. Measurements

The 1998 cruise was carried out according to the agreement between the Greenland Institute of Natural Resources and the Royal Danish Administration of Navigation and Hydrography during the period June 24 - July 8 onboard the Danish naval ship **"TULUGAQ".** Observations was performed on the following stations:

- Cape Farewell St. 2 - 5
- Cape Desolation St. 1 - 5
- Frederikshaab St. 1- 5
- Fylla Bank St. 1- 5
- Lille Hellefiske Bank St. 1 - 5
- Holsteinsborg St. 1 - 5

On each station the vertical distributions of temperature and salinity was measured from surface to bottom, except on stations with depths greater than 1000 m where 1000 m was the maximum depth of observation.

The cruise was blessed with favourable weather and ice conditions. “Vestice” was not present at the Holsteinsborg section and only at the innermost station at the Cape Farewell section “Storis” was observed in quantities preventing navigation to the station.

3. Data handling

Measurements of the vertical distribution of temperature and salinity was carried out using a SEABIRD SBE 9-01 CTD. For the purpose of calibration of the conductivity sensor of the CTD, water samples were taken at great depth on stations with depths greater than 500 m. The water samples were after the cruise analysed on a Guildline Portosal 8410 salinometer.

The CTD data were analysed using SEASOFT 4.217 software provided by SEABIRD.

All quality controlled data are stored in the Marine Database at the Royal Danish Administration of Navigation and Hydrography from where copies have been sent to ICES and MEDS.

4. Oceanographic conditions off West Greenland in 1998

The climatic conditions in the West Greenland area has after the cold period 1989 - 1994 been relative mild in 1996 - 1997 as can be seen in Fig. 3 showing the anomaly of the annual mean air temperature at NUUK for the period 1873 to 1997. The anomaly is taken relative to the mean temperature for the whole period. The conditions during the first ten months of 1998 are similar to those observed in 1996-97.

As discussed by Buch (1997) the air temperatures over Greenland are closely coupled to the strength of the North Atlantic Oscillation (NAO), which refers to a meridional oscillation in the atmospheric mass with centres of action near the Iceland Low and the Azores High (van Loon and Rogers, 1978). A high NAO index will therefore result in cold conditions in the Greenland area, while a low NAO index value means relatively mild climatic conditions.

The NAO index has been high since 1980, the values observed in 1983, 1989 and in 1990 being the highest recorded since 1863, and these years were some of the coldest ever experienced in Greenland. In 1996, however, the NAO index shifted from high to low values and a milder climate are now present in the Greenland region.

