Northwest Atlantic Fisheries Organization

Serial No. 1979 NAFO SCR Doc. 91/94

SCIENTIFIC COUNCIL MEETING - JUNE 1991

Thermohaline Variability of the West Greenland Current - How useful are Monitoring Stations ?

by

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Abstract

Time-series along deep-water standard oceanographic sections Cape Farewell, Cape Desolation and Frederikshaab are analyzed for changes in the water column. The sensitivity of a given NAFO Standard Oceanographic Station, to longer-term changes in the West Greenland Current system, seems to be highly dependent on the site of the station. Areas of steady flow, which show reduced horizontal interleaving might serve primarily as stations to monitor interannual changes in the thermohaline field.

Introduction

West Greenland waters obtain their heat input largely from solar radiation and from the Irminger component of the West Greenland Current system which is the northwestern branch of the North Atlantic Current (BUCH, 1982; STEIN and BUCH, 1985a; BUCH and STEIN, 1989; STEIN, 1991). Seasonal changes of heat transfer from atmosphere to ocean (ocean to atmosphere) and changes in the advective component of heat flow into West Greenland waters were considered by BUCH (1987) on a theoretical basis. Off Cape Farewell, the East Greenland Current component and the Irminger Current component which form the West Greenland Current system round the cape on their way to the north off West Greenland. Bottom topography guides the flow of water masses (STEIN and WEGNER, 1990).Very little is known on the internal structure of this current system, on horizontal and vertical scales. Assumptions are mostly made that the West Greenland Current is uniform in its lateral and vertical extension. Based on time-series of deep CTD-profiles at NAFO Standard Oceanographic Stations Cape Farewell 3, 4, Cape Desolation 3, 4, and Frederikshaab 3, 4 (STEIN, 1988), the present paper elucidates the structure of the thermohaline fields at these stations off southwestern Greenland during autumn.

The Data

The data were obtained during the annual autumn groundfish surveys to the area off West Greenland by RV"Walther Herwig" working along NAFO Standard Oceanographic Sections Cape Farewell, Cape Desolation and Frederikshaab (dots in fig. 1). All CTD-profiles were obtained with the same device, a regularly calibrated CTD of KIEL-Multisonde type. Water samples were taken by means of a Rosette water sampler at depth intervals of about 500m below 500m depth. Temperature readings were checked against reversing thermometers. Salinity was determined with a GUILDLINE-Autosal salinometer. The data set covers the years 1983 to 1990 with the exception of 1985, where the deep water sections were not performed. The original data sets cover the entire water column from the sea surface down to 5 m above the bottom. The temperature/salinity profiles were reduced to North Atlantic standard depth data. This data set was used to perform anomaly calculation with reference to the 1983 - 1990 mean. A software package (SURFER 4.0) was used to delineate negative and positive anomalies (Fig. 2 through 7). The contouring interval was choosen to 0.05 K for temperature and 0.05 PSU for salinity. For better reading the areas of positive anomaly are hatched. The horizontal scale denotes the time axis with 1983 being at the left side and 1990 at the right side of each panel. The vertical axis is given in pressure units. Due to strong gales only at Cape Farewell station 3 the 1984 measurements were not performed.

Results

Figure 1 displays the stations from the deepwater sections used in this analysis(dots). Anomaly of temperature and salinity off Cape Farewell is given in figs. 2a, b and 3a, b. After 1986 warming is observed at St. 4 of the Cape Farewell section which comprises about the upper 1000m of the water column (fig. 2a). Also the deep layers, 1500 dbar and 2000 dbar, indicate warming. Salinity at this stations reveals a similar trend, however, the majority of salinity increase is observed after 1987 (fig. 2b). Station 3 of the Cape Farewell section (fig. 3) indicates warming largely after 1986. Salinity increase takes place mainly after 1986 but the internal structure of this increase differs from the adjacing station. There are large portions of the water column which do not take part in the rising salinity trend (e.g. the pressure range around 200 and 300 dbar). Since there are no data available for 1985, the onset of positive thermohaline anomalies before 1986 is speculative.

