

Freshening of the Barents Sea during the recent decade and its impact on the outflow of dense waters

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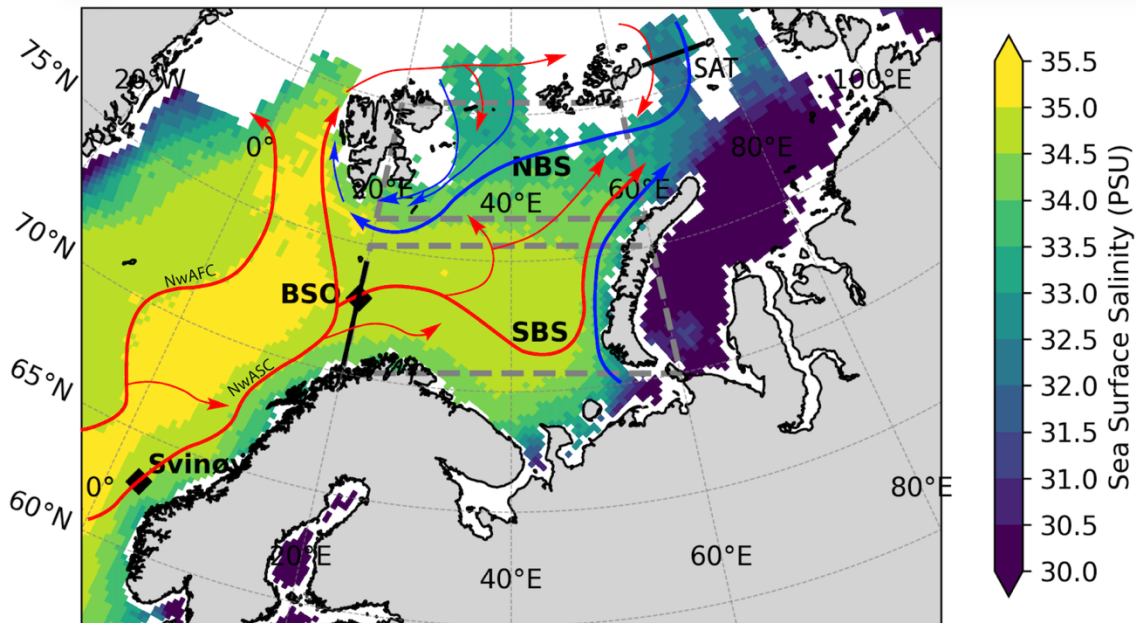
Abstract

Dense water exiting the shallow Barents Sea feeds the deep branch of the Atlantic Meridional Overturning Circulation, an important part of the global climate system. The formation of dense waters in the Barents Sea is sensitive to both the temperature and the salt content of the water masses advected into the region. Here, using a suite of satellite, reanalysis and in situ data for the time-period 1991-2024, we investigate the drivers of the interannual variability and recent changes in the hydrographic properties of the dense waters exiting the Barents Sea. The salinity of the whole Barents Sea declined during the period 2016 to 2022 due to an influx of anomalously low salinity water from the North Atlantic. The reduction in the southern Barents Sea salinity was found to be caused mainly by the properties of the Atlantic Water transported into the region. The salinity in the northern Barents Sea, on the other hand, was additionally influenced by increased sea ice import from the central Arctic due to changes in the atmospheric circulation pattern, pausing a trend of “Atlantification” previously reported. The freshening of the Barents Sea in the recent years, together with relatively high temperatures, resulted in the lowest density of the dense waters exiting to the Nordic Seas and to the central Arctic in the three decades model data record.