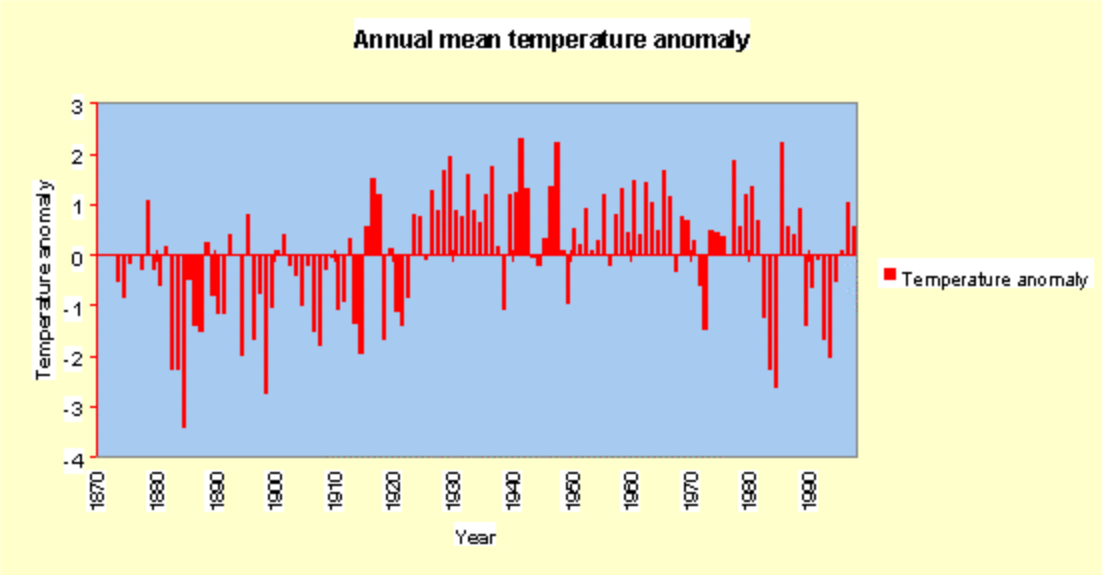


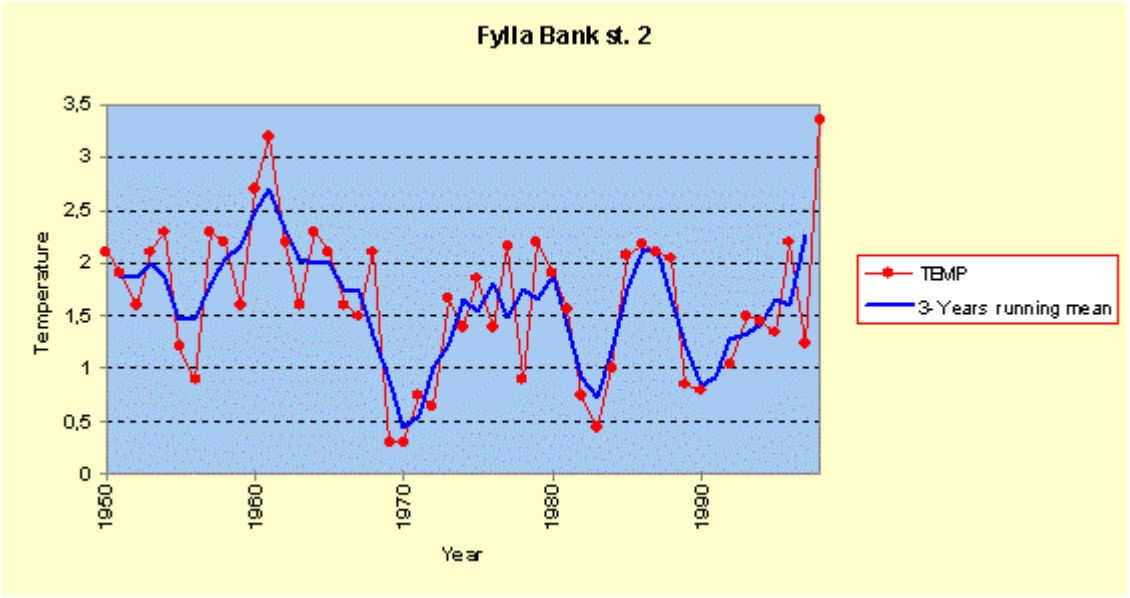
Fig. 3. *Anomaly in the annual mean air temperature observed at NUUK for the period 1873 to 1997. The anomaly is taken relative to the mean temperature for the whole period*

The mean temperature and salinity on top of Fylla Bank in the middle of June, Fig. 4a, show that a remarkably low temperature was observed in 1997 although the atmospheric conditions were relatively warm, which could indicate a high inflow of Polar Water in 1997. Additionally relatively low salinity's were observed in 1996 and 1997 indicating that the inflow of Polar Water have been above normal in these years.

In 1998 the oceanographic conditions were markedly different. The 1998 value of the Fylla Bank medio June temperature is the highest in the time serie, the most recent value of similar size was observed in 1961. Additionally salinity observations show that the 1998 mean salinity value on top of Fylla Bank (Fig.4b) was slightly above normal.

The surface temperatures and salinity's observed during the 1998 cruise are shown in Figs. 5 and 6. The high temperature conditions are seen to occupy most of the area of investigation. Temperatures below 2^{o}C was observed only close to the coast at the in the southern part i.e. the area dominated by inflow of Polar Water and in the north-western part which is influenced by recent melting of westice. Water of Atlantic origin (T> 3^{o}C; S> 34.5 psu) are found at surface only at the outermost of the Cape Farewell section..

a)



b)

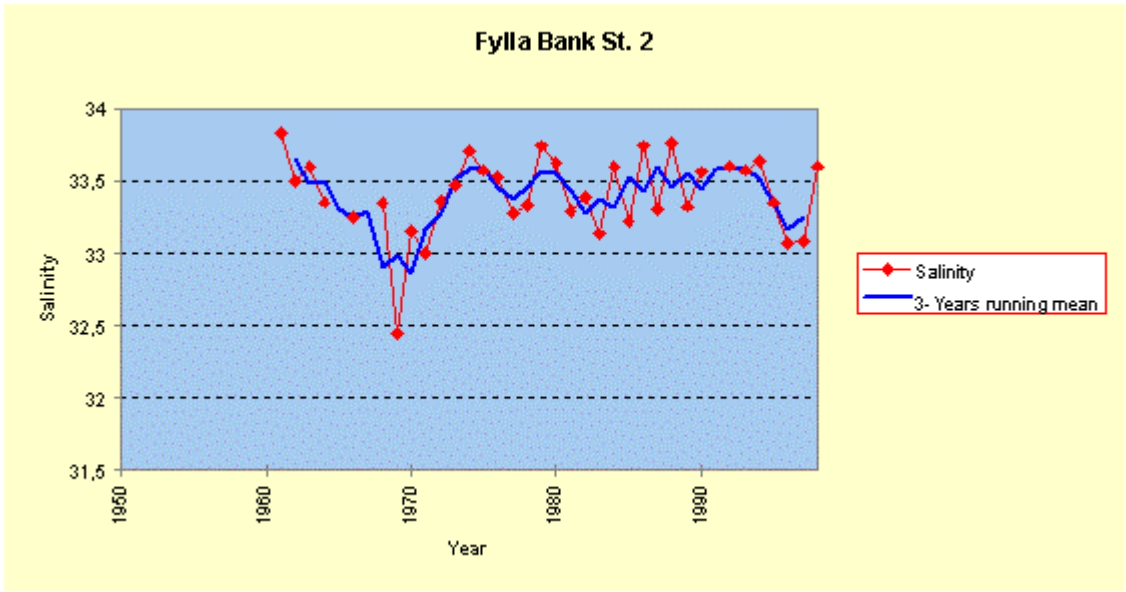


Fig. 4. *Time series of*

a) mean temperature (observations and 3 year running mean)

