Journal of Marine Systems 75 (2009) 56–69

Contents lists available at ScienceDirect

Journal of Marine Systems

journal homepage: www.elsevier.com/locate/jmarsys

Mass and heat transports in the NE Barents Sea: Observations and models

Tor Gammelsrød [a,b,*], Øyvind Leikvin [a,b,e], Vidar Lien [c], W. Paul Budgell [c], Harald Loeng [c], Wieslaw Maslowski [d]

[a] Geofysisk Institutt, University of Bergen, 5007 Norway
[b] The University Centre in Svalbard, P.O. Box 156, 9171 Longyearbyen, Norway
[c] Institute of Marine Research, P.O. Box 1870, Nordnes, 5817 Bergen, Norway
[d] Oceanography Department, Naval Postgraduate School, Monterey, California, USA
[e] Akvaplan-niva, Polar Environmental Centre, 9296 Tromsø, Norway

ARTICLE INFO

Article history:
Received 17 March 2008
Received in revised form 17 July 2008
Accepted 21 July 2008
Available online 26 July 2008

Keywords:
Barents Sea
Current measurements
Numerical models
Ocean circulation
Thermohaline circulation
Water masses

ABSTRACT

The strait between Novaya Zemlya and Frans Josef Land, here called the Barents Sea Exit (BSX) is investigated using data obtained from a current-meter array deployed in 1991–1992, and two numerical models (ROMS and NAME). Combining the observations and models the net volume flux towards the Arctic Ocean was estimated to 2.0 ± 0.6 Sv (1 Sv = 10^6 m^3s^{-1}). The observations indicate that about half of this transport consists of dense, Cold Bottom Water, which may penetrate to great depths and contribute to the thermohaline circulation. Both models give quite similar net transport, seasonal variations and spatial current structures, and the discrepancies from the observations were related to the coarse representation of the bottom topography in the models. Also the models indicate that actual deployment did not capture the main in- and outflows through the BSX. A snapshot of the hydrographic structure (CTD section) indicates that both models are good at reproducing the salinity. Nevertheless, they react differently to atmospheric cooling, although the same meteorological forcing was applied. This may be due to the different parameterisation of sea ice and that tides were included in only one of the models (ROMS). Proxies for the heat transport are found to be small at the BSX, and it can not be ruled out that the Barents Sea is a heat sink rather than a heat source for the Arctic Ocean.

1. Introduction

Processes within the Arctic Ocean and the Arctic Mediterranean produce dense water and therefore contribute to the global thermohaline circulation. Cooling and ice formation with subsequent brine release is most effective in polynyas on the vast shallow shelves in the Arctic. The Barents Sea is of particular interest since it is one of the largest shallow shelves adjacent to the Arctic Ocean, and also the deepest shelf with an average depth of about 230 m. Some of the dense water formed here (Midttun, 1985) is observed to contribute to the deep water formation in the Arctic, e.g. Rudels (1987), Quadfasel et al. (1988), Rudels et al. (1994), Schauer et al. (1997) and Schauer et al. (2002).

Observations (e.g. Schauer et al., 2002) and model experiments, (Karcher and Oberhuber, 2002; Maslowski et al., 2004; Budgell, 2005) indicate that most of the locally produced dense water will leave the Barents Sea via the strait between Novaya Zemlya and Frans Josef Land (Fig. 1), here designated as the Barents Sea Exit (BSX). This water continues via St. Anna Trough (Schauer et al., 2002) and enters the Eurasian Basin, where it may sink to more than 1000 m depth (Rudels et al., 1994).

The major influx to the Barents Sea takes place via the strait between Fugløya and Bjørnøya, often called the Barents Sea Opening (BSO). Based on a current-meter array, (Ingvaldsen et al., 2002, 2004), now extended to 10 years (1997–2006) Skagseth et al. (2008), found that the net flow into the Barents Sea was 1.8 Sv. The inflow consisted mainly of warm and saline Atlantic Water (AW). This compares well with the estimate by O'Dwyer et al. (2001) of 1.6 Sv based on hydrography and ADCP sections repeated 13 times in the period 1997–1999.

* Corresponding author. Geofysisk Institutt, University of Bergen, 5007 Norway.
E-mail address: torg@gfi.uib.no (T. Gammelsrød).