1. Introduction

The Atlantic Water (AW) transport from the North Atlantic to the Arctic Ocean and its densification through heat and freshwater exchanges while en route is a main driver of the thermohaline circulation (Aagaard, 1981; Rudels et al., 2015; Raj and Halo, 2016; Bashmachnikov et al., 2023). The shallow Barents Sea shelf (mean depth of 230 m) accounts for a substantial part of the dense water that is formed within the Arctic (Martin & Cavalieri 1989). Changes in dense water formation in the Barents Sea can weaken the downstream overflows that feed the lower limb of the Atlantic Meridional Overturning Circulation (AMOC), and ultimately influencing the large-scale ocean heat transport and climate variability (Smedsrud et al. 2013; Lind et al. 2018;

35 Årthun et al. 2019). A major source of interannual variability in the Barents Sea hydrography is
 36 the inflow of AW (Arthun et al., 2012; Lien et al., 2024), branching out from the Norwegian
 37 Atlantic Current and entering the Barents Sea from the southwest through the Barents Sea Opening
 38 (BSO; Figure 1). The propagation of temperature and salinity anomalies from the North Atlantic
 39 through the Nordic Seas and into the Barents Sea through the BSO is well documented (e.g.,
 40 Furevik, 2001; Sundby & Drinkwater, 2007; Årthun & Eldevik, 2016). These previous studies
 41 have found typical propagation speeds of 2-3 cm/s within the Nordic Seas, a 2–3 year lag between
 42 the Nordic Seas AW inflow region and the BSO. During the years 2012-2016, an unprecedented
 43 freshening was observed in the north-eastern North Atlantic. Holliday et al. (2020) attributed this
 44 freshening to anomalous winter wind patterns rerouting Arctic-origin water in the Labrador
 45 Current off the continental shelf poleward into the northern North Atlantic (Holliday et al., 2020).
 46 On the other hand, according to Kenigson and Timmermans (2021), this anomalous event can be
 47 linked to the wind-driven displacements of the Subpolar Front due to persistent positive North
 48 Atlantic Oscillation (NAO+) conditions during 2014–16. These events were possibly
 49 superimposed on the decadal variability in the subpolar North Atlantic gyre circulation, which
 50 largely controls the Atlantic Water intrusion in the Nordic seas (Hatun et al. 2005), and exhibited
 51 a strong (weak) gyre circulation favouring negative (positive) salinity anomaly in the AW during
 52 2005-16 (1993-2005) (Chafik et al., 2019). The northward propagation of the negative salinity
 53 anomaly into the downstream Nordic Seas in the recent decade is well documented (Mork et al.,
 54 2019).
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 57 **Figure 1.** Mean sea surface salinity (SSS) in the eastern Nordic Seas and the Barents Sea (2010-
 58 2023) from ESA CCI SSS satellite database (see Table 1 for details). Thick black lines indicates
 59 the location of sections, Barents Sea Opening (BSO) and St. Anna Trough (SAT) shown in Figure
 60 6. Two black square boxes represent the locations of Svinøy and BSO shown in Figure 2. The

main circulation features of the region are overlayed (Red: Atlantic Water; Blue: Arctic Water) on the mean SSS. The Norwegian Atlantic Slope Current (NwASC; Orvik et al., 2001) and Norwegian Atlantic Front Current (NwAFC; Raj et al., 2019) transporting warm AW poleward are also indicated. The location of the NBS and SBS are represented by two dashed grey boxes.

After entering the southern part of the Barents Sea, a large amount of the heat carried by the AW is released to the atmosphere (Serreze et al. 2007; Smedsrud et al. 2010), before travelling further north and setting the southward limit of sea ice extent in the northern Barents Sea (Barton et al., 2018). In addition to the AW flow from the south, the hydrographic variability in the northern Barents Sea is dominated by variations in the inflow of AW from the north (Lind & Ingvaldsen, 2012) and the import of sea ice and lower salinity Arctic Water from the Polar Basin (Lind et al., 2018). After undergoing considerable modifications within the Barents Sea, the poleward AW flow enters the Polar Basin through the St. Anna Trough (e.g., Schauer et al., 2002), thereby contributing to the renewal of the intermediate and deep water in the Arctic Ocean (Rudels et al. 1994; Jones et al. 1995; Rudels et al. 2000). Several processes contribute to this water mass modification within the Barents Sea (Pfirman et al. 1994; Rudels et al. 1994; Ozhigin & Ivshin 1999; Rudels et al. 2004). These processes include freshwater input from river runoff, sea-ice melting and net precipitation (Coachman & Barnes 1963; Steele et al. 1995), wind and tidal mixing (Sundfjord et al. 2007), atmospheric cooling and subsequent sea-ice formation (Aagaard et al. 1981; Jones et al. 1986, Smedsrud et al., 2013; Skagseth et al., 2020). The dense water formed within, exits the Barents Sea at the northern part of the BSO and along the St. Anna Trough into the Nordic Seas and into the central Arctic respectively.