b) mean salinity (observations and 3 year running mean)

on top of Fylla Bank (0 - 40 m) in the middle of June

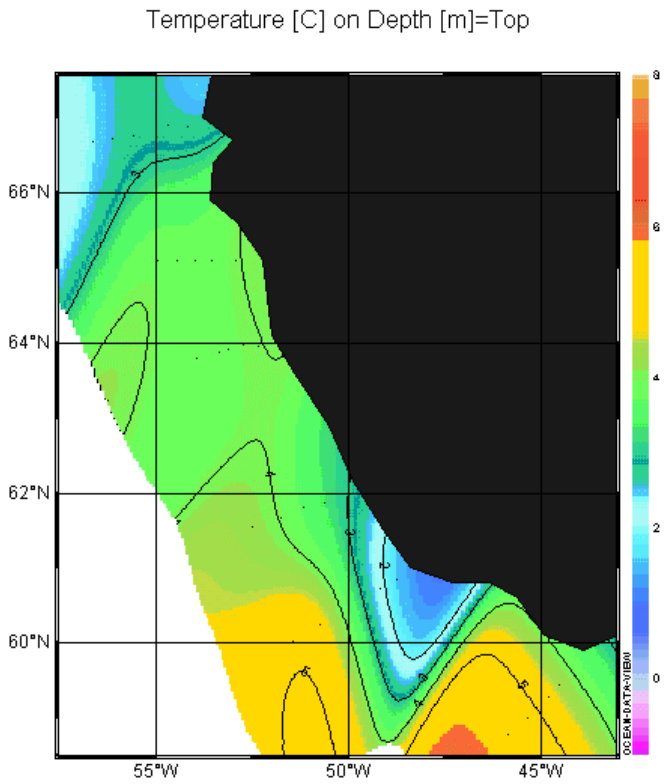


Fig. 5. *Surface temperature, June - July 1998*

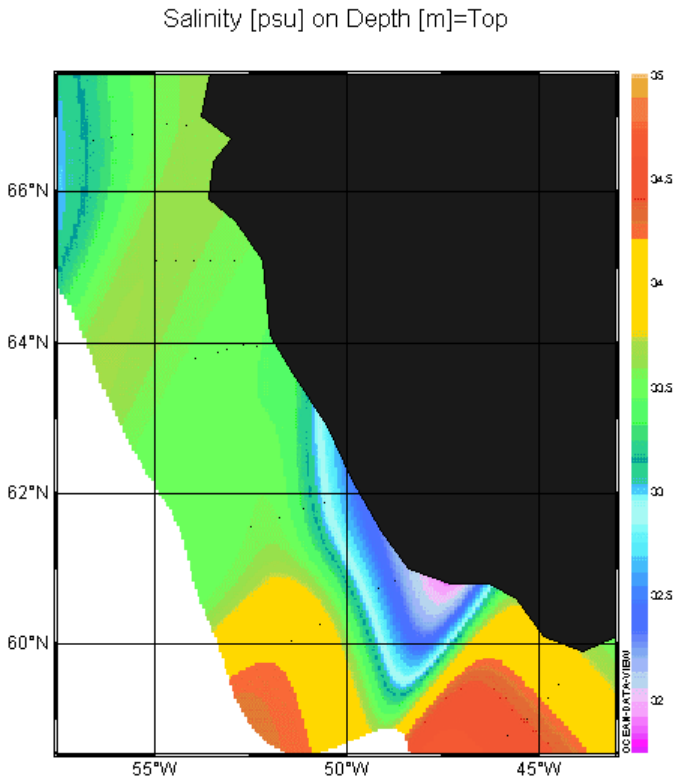


Fig. 6. *Surface salinity, June-July 1998*

The vertical distribution of temperature, salinity and density as well as TS-relations at the six observed sections is given in Figs. 7 - 12.

In the surface layer strong gradients between the cold, low-saline Polar Water and the warm, high-saline water of Atlantic origin is observed at the three southernmost sections. Further north the gradient is rather weak and the normally observed core of Polar Water just west of especially Fylla Bank at a depth of 50 - 150 m was absent in 1998.

Temperature and salinity observations at greater depth show that in 1998 an extremely high inflow of pure Irminger Water ($T \sim 4.5^{o}C$, $S > 34.95$ psu) took place. A tongue of Irminger Water was observed as far north as beyond the Frederikshaab section, and salinity values even above 35.0 psu was observed at the Cape Farewell and Frederikshaab sections. The center of the core of inflowing Irminger Water was found at around 200 m's depth at Cape Farewell increasing to 400 m at the Frederikshaab section. The TS-plots show that the Irminger Water ($S>34.95$) in 1998 had temperatures above $5^{o}C$ - at some locations even above $6^{o}C$ - meaning that the heat content of the Irminger Water was above normal, which can serve as an explanation to the high temperatures in the surface layer along the West Greenland coast in 1998.

