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Transports of heat and volume in the West Greenland Current during autumn 1979

by

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Introduction

As reported earlier (STEIN, 1980) during the annual groundfish survey off West Greenland, NAFO Division 1D, 1E and 1F, RV WALTHER HERWIG completed parts of four NAFO Oceanographic Standard Sections between October, 28th and November, 15th, 1979. The positions as given in fig. 1 were chosen according to ICNAF Circular Letter 76/79, with the exception of stations 86, 88 and 92 (cf. figs. 4, 5). Section 5, the Holsteinsborg Section, was worked completely (fig. 7). The quality of the data collected off West Greenland enables a closer view to water masses, geostrophic currents and transports of heat and volume in the West Greenland Current.

Data and analysis

A total of 24 CTD profiles was accomplished along the five sections off West Greenland. Following the routine analysis as given by CORNUS & STEIN (1979) the individual profiles were smoothed and interpolated to 1 decibar.
The resulting set of data was then used to plot Θ,S - diagrams, as well as the vertical distribution of temperature along the Standard Sections. By means of standard programs the geostrophic currents and volume transports were calculated.

The thermohaline situation

Potential temperature versus salinity is given in fig. 2 for the offshore stations of the Standard Sections. Water mass characteristics of the main three water masses off West Greenland are given for the polar component of the

West Greenland Current during autumn (T<=1.0'C, S<=33.0 ppt), Irminger Atlantic Water (4.0 to 6.0'C, 34.95 - 35.10 ppt) and Northeast Atlantic Deep Water (3.0'C potential temperature, 34.95 ppt). Whereas the definition of the polar component is based on our own observations (STEIN, 1980) the characteristics for the warm component of the West Greenland Current as well as for the Deep Water are based on the results of the NORWESTLANT Surveys (LEE, 1968). The Θ,S - diagrams clearly demonstrate that the greatermost part of the water columns of the off-shore stations is composed of three water masses.

Along the Cape Farewell Section (st. 21, 22, 23) the polar component in its pure form occurs only at the nearshore station 21, whereas it is mixed with Irminger Atlantic Water on station 22 and does not appear at station 23. The warm component of the West Greenland Current was observed at all stations, whereas the Northeast Atlantic Deep Water was found at the two outermost stations of the section. Off Cape Desolation the surface water consists of a mixture between the cold polar component and the warm Irminger component (c.f. st. 91, 92, 93). Below the surface layer the influence of the Irminger Atlantic Water is evident (fig. 4). The Northeast Atlantic Deep Water was found at the two outermost stations of the Cape Desolation Section.

Similar to the previous section the Frederikshaab Bank Section is governed by the mixed surface water as denoted above (fig. 5). The influence of the warm Irminger Atlantic Water may be traced down to about 900m, whereas the Deep Water was found below 2300m. The inshore parts as well as the offshore portion of the Fyllas Bank Section (fig. 6) are covered by the cold, fresh polar water of the West Greenland Current. Off the slope the water column is composed of the warm Irminger Atlantic Water. Due to the topography of the outermost station the Deep Water which is usually found around 2000m depth (LEE, 1968) was not observed along this section.

A completely different thermohaline situation governs the structure of the water off Holsteinsborg. As denoted by the Θ,S - diagrams mixing plays an important role along this northern section (figs. 2, 7).

Methods of computation

a) Geostrophic currents

From the deeper parts of the sections 8 stations were chosen to calculate the relative geostrophic current profile. The depth of 'no motion' in the area under regard was defined as

$$\frac{\partial v_{rel}}{\partial z} \approx 0 \qquad (1)$$

with v_{rel} being the relative geostrophic velocity between two stations. Vertical integration of the absolute current profiles was accomplished as follows

$$\bar{v} = \frac{1}{D} \int_0^D v(z)\, dz \qquad (2)$$

with D being the depth of 'no motion' and v(z) the geostrophic current profile.

b) Heat transport at the outer portions of the sections

The heat content of the water column was obtained by integrating the temperature profile at the individual stations from the surface to the depth of 'no motion' D:

$$H = \frac{\varrho_0 c_p}{D} \int_0^D T(z)\, dz \qquad (3)$$

with ϱ_0 being the mean density of the water column and c_p being the specific heat at constant pressure, c_p = 0.96 g $°C^{-1}$ (DENMAN, 1973).