Whereas the thermohaline anomalies at the previous section stations 3 and 4 indicate some coincidence as to the onset and duration of changes, the Cape Desolation stations 3 and 4 (figs. 4a, b, 5) reveal warming during the first half of the eighties and cooling from 1987 onwards which influences the water layers down to the 1500 dbar level. At deeper levels (2000, 2500) positive anomalies occur at both stations. This is consistent with the previous section for the 2000 dbar level. Salinity at station 3 (fig. 4b) behaves different to the thermal changes with negative anomaly mainly during 1987 and 1988, but there is indication for negative anomalous salinities in the subsurface layers from 1983 through 1986, and during 1989. Due to the lack of the temperature data for Cape Desolation station 4, only the salinity anomaly is displayed in this paper. The haline structure reveals increase of salinity largely between 1983 and 1987. During 1988 the layer 300-600 dbar was negative anomalous, whereas the following observations reveal decrease of salinity in the upper 1000m (1989), and in the upper 2000m (1990).

Frederikshaab section stations 3 and 4 (figs. 6, 7) indicate warming of the upper 1000m which began after 1984 (figs. 6a, 7a). Warming continues in this layer largely until 1990. There are, however, cooling periods imbedded which occured during 1987 (station 4), and a near-surface cooling which began 1988 at station 4, and during 1989 at station 3.

At station 4 salinity changes show some consistency with the thermal changes, with a dilution between 1983 and 1987, and positive anomalies for the upper 500m (1988) and most of the top 1200m for 1989 and 1990. The time-series of salinity anomaly at station 3 yields negative values for the 1984 through 1987 period. 1988 and 1989 are characterized by positive anomalies. In the top 500m the 1990 observations reveal diluton, whereas the deeper layers are positive anomalous.

Discussion

The present data show that anomalies in the thermohaline fields off Southwest Greenland vary on time and space scales. It would appear that at station 4 of the Cape Farewell section the inflow of the Irminger component to the area of West Greenland is rather uniform. Changes in both parameters are on largely the same time and depth scales (fig. 2). Nearer to the coast, station 3 of this section is washed frequently by the near-shore polar component of the West Greenland Current which is derived from the East Greenland Current. Cold, diluted intrusions of polar water were observed at this station during 1988. Layers of colder and less saline than normal water masses, interleaved with warmer and more saline than normal water layers seem to be characteristic for station 3.

On its way further to the northwest, the West Greenland Current leaves the continental slope off Cape Desolation (STEIN and WEGNER, 1990), and, as typical of boundary currents, the flow is likely to split up in meanders. Stations 3 and 4 of this section, being deeper than 3000 m (STEIN, 1988), reveal an anomaly scenario which quite differs from the initial signals as shown by the Irminger component off Cape Farewell. Near-surface cooling might reflect the existence of local cold and diluted water masses deriving from increased ice accumulation or from horizontal displacement of water mass boundaries (STEIN and WEGNER, 1990; STEIN and BUCH, 1985b; STEIN, 1989) (fig. 4). The reversal of time-scales for warming/cooling might be indicative for intense mixing with the polar component of the West Greenland Current.

Off Frederikshaab, station 4 outlines time and depth scales for negative/positive anomalies of the thermohaline field which ressemble the Cape Farewell station 4 scenario. At the near-shore station of this section, station 3, the time and space scales of changes are reduced as concerns the early eighties. At the end of the time-series, however, warming is not observed in this region. Also salinity shows a considerable decrease in the upper 500 m.

To conclude, the sensitivity of a given NAFO Standard Oceanographic Station, to longer-term changes in the West Greenland Current system, seems to be highly dependent of the site of the station. Areas of steady flow, such as the Cape Farewell station 4, which show reduced horizontal interleaving might serve primarily as stations to monitor interannual changes in the thermohaline field.