Modified Irminger Water ($34.88 < S < 34.95$) reached as far north as just south of the Fylla Bank section and was present in great quantities at the three southernmost sections.

Sub-Atlantic water ($3.5 < T < 4.5$; $34.5 < S < 34.88$) was observed at all six sections in 1998.

References

BUCH, E. 1997. Oceanographic conditions in the West Greenland Waters 1981-1997. NAFO Ser. Doc. XXX

VAN LOON, H., and J. C. ROGERS. 1978. The The Seesaw in Winter Temperatures between Greenland and Northern Europe. Part 1: General Description. *Mon. Wea. Rev*., **106**: 296-310.

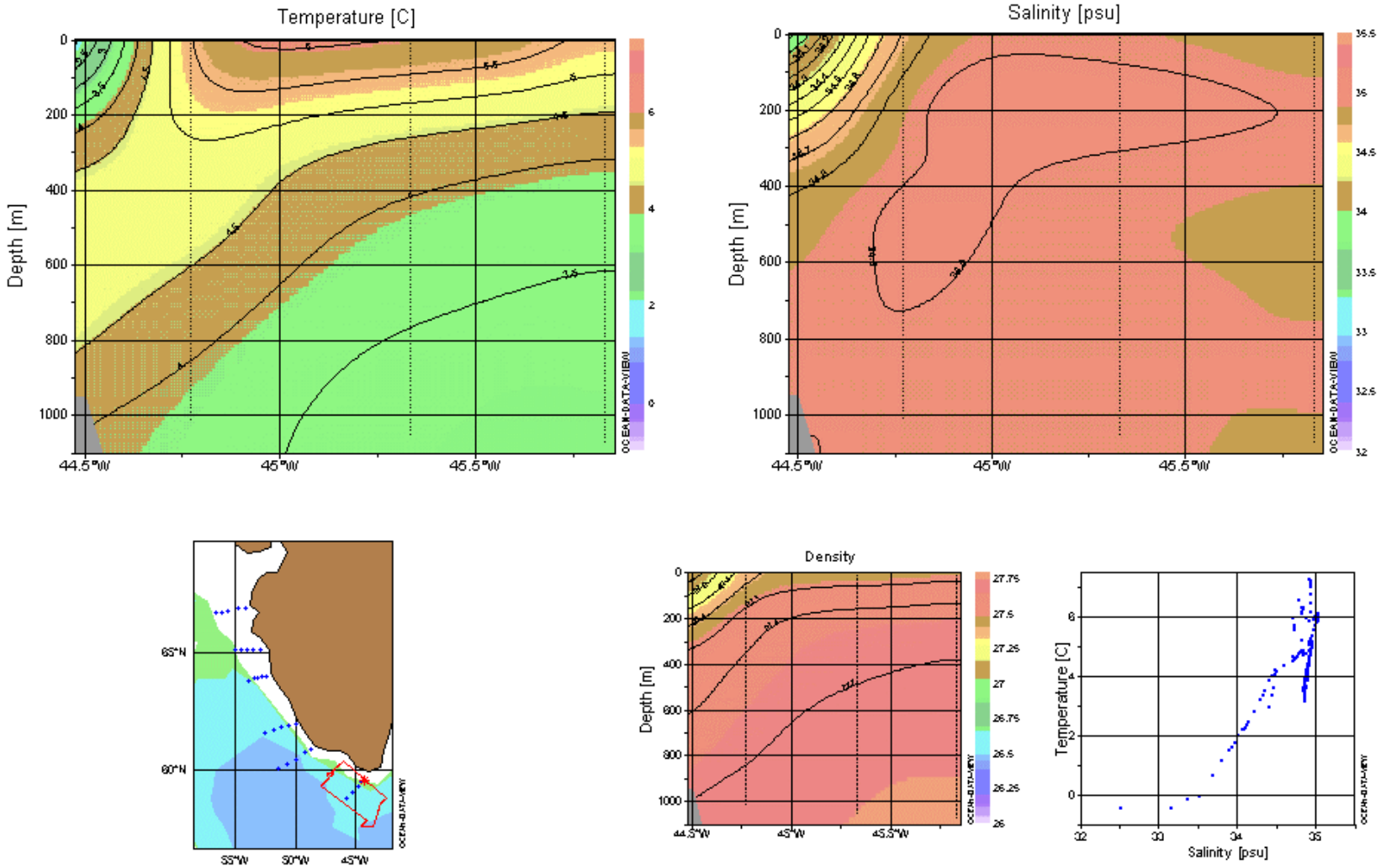


Fig. 7. *Vertical distribution of temperature, salinity and density at the Cape Farewell section, July 4, 1998*