Discussion

At the deeper portions of the sections the baroclinic component of the West Greenland Current amounts 2.1 cm sec^{-1} to 6.0 cm sec^{-1}. Since $\bar{H}$ equals about 273 cal cm^{-3} (relative to 0°K) at each station, the heat transport reflects the baroclinic flow pattern relative to the surface of 'no motion'.

The heat transports between the selected stations are given in table 1:

Table 1: Transports of heat and volume across the outer parts of the West Greenland Standard Sections

Stations	Section	Volume transport	Heat transport
23 - 22	Cape Farewell	4.000 Sv	1.1 * 10^{15} cal sec^{-1} (1517m)
22 - 21	Cape Farewell	0.210 Sv	—
93 - 92	Cape Desolation	1.918 Sv	0.5 * 10^{15} cal sec^{-1} (1585m)
92 - 91	Cape Desolation	0.872 Sv	—
89 - 88	Frederikshaab Bk.	-0.443 Sv	0.1 * 10^{15} cal sec^{-1} (1216m)
72 - 71	Fyllas Bank	-1.441 Sv	0.4 * 10^{15} cal sec^{-1} (790m)
62 - 61	Holsteinsborg	0.073 Sv	—
61 - 60	Holsteinsborg	-0.276 Sv	—

1 Sv = 1 Sverdrup = 1*10 m sec

The transport numbers clearly indicate the areas of maximum heat transport. The largest amount of heat input to the waters west off Greenland was found at the outer portions of the Cape Farewell Section and the Cape Desolation Section.

The previous stations were selected for transport calculations during autumn 1979. Future measurements along the same sections at the same positions will be performed to estimate annual changes in the heat transport of the West Greelanc Current system.

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DENMAN, K.L., 1973: A Time Dependant Model of the upper Ocean J. Phys. Oceanogr., 6, 173 - 184.