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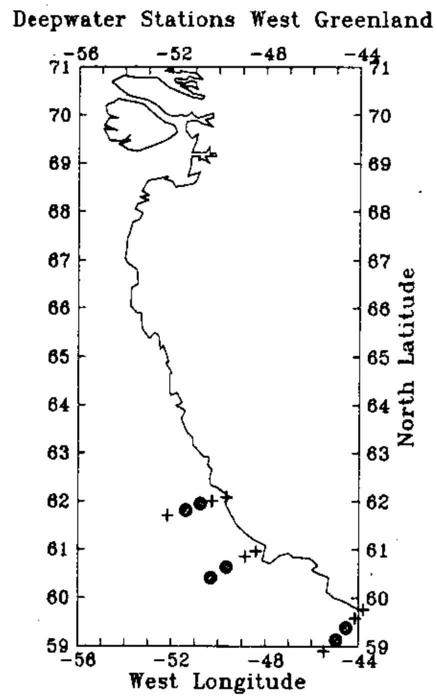
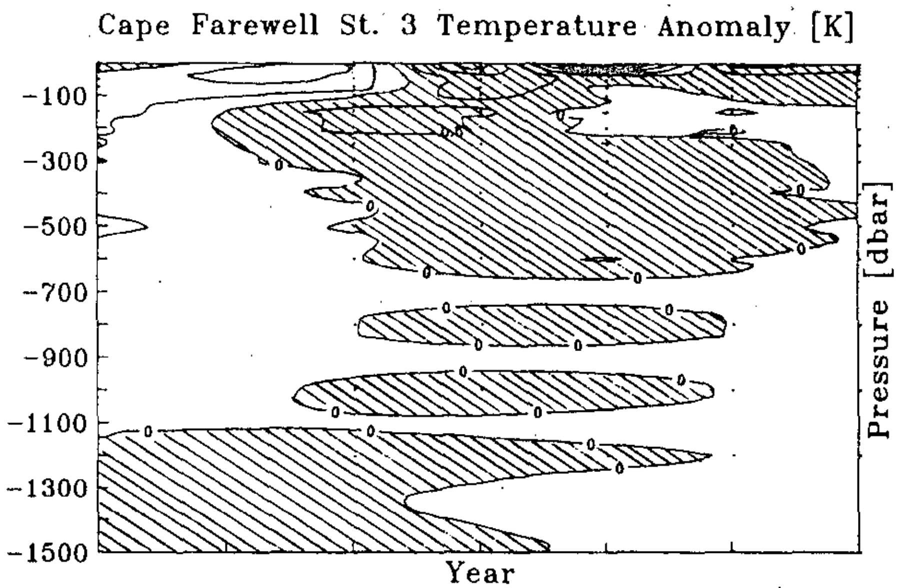


Fig. 1. Deepwater Stations West Greenland



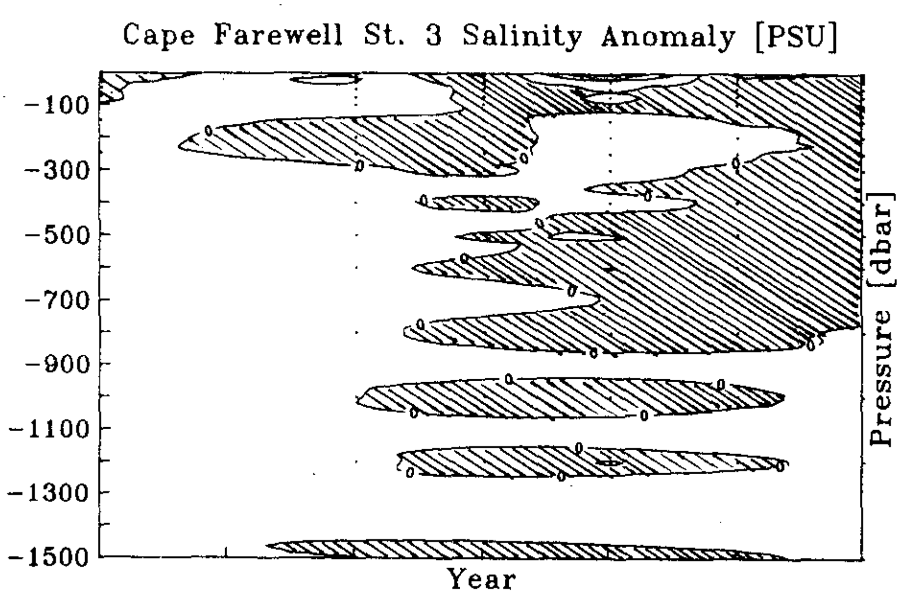


Fig. 2. Cape Farewell Station 3 Temperature (a) and Salinity (b) Anomaly.

