Communications

Dense bottom waters in Storfjord and Storfjordrenna

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Water masses
Circulation

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Abstract

On the basis of published information and our previous data, special attention was paid to the presence of dense bottom waters around the south-eastern tip of Spitsbergen during the 1995 'Oceania' cruise. Such waters, with a temperature of 1.6–2.0°C below zero, a salinity around 35 PSU and a density of 28.00–28.16, were recorded in Storfjordrenna and Storfjord. In Storfjordrenna this type of water appeared in separate bodies with a relatively large vertical extension, which was most probably caused by an eddy-type of circulation.

1. Introduction

Production of very dense waters during freezing processes in shallow seas, in the Barents Sea in particular, and their role in the ventilation of deep waters has received much attention in recent years (Aagaard *et al.*, 1981; Swift *et al.*, 1983; Midttun, 1985; Rudels, 1986). Brine rejection during the freezing of seawater causes the salinity to increase; this, together with freezing temperatures, produces the densest waters, which concentrate in the near-bottom layer and move down the continental slope to deeper parts of the sea.

Very dense, saline waters have been recorded in Storfjord several times already (Novitsky, 1961; Midttun, 1985; Andersson *et al.*, 1988). Quadfasel *et al.* (1988) has published some information on the sinking, mixing and transport of these waters down the continental slope into the Greenland Sea, and Schauer (in press) has presented the results of his measurements of these dense-water movements in 1991/92.

A more detailed study of the process has lately been undertaken by Maus and Rudels (in press), as have attempts at modelling the phenomena by Jungclaus *et al.* (in press), Maus (1995).

Anderson *et al.* (1988) reported water at freezing point and a salinity of 35.5 PSU. Traces of this water were slso noted by ourselves during previous 'Oceania' cruises, especially in summer 1993 (Piechura, 1993; Piechura and Walczowski, 1996). So during the summer 1995 expedition we decided to pay special attention to this problem.

2. Data

During the regular summer cruise of r/v 'Oceania' to the confluence zone in July 1995 (3–15.07.1995), we performed further detailed measurements in the Bjornoyarenne, Kveitehola Canyon, Storfjodrenna and Storfjord (Fig. 1).