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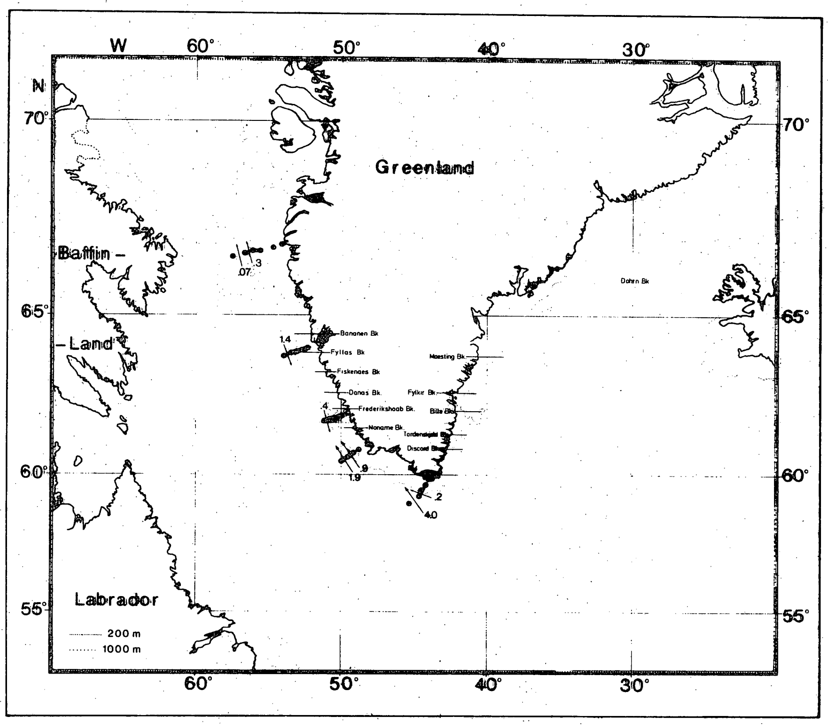
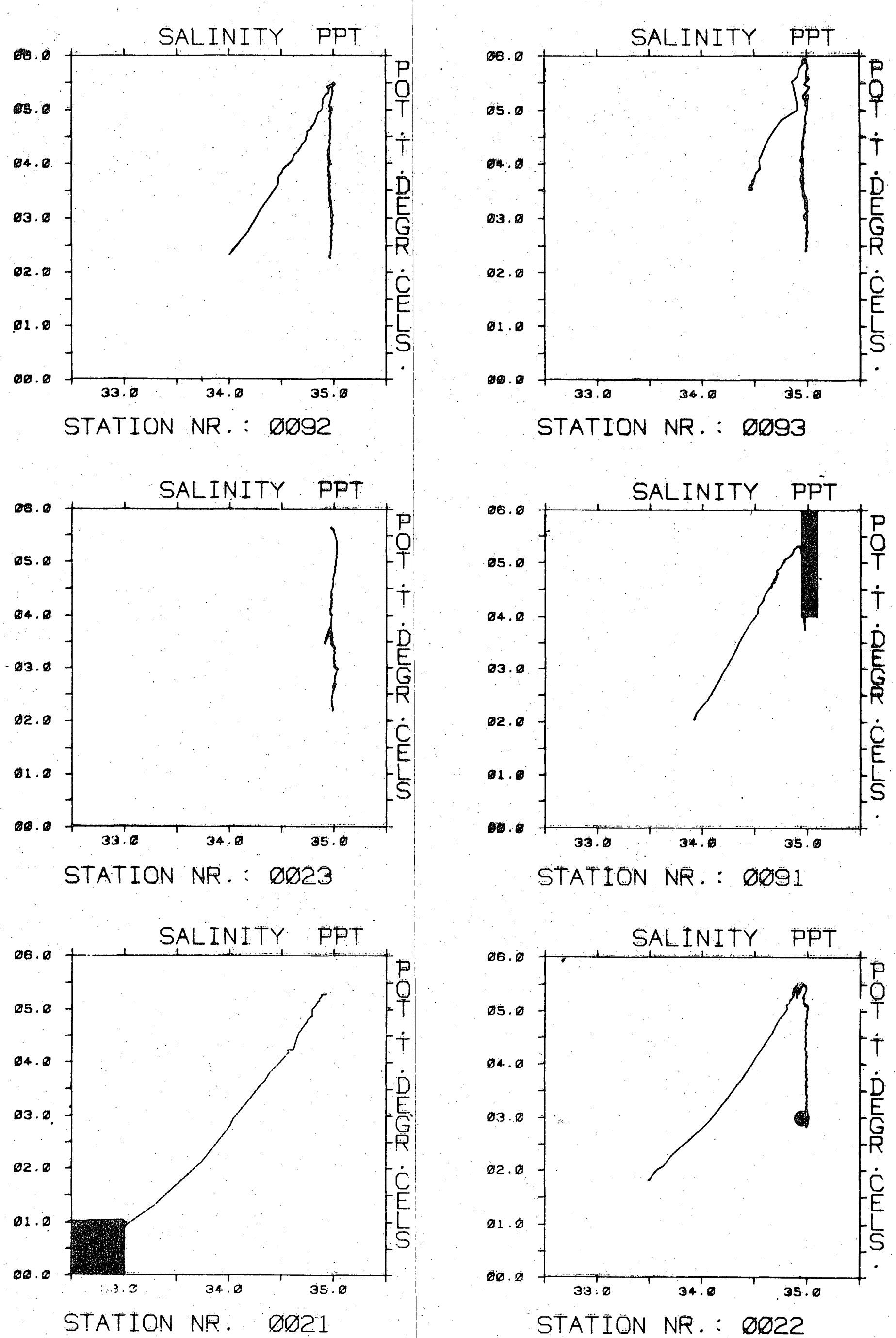