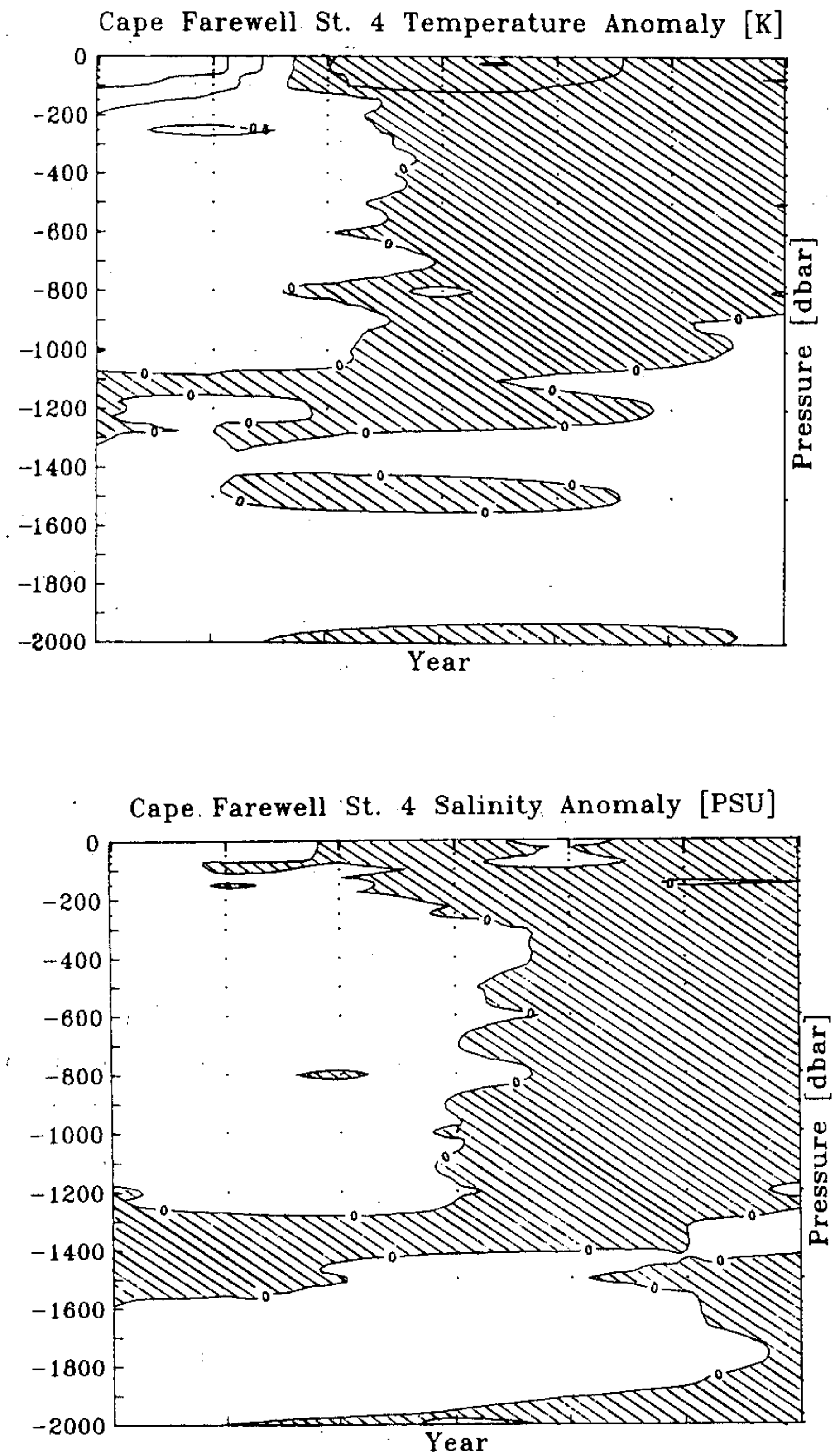
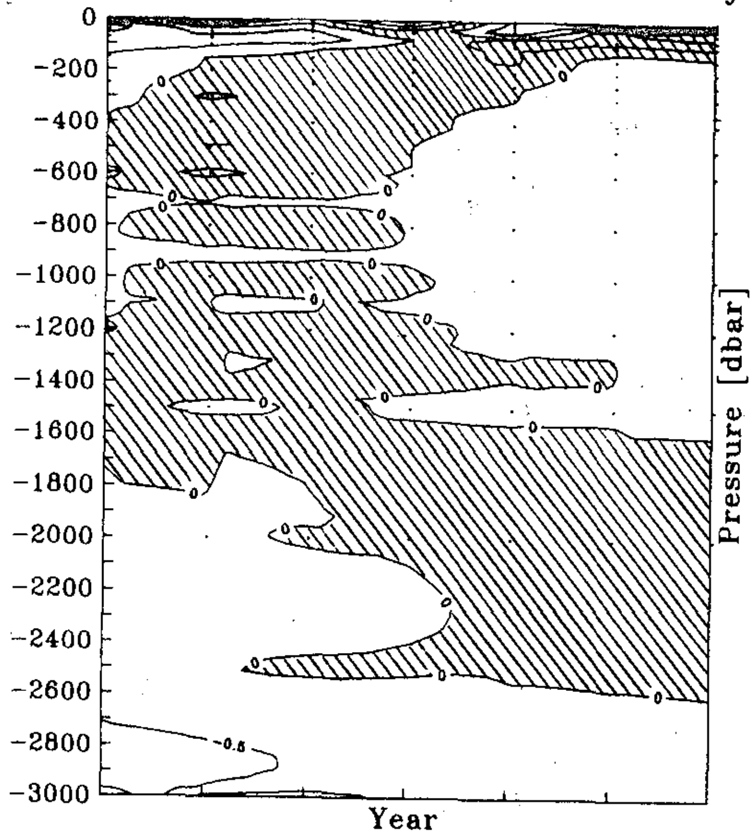