During recent years, the Barents Sea has been experiencing rapid changes involving complex feedback mechanisms that make the region a focal point for understanding ongoing and future Arctic climate change and its further implications (Lind et al., 2018; Chatterjee et al., 2024; Challet et al., 2025). While the atmospheric heat loss in the southern Barents Sea has been found to decrease (Skagseth et al., 2020), it has increased in the northern Barents Sea (Shu et al., 2021). The reduced heat loss affects the outflow of dense water, which enters the Nordic Seas through the northern parts of the BSO (Blindheim, 1989; Årthun et al., 2011; Skagseth et al., 2020). The dense outflow waters exiting the Barents Sea at BSO and the St. Anna Trough are also expected to be affected by changes in salinity due to the downstream impact of the unprecedented freshening noted in the northern North Atlantic (Holliday et al., 2020) and due to the changes associated with freshwater or sea ice import from the north (Lind et al., 2018).

In here, we utilize a suite of regional ocean reanalysis, in situ and satellite remote sensing datasets to document recent changes in the Barents Sea salinity, its drivers, and assess the potential impact on the dense waters exiting the Barents Sea to the Arctic via the St. Anna Trough and to the Nordic Seas through the BSO.

2 Data & Methods

Details of the model data, satellite data obtained from the Climate Change Initiative (CCI) of the European Space Agency (ESA), ECMWF Reanalysis Version5 (ERA5) atmospheric reanalysis and insitu data from International Council for the Exploration of the Sea (ICES), is given below.

TOPAZ: Model data used are the Copernicus Marine Service reanalysis for the Arctic region (ref. 1 in Table 1). TOPAZ4, a coupled ocean and sea ice data assimilation system for the Arctic based on the HYbrid Coordinate Ocean Model (HYCOM), with 50 hybrid z-isopycnal layers at a horizontal resolution of 12 to 16 km, uses the ensemble Kalman filter method (EnKF; Evensen 2003; Ali et al., 2019; Raj et al., 2020) to assimilate consistently multiple types of observations in the ocean and sea ice (Xie et al., 2016, 2019). TOPAZ4, forced by ERA5 reanalysis, assimilates observations including along-track altimetry data, sea surface temperatures, sea ice concentrations and sea ice drift from satellites along with in situ temperature and salinity profiles. The detailed setup of the TOPAZ4 reanalysis and its performance is detailed in Sakov et al. (2012) and Xie et al. (2023).

ESA CCI SSS data: The CCI+SSS project aims to generate improved calibrated global SSS fields from all available satellite L-band radiometer measurements, with regional extensions utilising C-band radiometer data. This initiative seeks to leverage the full potential of the ESA/Earth Explorer Soil Moisture and Ocean Salinity (SMOS), in conjunction with the Soil Moisture Active Passive (SMAP) and AQUARIUS satellite missions, by assembling expert teams in earth observation, satellite data validation, and the study of climate variability. Monthly sea surface salinity product for the Northern Hemisphere on a 25km EASE grid, v5.5, available for the time-period 2010 to 2023 is used here (Boutin et al., 2025).

ERA-5: Monthly mean sea level pressure (MSLP) data for the time-period (1991-2024) is used in this study to investigate the role of large-scale atmospheric forcing.

ICES data: The temperature, salinity, density data at BSO and Svinøy section are obtained from the ICES database (<https://ocean.ices.dk/core/iroc>).