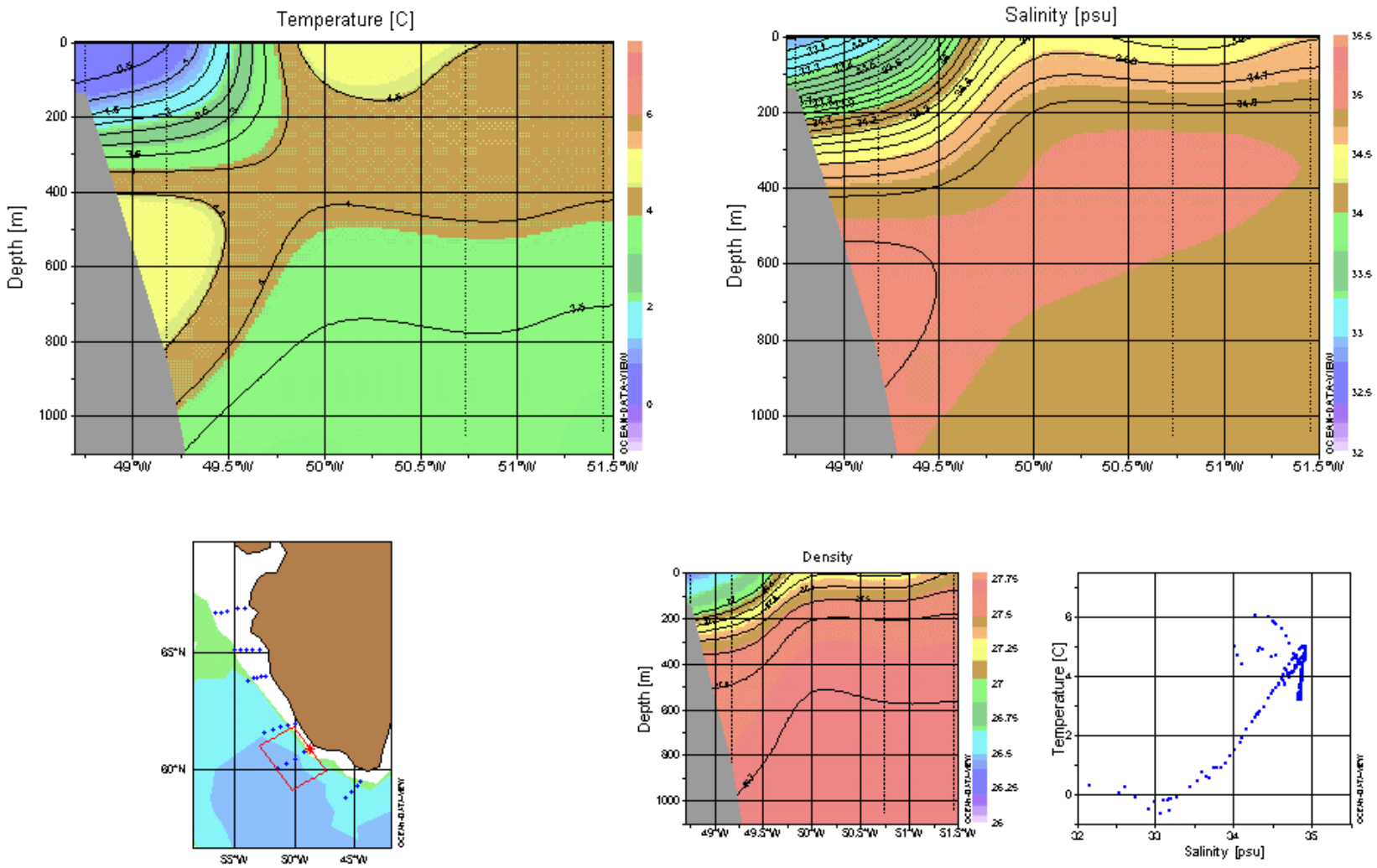


Fig. 8. *Vertical distribution of temperature, salinity and density at the Cape Desolation Section, June 30, 1998.*