Fig. 3. Cape Farewell Station 4 Temperature (a) and Salinity (b) Anomaly.

Cape Desolation St. 3 Temperature Anomaly [K]



Cape Desolation St. 3 Salinity Anomaly [PSU]

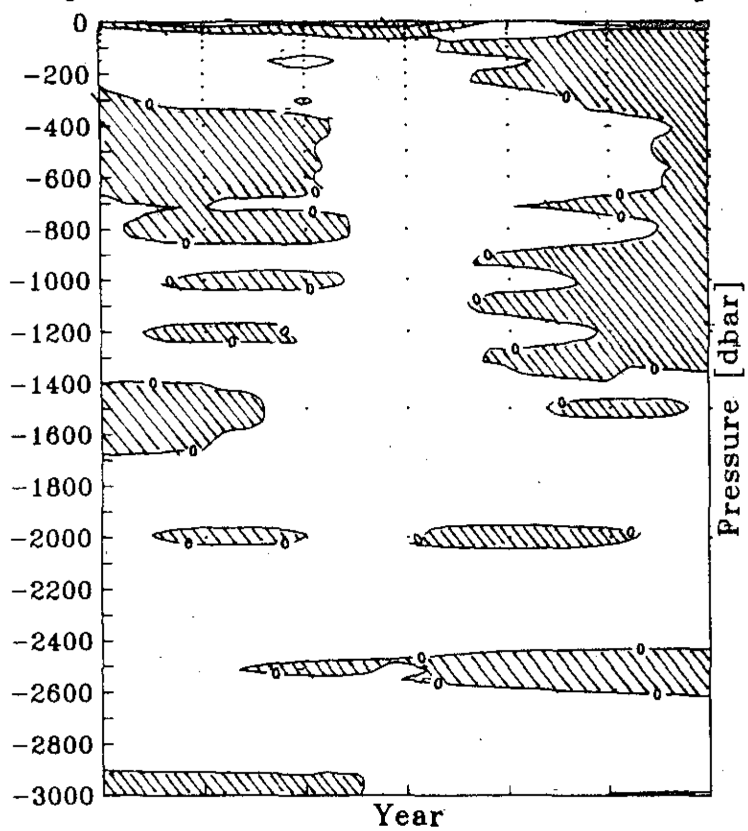


Fig. 4. Cape Desolation Station 3 Temperature (a) and Salinity (b) Anomaly.

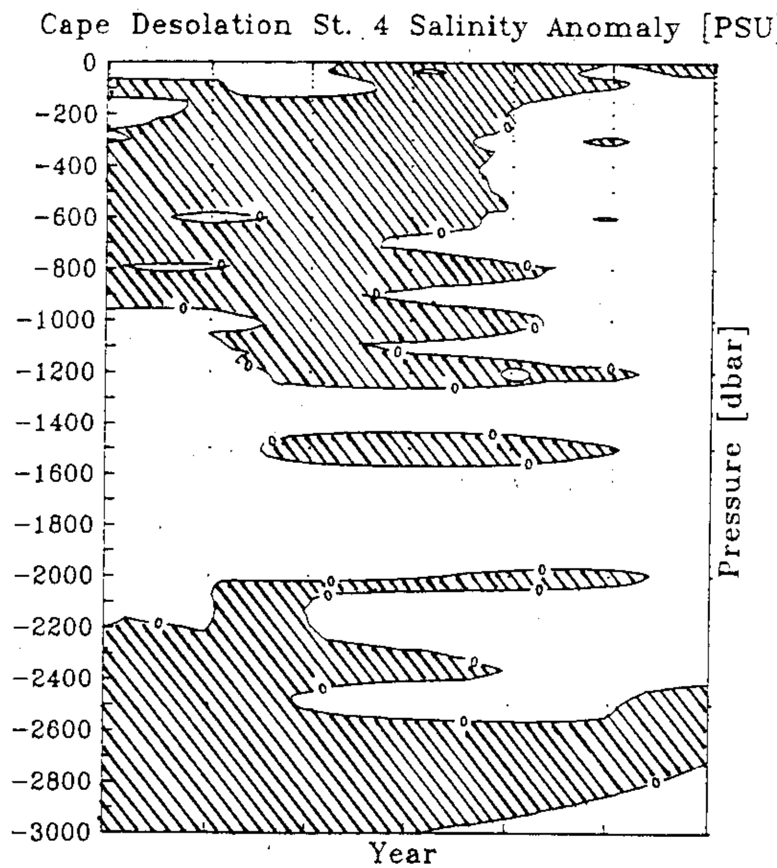


Fig. 5. Cape Desolation Station 4 Salinity Anomaly.