Table 1. Product ID & Type, data access and documentation details of different datasets used in this study

Product ref. no	Product ID & Type	Data access	Documentation
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1	ARCTIC_MULTIYEAR_PHY_002_003, numerical models	EU Copernicus Marine Service Product (2025)	Quality Information Document (QUID): Xie and Bertino (2025) Product User Manual (PUM): Ali et al. (2025)
2	MULTIOBS_GLO_PHY_TSUV_3D_MYNRT_015_012, in-situ observations, satellite observations	EU Copernicus Marine Service Product (2023)	QUID: Grenier et al. (2023) PUM: Verbrugge (2023)
3	ESA CCI SSS, satellite observations	NERC EDS Centre for Environmental Data Analysis, https://catalogue.ceda.ac.uk/uuid/0397ca6f625e47f489684bad2bd533bb , last access: August 2025	Boutin et al., 2025
4	In-situ Observations (CTD)	ICES Report on Ocean Climate (IROC), https://ocean.ices.dk/core/iroc , last access: August 2025	González-Pola et al., 2023
5	ERA-5 MSLP, numerical models	Copernicus Climate Change Service (2023): ERA5 monthly averaged data on single levels from 1940 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.f17050d7 last access: August 2025	Hersbach et al., (2020)

125 3. Results

126 3.1. Southern Barents Sea

Reanalysis data averaged over the full Barents Sea domain (20°E to 60°E; 70°N to 80°N) and from surface to bottom show a rapid decline in the overall salinity in the Barents Sea after 2016-2017, followed by a salinity minimum in 2021-2022 (trend, 2016-2022: -0.1 ± 0.02 psu/decade). The salinity decline followed a period of gradual salinity increase (1991-2016; trend: 0.01 ± 0.002 psu/decade; Fig. 2a). This salinity minimum aligns with the rapid decline in salinity in the North Atlantic during the period 2012-2016 (Holliday et al., 2020), and subsequently in the Norwegian Sea (Mork et al., 2019), provided an advection time of a few years from the North Atlantic to the entrance of the Barents Sea (Furevik, 2001; Årthun and Eldevik, 2016). To understand the regional drivers of this salinity change, we further focus our analysis on the southern (SBS; 20°E to 60°E; 70°N to 75°N) and northern (NBS; 20°E to 60°E; 76°N to 80°N) Barents Sea separately (Fig 1). The spatial variability of mean SSS shown in Figure 1 is used to qualitatively separate the BS into the AW dominated SBS and the Arctic Water dominated NBS. In general, from visual analysis the long-term variability in the salinity of the two regions shows a positive trend followed by a sudden drop in salinity since mid 2010s, at a lag (Fig. 2a).

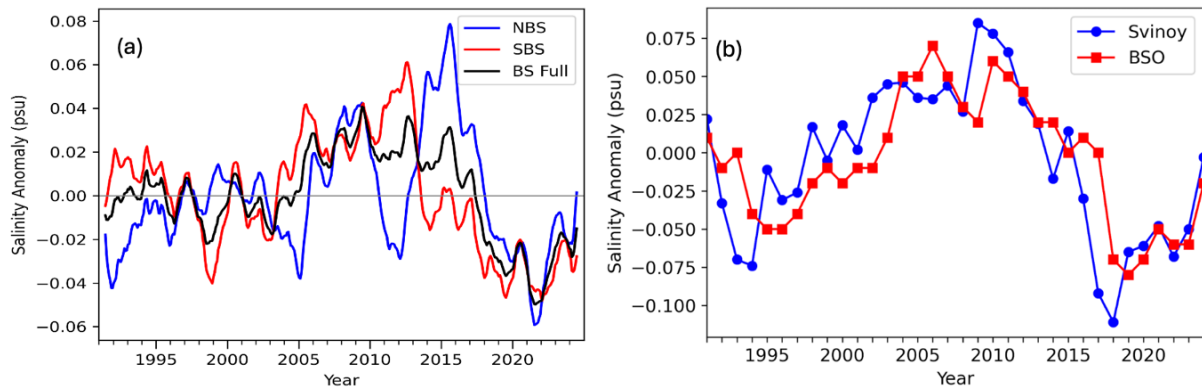


Figure 2. a. Interannual (12 month running mean) variability of depth-averaged salinity anomaly in the southern Barents Sea (SBS; red), northern Barents Sea (NBS; blue) and the full Barents Sea (BS_Full; green) obtained from TOPAZ reanalysis. b. Time series showing annual averaged salinity anomaly in the upper 200 m depth at the Svinøy (63°N, 3°E; Figure 1) and Barents Sea Opening (BSO; Figure 1; 73°N, 20°E), from in situ observations (ICES data) during the TOPAZ time period (1991-2024).