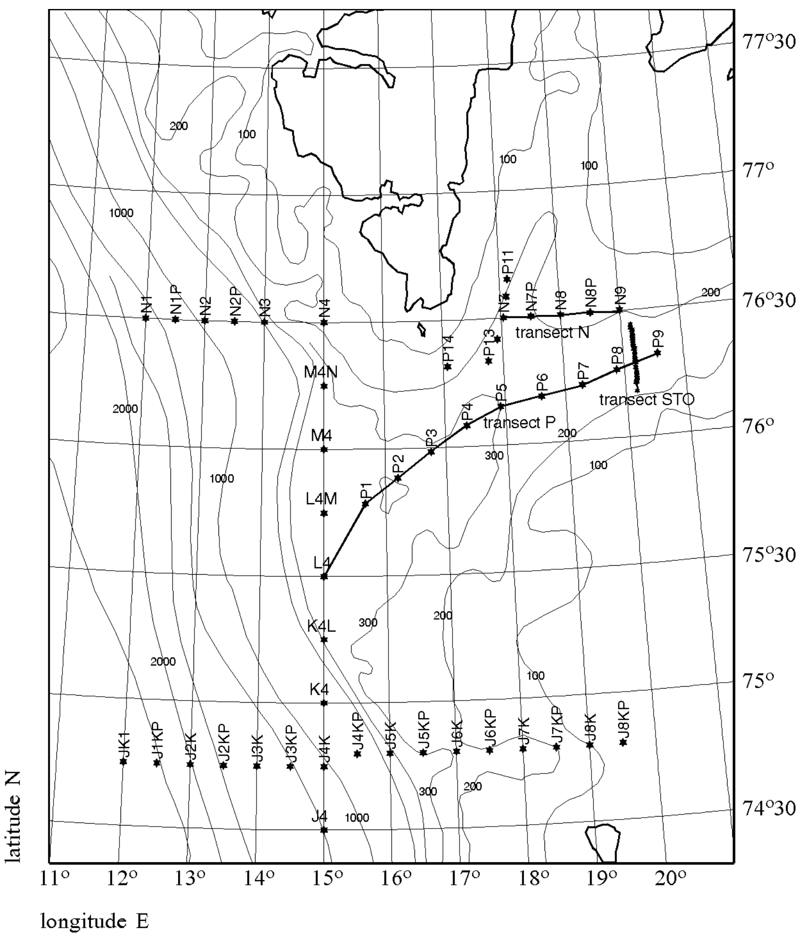

Fig. 1. CTD stations, 'Oceania' cruise, July 1995

Two CTD transects – one along Storfjordrenna (from station L4 at 75°45′N, 15°00′E to station 09 at 76°20′N, 20°40′E) with stations every 10 miles, and the other across Storfjord (along 76°30′N from 20°E to 18°E) every 30′ of longitude (about 7 nM), and two more crossing with the undulated CTD – across Storfjordrenna along 20°E and across Storfjord along 76°30′N have yielded very interesting results. Measurements in the western part of the transsect across Storfjord were prevented by ice cover. All ups in the undulated CTD results were eliminated, so we were finally able to obtain records with a resolution of about 800–1000 m.

Sea Bird CTD was used for regular casting and the Guideline CTD was adapted for continuous recording.

3. Results

There are two large bodies of very dense winter waters on the transect along the axis of the Storfjordrenna. One of them – we shall call it A – is located in the north-eastern part of the Storfiordrenna between stations P6 and P9. Its temperature is as low as –2°C, the salinity is close to 35 PSU and the density over 28.16 (Fig. 2). The other body (B) is located at the opposite end of the transect, *i.e.* between stations L4 and P2; the temperature in its core is –1.8°C and the density is 28.12–28.14. The salinity rises to nearly 35 PSU but only in a very thin bottom layer. The salinity increase in the western part of the lens is more probably due to the Atlantic waters located in the intermediate layer to the west. Intrusions of low salinity water are observed in the upper part of these cold water lenses: < 34.84 PSU in body B and < 34.76 PSU in body A. The slight drop in temperature, the rise in salinity and the density observed in a very thin bottom layer between stations P3 and P4, could be regarded as a trace of dense winter water (C) as well.

Above this layer a salinity decrease was also noted. So it appears that the combination of cold, more saline and dense waters at the bottom, with fresher water above, is a stable feature. Furthermore, the location of large bodies of dense winter water is in agreement with two cyclonic gyres. These cause the uplift of dense, bottom waters in these areas, especially at location B, where the geostrophic current velocity reaches almost 20 cm s^{-1} and the cyclonic gyre is accompanied by an anticyclonic eddy to the east that forces warmer and lighter water downwards (Figs. 2 and 3). The small intrusion C coincides with the area of very slow geostrophic movement (Fig. 3). These eddies influenced the entire layer, causing the temperature and salinity of the surface layer (lenses of colder and warmer, more and less saline waters) to vary as well.

