1.13 COHERENCE AND TRENDS OF ANOMALIES IN BARENTS SEA HYDROGRAPHIC DATA AND ARCTIC ATMOSPHERIC SYSTEMS

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1. INTRODUCTION

The Barents Sea plays an important role in the Arctic Ocean's thermohaline structure due to its influence on incoming Atlantic water. Current studies of warming trends in the Arctic Ocean and decrease of ice extent recognize the influence of the variations in Atlantic water properties. It is thought about half (roughly 2 Sverdrups) of the Atlantic derived water enters the Arctic Ocean via the Barents Sea, and the other half through Fram Strait (Loeng et.al., 1993; Rudels, 1987). Thus it is important to understand the processes that bring the Atlantic water onto the shelf and how it is modified before entering the Arctic Ocean. While circulating over the Barents Sea, Atlantic derived water is cooled, freshened, and in some areas made saltier by surface heat loss, mixing and brine rejection from ice formation. Understanding the variability in these processes allows us to determine the variability of the water properties flowing into the Arctic. However, there are also large variations in the incoming Atlantic water's volume flux, temperature and salinity. Because processes occuring on the shelf will be modified by the properties of the incoming Atlantic water, both aspects must be considered.

The North Atlantic Oscillation (NAO) represents a pattern of large scale atmospheric forcing that corresponds to much of the interannual variability seen in the GIN and Barents Seas. It has already been shown that the positive index of the NAO, which generally indicates a stronger cyclonic atmospheric circulation centered over Iceland and reaching north into the Barents Sea, corresponds with higher precipitation over the Norwegian coast, stronger and warmer Norwegian Atlantic Current, increased mass flux into the Barents Sea based on a wind driven baratropic model, and retreat of ice extent in the Barents Sea (Dickson et. al., 2000). The authors point out that although the NAO corresponds well to these properties, the temporal stability of these connections are not known.

This study focuses on the southwest Barents Sea. The key questions addressed are:

- What is the magnitude of the oceanographic interannual variability in the Barents Sea?
- How much of this variability is due to processes occcuring within the Barents Sea?
- What are the driving dynamics forcing this variability?

2. DATA AND METHODS

The oceanographic data used in this study was taken from the Barents and Kara Seas Oceanographic Data Base (BarKode) by Golubev and Zuyev (1999). This is a compilation of many countries' data sets from the Barents and Kara Seas spanning 1898 to 1998, put into one format with basic quality control steps applied. One zonal and one meridional section were taken from the data set for this study, chosen because they bound the inflowing Atlantic water in the southwest Barents Sea. These hydrographic lines were repeatedly sampled in summer and winter. Seasonal and interannual changes were computed over the years 1950 to 1995, a time period that includes both positive and negative phases of atmospheric patterns such as the North Atlantic Oscillation and the Arctic Oscillation (Thompson and Wallace, 1998).

Section 1, an extended version of the Russian Kola section, starts at 70°N and ends at 80°N. It includes all stations found between 32°E and 34°E. Section 2 is zonal, extends from 10°E to 50°E and includes all stations between 74°30'N and 75°N. These sections are approximately 1000 km long and intersect over Central Bank in the middle of the Barents Sea. The best spatial and temporal coverage occurs after 1975 to the south and west of this intersection. Data are restricted to standard depth levels which were chosen to give full vertical coverage and match the most frequently sampled depths within the data set.

Monthly means were calculated for a description of the annual temperature and salinity signal. The monthly means were then removed from each year's monthly values to produce a set of interannual anomalies. Linear trends in temperature and salinity, and correlations between

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the variations in oceanographic properties and with large scale atmospheric patterns were assessed.

3. RESULTS

3.1 *Annual signal*

The differences in temperature and salinity within a year occur most strongly at the surface and weaken with depth. At the surface, the seasonal change in temperature is around 10°C. At a depth of 150 m it has decreased to 2°C. Salinity's annual variability at the surface varies from 2 in regions which encounter ice melt, to 0.2 in areas without ice melt or surface polar water influence. The annual signal in salinity is damped with depth more quickly than with temperature. By 50 m the salinity has reduced to 0.5 in the regions that have a strong salinity signal at the surface and to 0.1 in the Atlantic water core. In comparison, interannual variations do not vary substantially with depth.

3.2 *Interannual variability*

Preliminary results show that Barents Sea waters have interannual variations in temperature of ±1°C and ±0.1 in salinity. The associated density variation is ±0.1 kg m^{-3}. The anomalies occur by roughly the same amount down to 200 m depths and persist over multiple seasons from 1 to 5 years before changing sign, indicating a large scale forcing of similar time period. Both oceanographic sections show similar temporal variations in temperature and salinity in the core of the Atlantic water. Anomalies are in phase with increased temperatures occurring with increased salinity. Closer to the coast however, from 70°N to 72°N in Section 1, and in Section 2 over Svalbard Bank (20°E to 25°E), temperature changes are less coherent with salinity changes.

Examination of trends in monthly data show a freshening of roughly 0.1 in the Atlantic Water over the 45 year period being studied. There is a warming trend just for the month of November of about 0.5°C over the study period. This warming may indicate a lengthening of summertime conditions.

Tests for coherence between the NAO index and temperature anomalies are in agreement with other studies (Dickson et. al., 2000). In general, a positive NAO index (or AO index) correlates with warm and salty anomalies. Interestingly, although the trend in the NAO has been positive over the study period, an overall warming is not seen and there is an overall freshening as well.

4. SUMMARY

The results show there are large interannual changes in ocean temperature and salinity occurring over the southwestern Barents Sea. These changes are being compared with those observed in the Norwegian Sea and at the entrance to the Barents Sea along the Bjørnøya-Fugløya section (Furevik, 2001). Increased flow of Atlantic water resulting from favorable winds associated with the NAO could cause the modification of the temperature and salinity structure of the Barents Sea. Comparisons with interannual changes outside the Barents Sea will address the question of how much of the variability is occuring within the Barents Sea. The increased precipitation over the Norwegian coast, connected to a positive NAO (Xie and Arkin, 1996) is consistent with overall freshening of the Atlantic water for the study period. The causal mechanism for the observed annual and interannual variability will be disscussed.

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