The propagation of salinity anomalies from the Nordic Seas into the SBS via BSO is visible in Figure 2b. In accordance with findings reported in the literature, the salinity variability (upper ocean, 200 m) in SBS follows that at the BSO and Svinøy located further upstream along the advection path of Atlantic Water in the Norwegian Sea (Fig 1). The positive trend in salinity followed by an abrupt drop is also seen at BSO and Svinøy, but with a lag. The minimum in salinity at Svinøy is found during 2018, while at BSO and SBS it is at around the time-periods 2019-2020 and 2021-2022 respectively. The lag correlation analysis (detrended and deseasoned) show a maximum significant correlation ($r=0.5$) at 18 months lag between Svinøy and BSO. Eventhough the mean speed of the Norwegian Atlantic Slope Current (NwASC; Fig 1) is around 30 cm/s (Orvik et al., 2001) with a variability of ± 10 cm/s (Raj et al., 2018), the hydrographic anomalies

propagating along with the NwASC is much slower, roughly an order of magnitude lower than the
 its core speed (Broomé & Nilsson, 2018). This accounts to a travel time, consistent with our result
 to cover a distance of around 1300 km between Svinøy (63°N, 3°E) and BSO (73°N, 20°E).

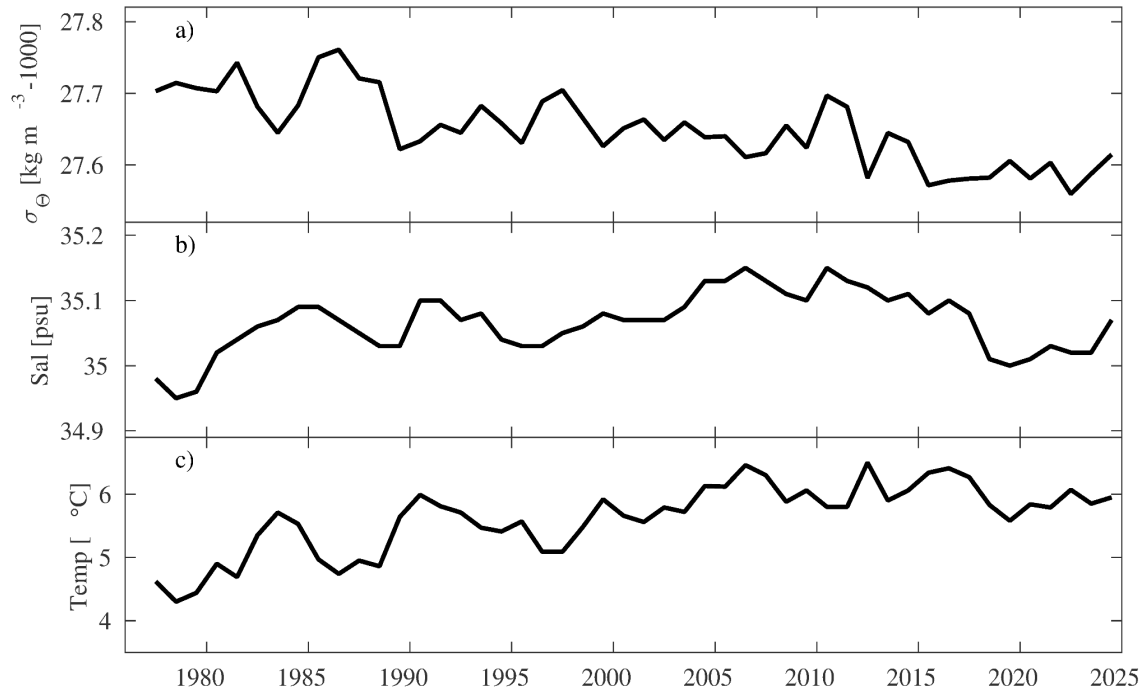


Figure 3: Time series showing annual average a) density, b) salinity, and c) temperature averaged over 50-200 m depth in the Barents Sea Opening section, based on CTD observations during the period 1978-2024.