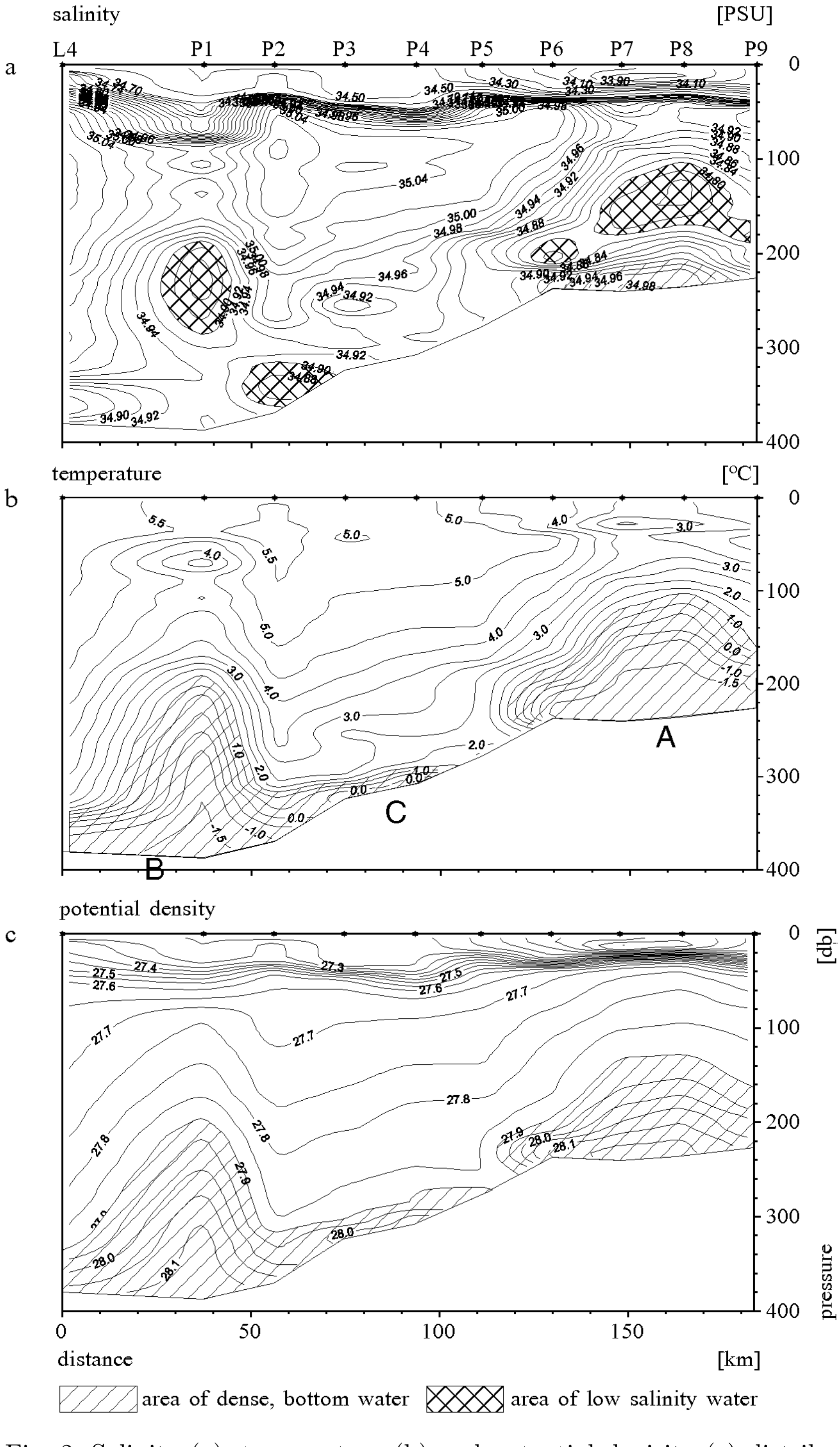

Fig. 2. Salinity (a), temperature (b) and potential denisity (c) distribution along transect P

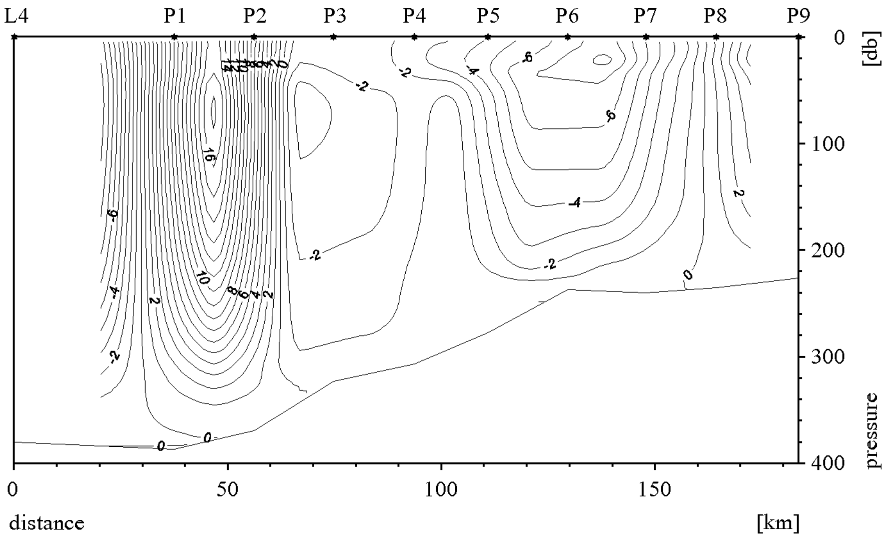

Fig. 3. Geostrophic velocity [cm s^{-1}] along transect P

To a lesser extent, dense winter water is also found along the transect made with undulated CTD across Storfjordrenna along 20°10′E (Fig. 4). In the deepest part of the channel (over 200 m) in a bottom layer about 50 m thick, cold (< –1.5°C), relatively saline (> 34.9 PSU) and dense (> 28.1) water was recorded.

On the transect N along 76°30′N dense winter waters were recorded as well. On both sides of the bottom rise, *i.e.* in the Storfjordrenna and in Storfjord itself, the bottom layer was occupied by water at a temperature of –1.4°C to –1.6°C, a salinity > 34.85 PSU and a density > 28.05 (Fig. 5). Unfortunately, ice-cover prevented measurements in the deepest part of the Storfjord, where the highest concentration of this water could be expected.