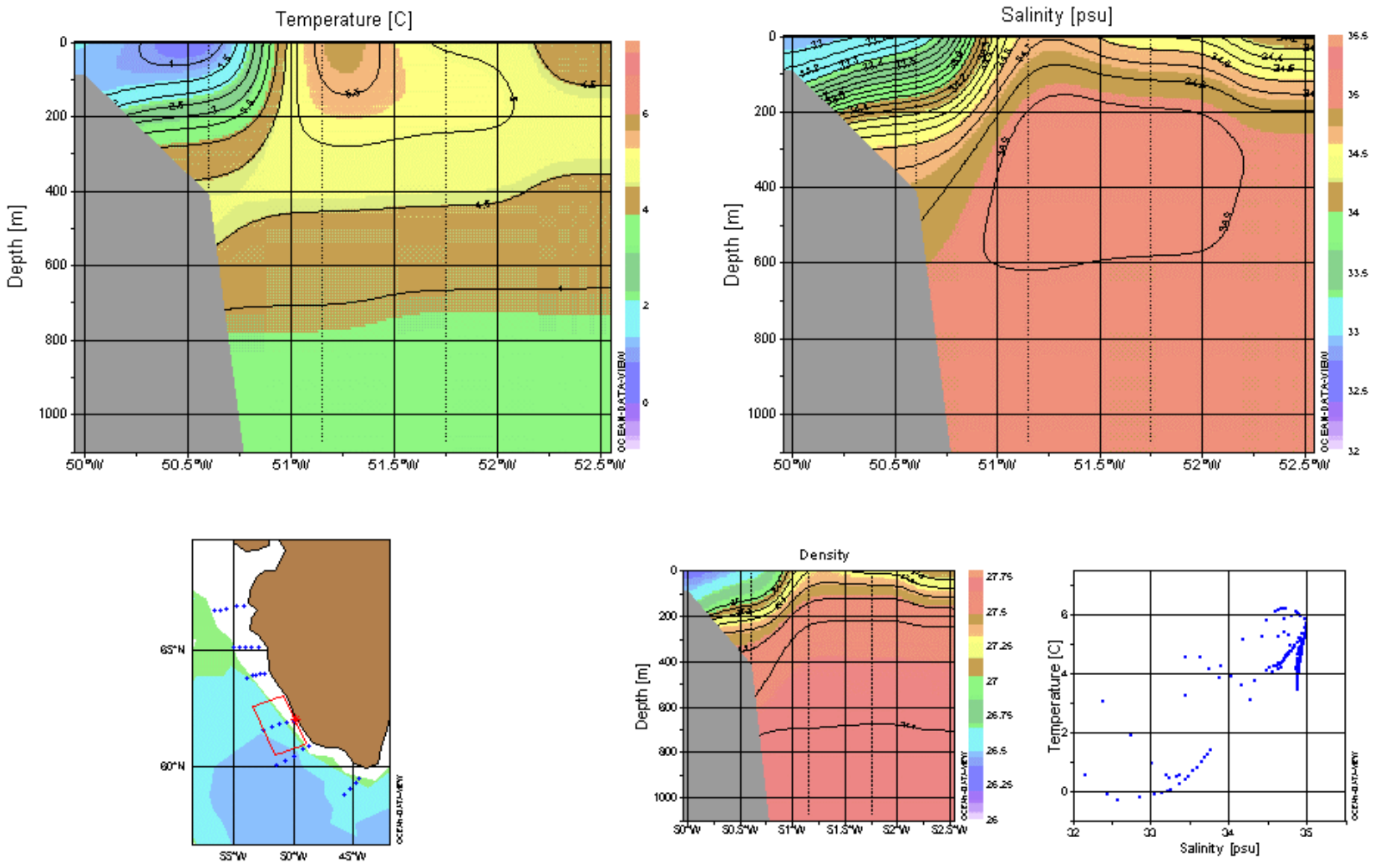


Fig. 9. *Vertical distribution of temperature, salinity and density at the Frederikshaab Section, June 29, 1998.*