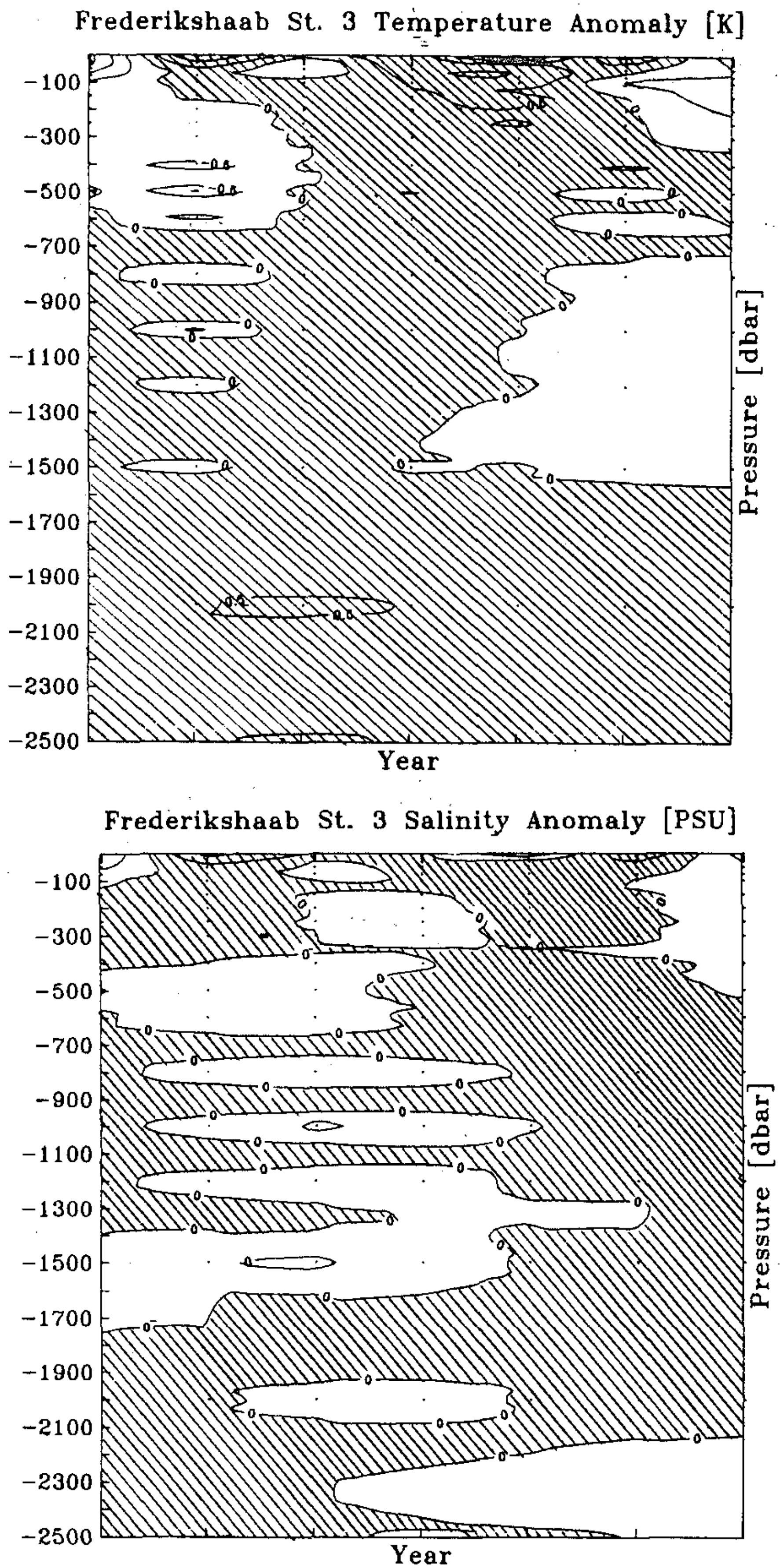