doi:10.1016/j.jmarsys.2008.07.010

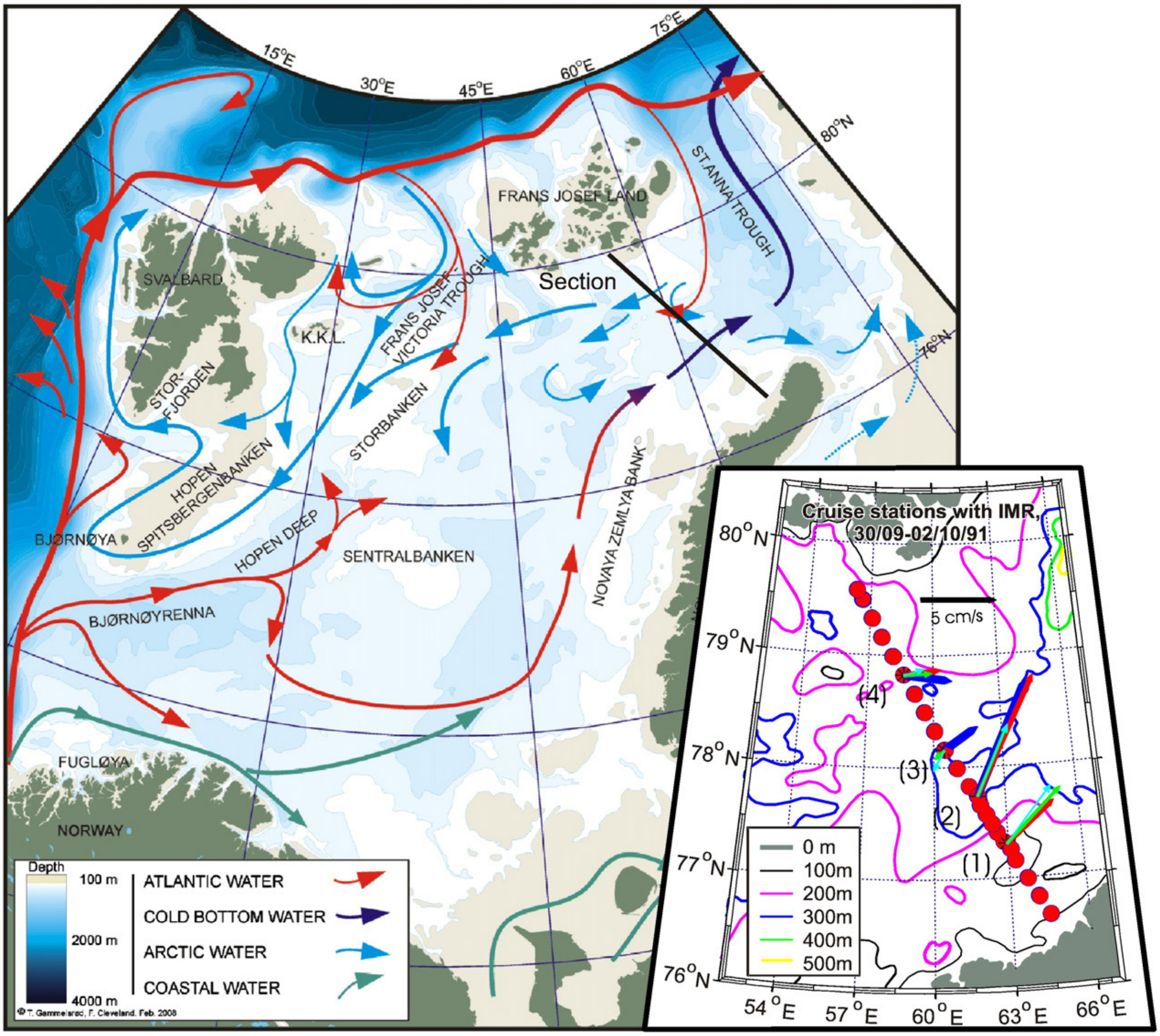

Fig. 1. Barents Sea bottom topography and schematic current system. Inset: Section between Frans Josef Land and Novaya Zemlya. The filled circles denote the 23 CTD-casts during deployment of the current-meter moorings, while the tails of the arrows and the numbers in parenthesis denote the mooring locations (1–4). The arrows represent the mean current vectors with the deepest instrument having the thickest arrow. Dark blue: deepest instrument, Red: 2nd from bottom, Green: 3rd from bottom, Light blue: closest to the surface. Note that at the southernmost station, there are only 3 instruments.

Changes in the oceanographic climate in the Arctic Ocean have been linked to anomalous heat transport in the AW from the Nordic Seas. Furevik (2001), using 16 years of data, discussed the variability of the AW inflow to the Barents Sea and related it to variability in the AW inflow to the Norwegian Sea, changes in the advection speed and interactions with the atmosphere. The variability of the AW flow may in turn be linked to the North Atlantic Oscillation; e.g. Furevik and Nilsen (2005). Two model experiments presented in Drange et al. (2005), and the experiments by Zhang et al. (1998) and Maslowski et al. (2004) indicate that the Norwegian Atlantic Current splits up into two major branches, one entering the Barents Sea via the BSO, while the other continues northwards as the West Spitsbergen Current (WSC). WSC dives below the surface and becomes insulated from direct atmospheric cooling, and is believed to be the larger heat source for the Arctic Ocean of the two branches. On the contrary, in the relatively shallow Barents Sea the AW is effectively modified by cooling and mixing due to wind and tidal currents and gradually looses its heat content on its way to the Arctic Ocean (Pfirman et. al., 1994). This denser, modified water is probably directly contributing to the deep water formation and therefore the thermohaline circulation; see for instance Meincke et al. (1997), Schauer et al. (1997) and Schauer et al. (2002).

The modification of the water masses in the Barents Sea critically depends on the ice cover and polynya activity (Pease, 1987; Martin and Cavalieri, 1989; Ivanov and Shapiro, 2005). In their model experiments Gerdes et al. (2003) demonstrate how an anomalous low heat inflow via the BSO in the 1960's did not produce a similar low signal in the heat flow through the BSX, because the Barents Sea was ice-covered and thus protected from atmospheric cooling. Conversely, a high heat inflow