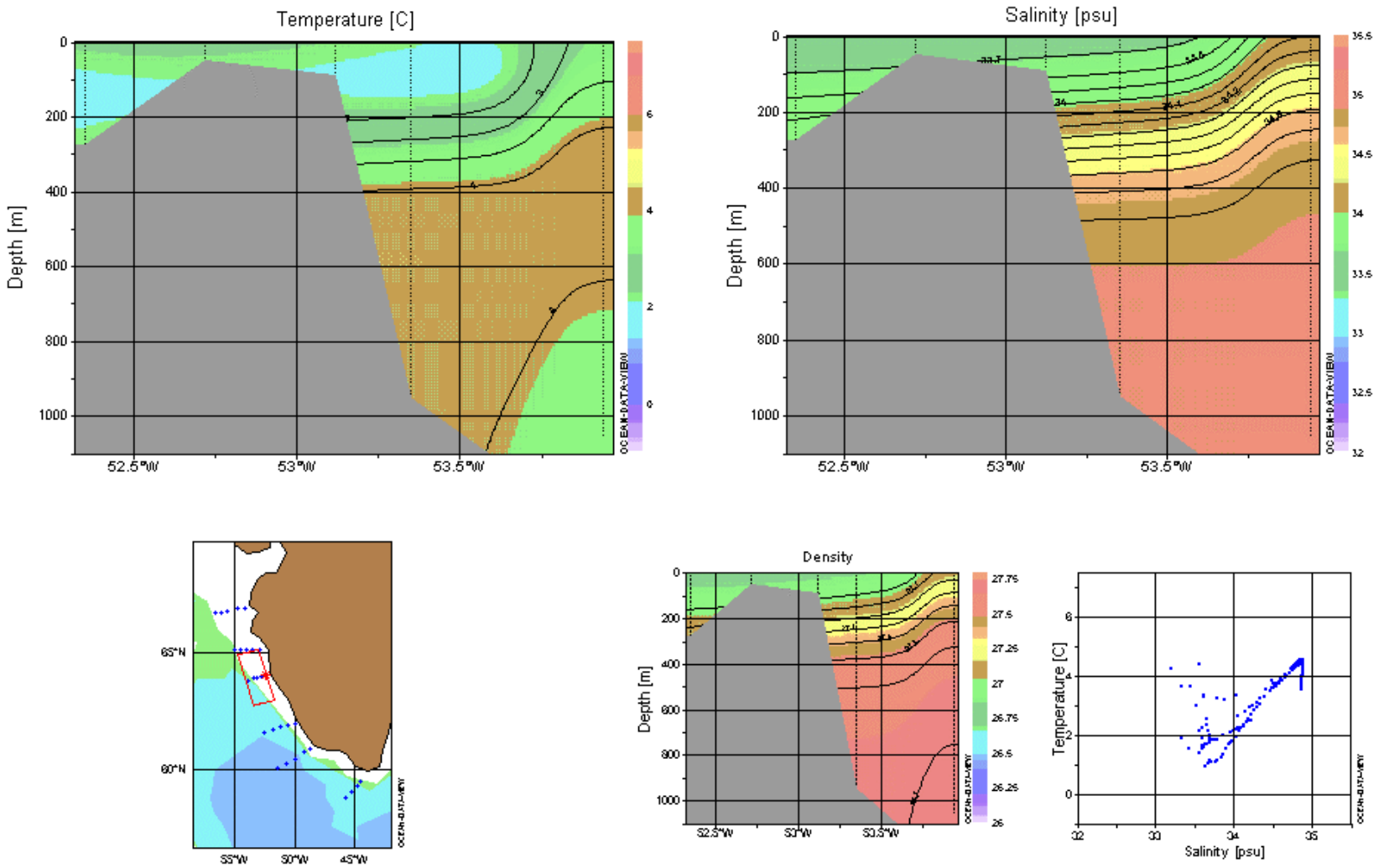


Fig. 10. *Vertical distribution of temperature, salinity and density at the Fylla Bank Section, June 26, 1998.*