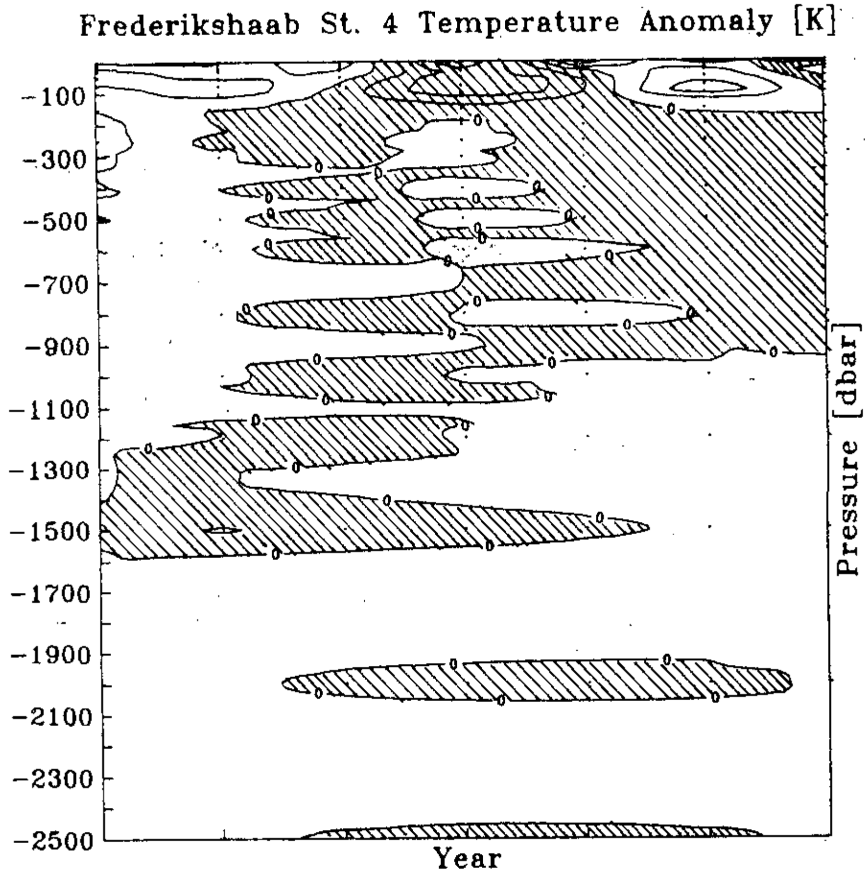