Summarising, the expected presence of cold, saline, winter waters was confirmed in Storfjordrenna and Storfjord but not in Kveitehola Canyon and Byornoya Trough. The continuous flow of dense waters moving down the slope of Storfiordrenna was broken up by an eddy-type circulation into two separate bodies of water. Additionally, a cyclonic circulation caused the uplifting of these waters, giving them a specific shape. The simultaneous forcing down in the neighbouring anticyclonic gyre gave rise to steep horizontal gradients of all the parameters, also in the deep layers in the south-western part of the Storfiordrenna. The presence of low-salinity waters on top of the highly saline, cold and dense bodies of waters can be partly explained by the water circulation but unfortunately not entirely. This phenomenon requires further examination.

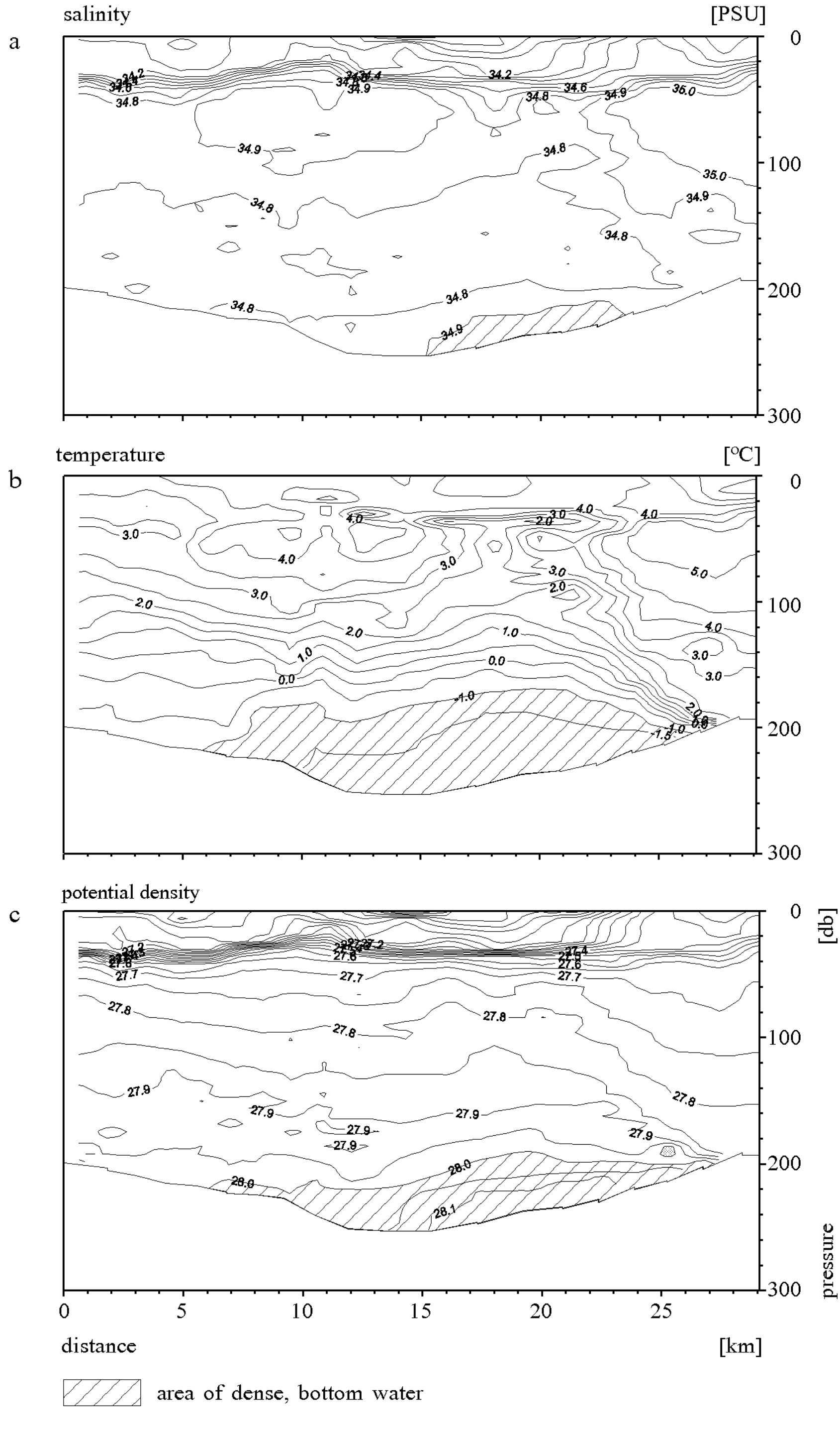

Fig. 4. Salinity (a), temperature (b) and potential density (c) along transect STO across Storfjordrenna