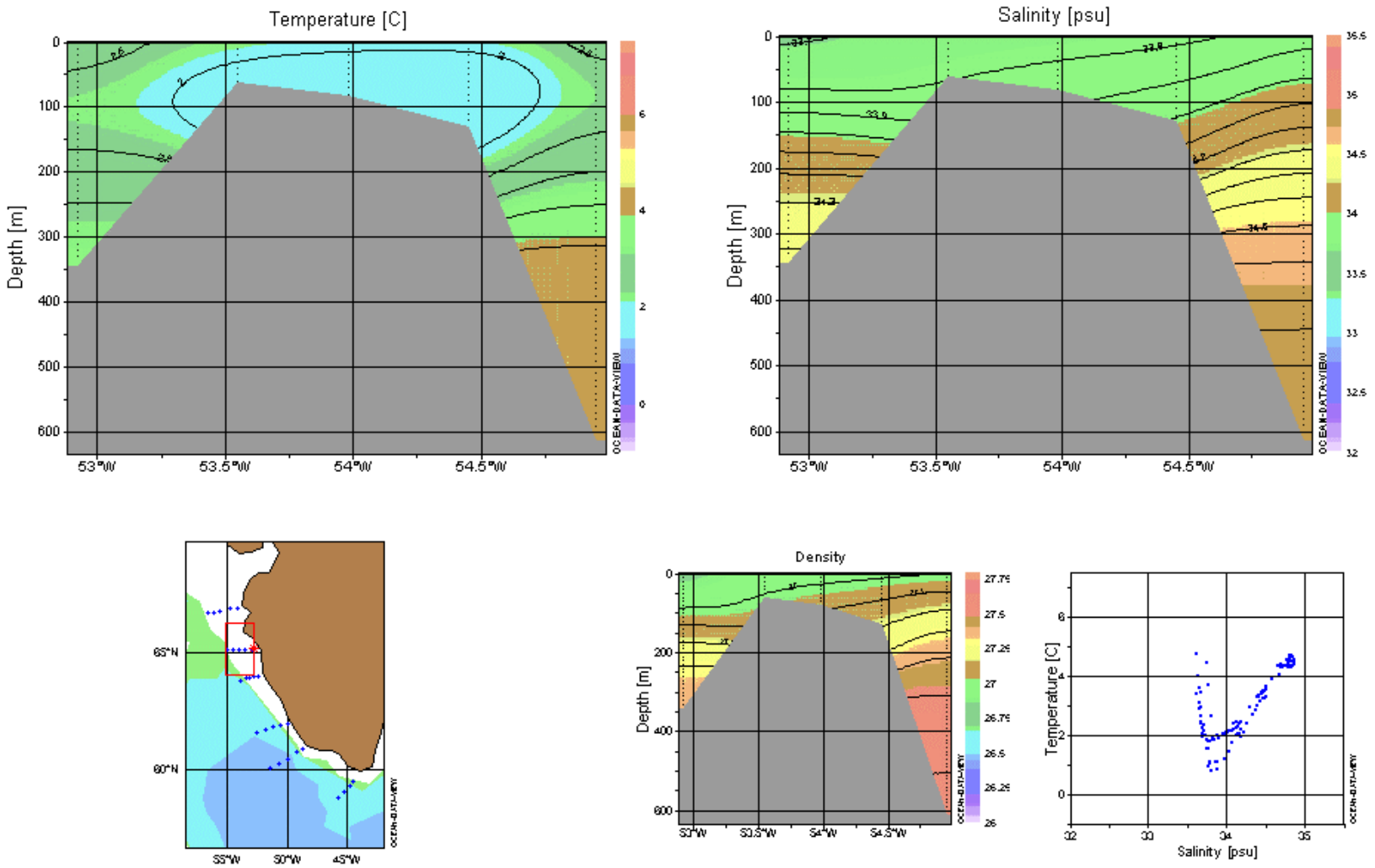


Fig. 11. *Vertical distribution of temperature, salinity and density at the Lille Hellefiske Bank Section, June 25, 1998.*

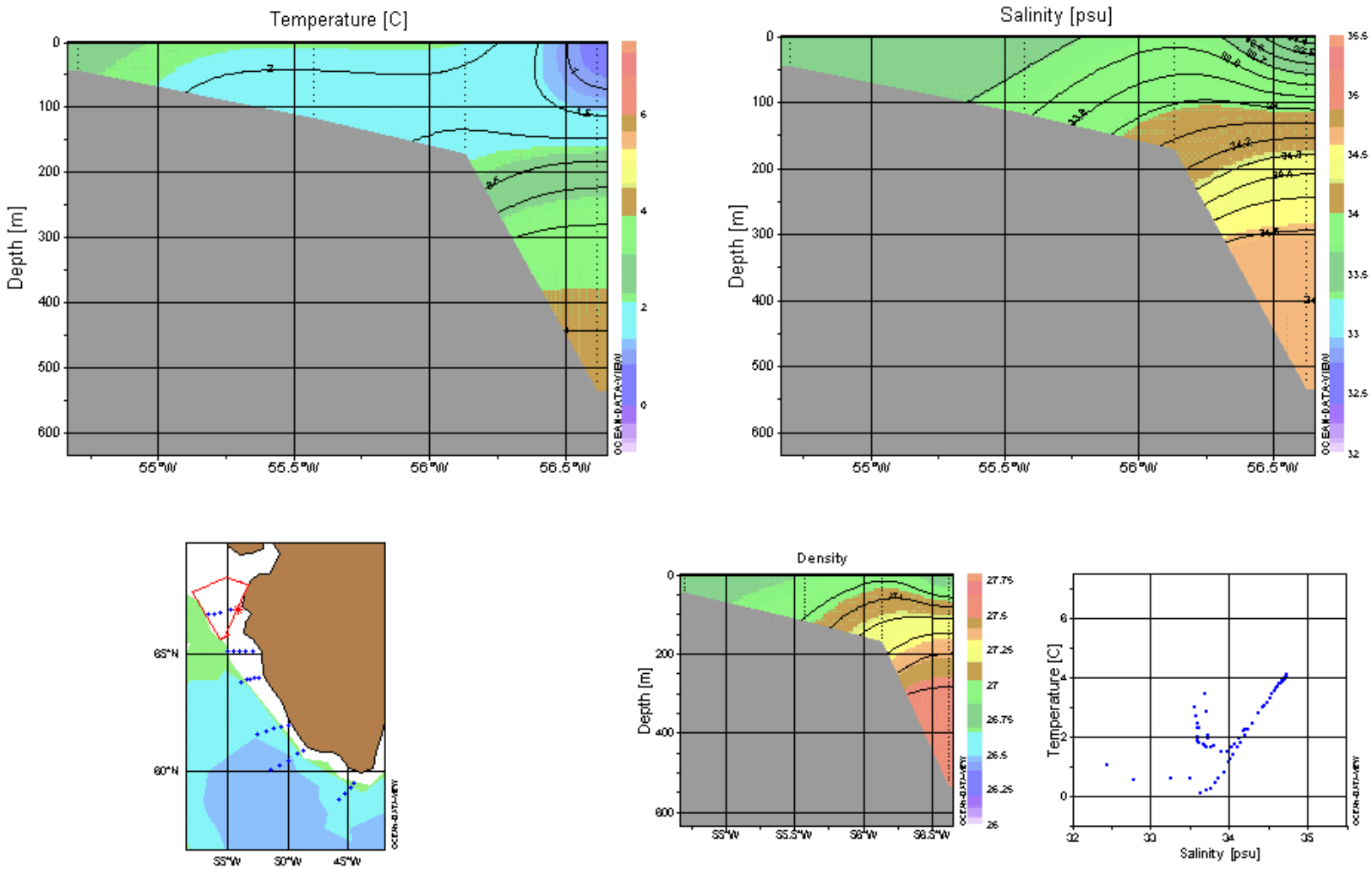


Fig. 12. *Vertical distribution of temperature, salinity and density at the Holsteinsborg Section, June 24 1998.*