Fig. 6. Frederikshaab Station 3 Temperature (a) and Salinity (b) Anomaly.



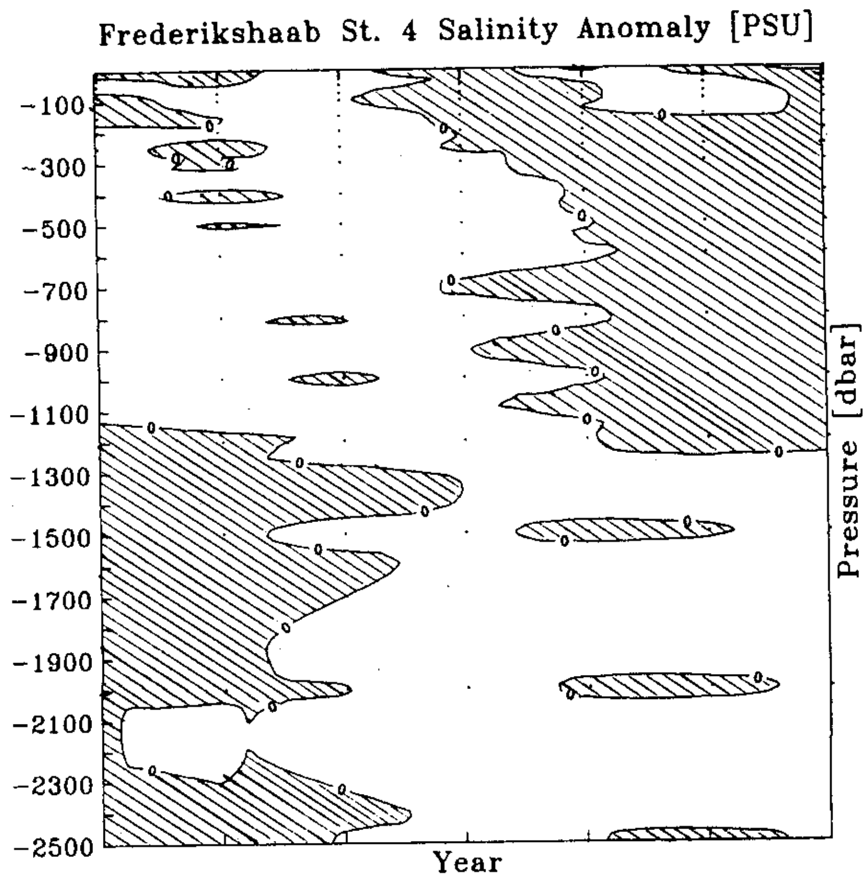


Fig. 7. Frederikshaab Station 4 Temperature (a) and Salinity (b) Anomaly.