Fig. 1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STATION NR.: 0093
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POT. T. DEGR. CELS.
STATION NR.: 0023
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STATION NR.: 0091
SALINITY PPT
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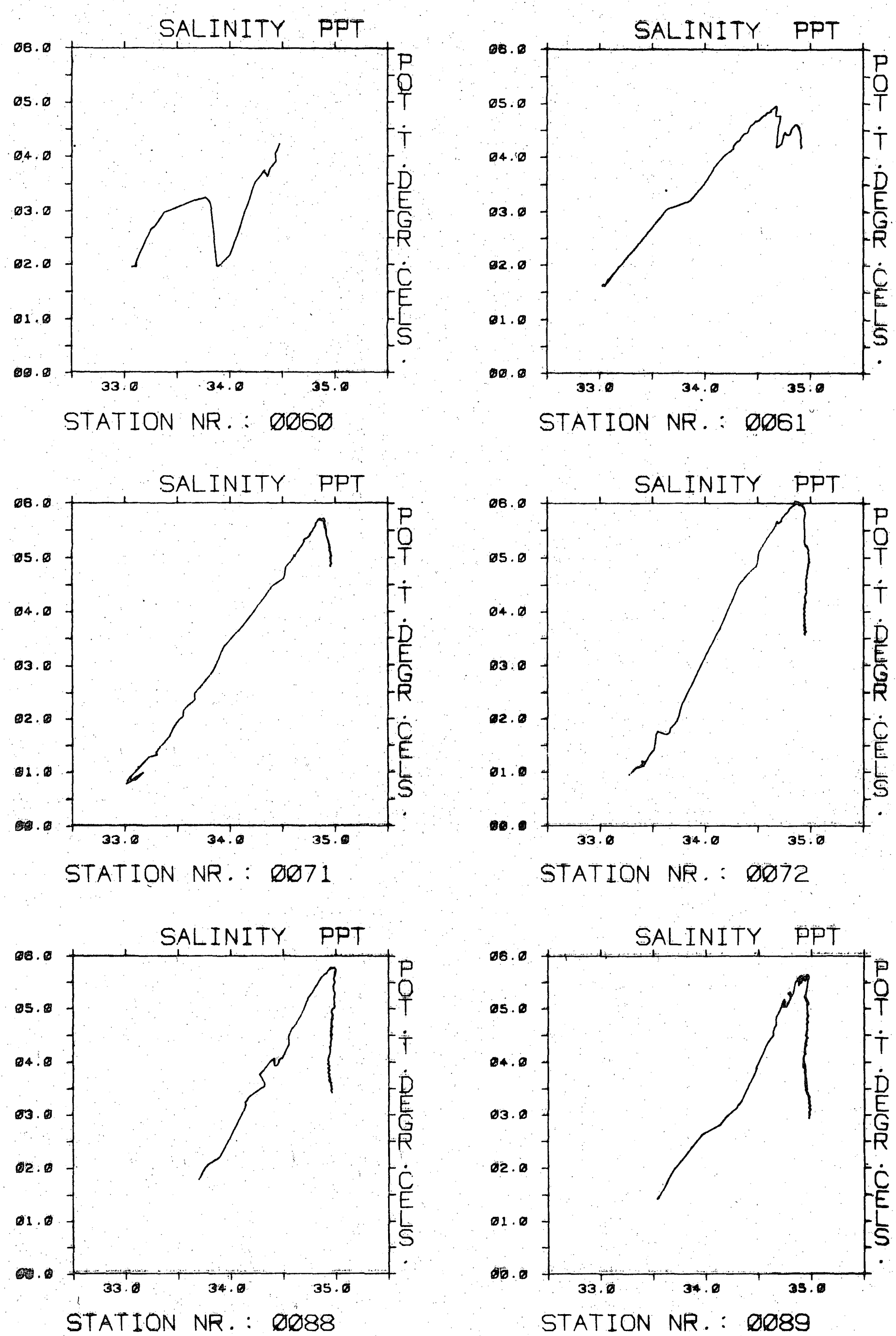
STATION NR. 0021
SALINITY PPT
POT. T. DEGR. CELS.
STATION NR.: 0022

Fig. 2a


SALINITY PPT
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06.0
05.0
04.0
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33.0
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STATION NR.: 0061
STATION NR.: 0071
STATION NR.: 0072
STATION NR.: 0088
STATION NR.: 0089