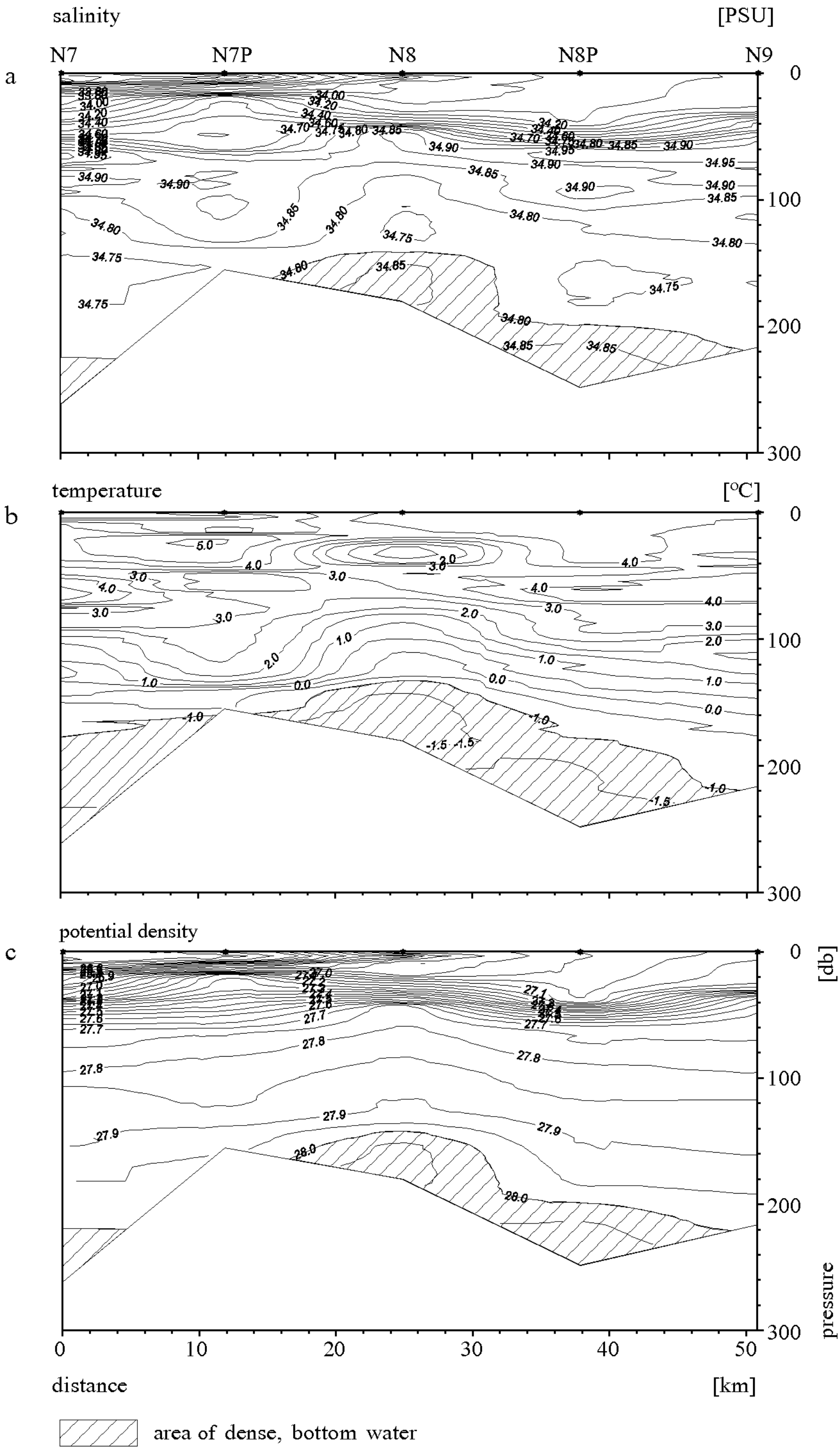

Fig. 5. Salinity (a), temperature (b) and potential density (c) along transect N

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