Fig. 2b

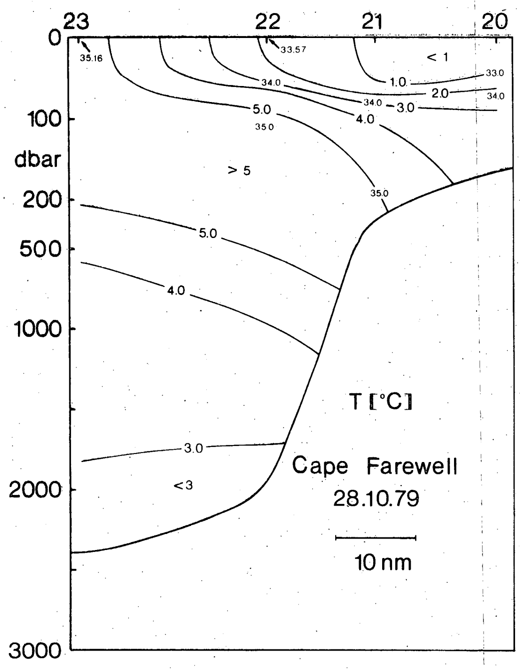


Fig. 3

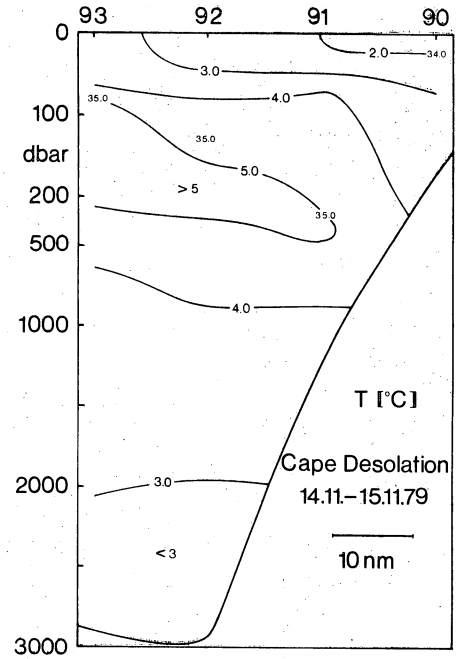
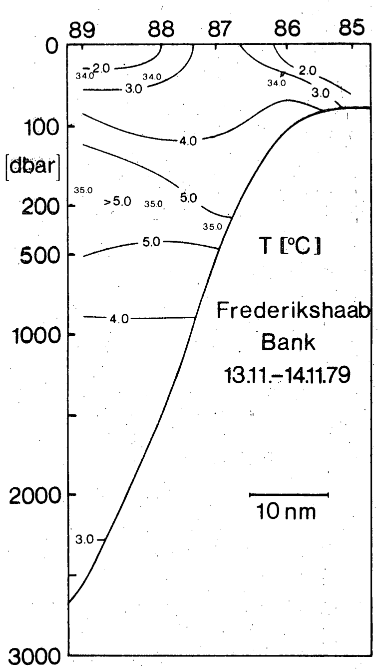


Fig. 4



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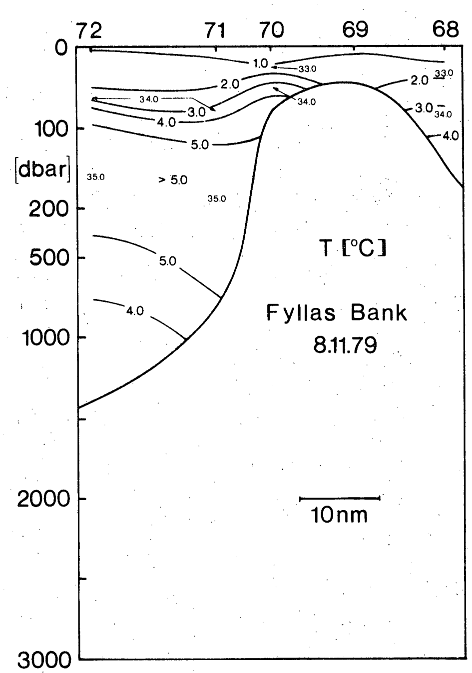
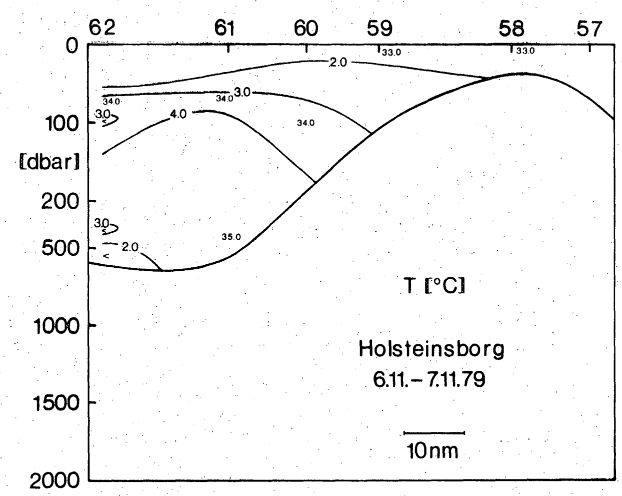


Fig. 6


62
61
60
59
58
57
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100
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200
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1500
2000
2.0
3.0
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T [°C]
Holsteinsborg
6.11.-7.11.79
10nm

Fig. 7