Extending the analysis to the 1970s using observations from the BSO (Blindheim and Loeng, 1981; González-Pola et al., 2020; Fig. 3b) shows that previous salinity anomalies have been even stronger, most notably in 1978-79 in comparison to one during 2018-2019. Figure 3b,c shows that while the salinity at BSO during the latest salinity anomaly events drops below the low salinity anomalies observed during the late 1980s and late 1990s, the temperature remained relatively high. The lower temperature during those earlier low salinity periods compensated for the lower salinity with respect to density changes. A consequence of the warming in recent decades is therefore an unprecedented (in the instrumental record) low AW density observed since 2016 in the Barents Sea (Fig. 3a).

3.2. Northern Barents Sea

We now shift our focus to the NBS, which, in addition to being influenced by AW, also is dominated by the exchanges of sea ice and less saline and colder Arctic Water from the Polar Basin (Pfirman et al., 1994; Lind et al., 2018). Moreover, the NBS has two sources of AW; inflow of AW from the SBS (Schauer et al., 2002), and the onshelf intrusion of AW flowing eastward along the northern Barents Sea shelf slope in the Polar Basin (Fig 1, Lind and Ingvaldsen, 2012;

Lundesgaard et al., 2022). Our analysis showed an increasing salinity in the NBS, especially during mid-2000s to mid-2010s (trend, 2004-2015: 0.05 ± 0.01 psu/decade), followed by a rapid decline from 2016 onwards until 2022 (trend, 2016-2022: -0.12 ± 0.02 psu/decade; Fig 2a). A lag correlation analysis (deseasoned and detrended) found a significant correlation ($r=0.5$) between the salinity variability of BSO and NBS at a lag of 15 months, which is consistent with the travel time reported by Arthun et al. (2016). Although the relationship becomes more pronounced ($r=0.6$) during the period after 2016 when salinity is declining, it is not significant ($r=0.2$) during the phase of increasing salinity in the NBS. This suggests that different processes govern salinity variability in the NBS during that time. Notably, Lind et al (2018) has attributed the increased salinity in the NBS during the mid 2000 to mid 2010 to the reduced sea ice import from the central Arctic. Since sea ice import is expected to mainly impact the SSS of the region, we further investigate SSS variability of the NBS. Fig. 4 shows the SSS in the NBS for the recent period (2010-2023) obtained from the ESA CCI satellite mission, and the salinity variability at depths from the TOPAZ reanalysis for a longer period. ESA CCI SSS data shows the drop in surface salinity after 2016, as well as during 2013, which may have been linked to extreme sea ice melting in 2012 (Parkinson and Comiso, 2013). The positive trend in salinity from the mid-2000s to mid-2010s is also seen in Fig. 4. This positive trend is consistent with the results of Lind et al. (2018), who showed a similar trend during the time-period due to a decrease in sea ice import from the central Arctic. Our analysis further show that in recent times this trend has changed due to a change in the atmospheric circulation pattern in the central Arctic. The recent freshening in NBS is consistent with an increased sea ice drift into the region (Fig. 5a). When comparing the difference in MSLP during the time-period with increasing salinity in the northern Barents Sea (1993-2015) and the period of rapid decline and lower salinity (2016-2024), we find anomalous northwesterly geostrophic winds that favour increased sea ice import from the central Arctic through the NBS during the latter period (Fig. 5b). Furthermore, the period of increasing salinity is also consistent with the negative trend in fresher Arctic water import from the eastern Barents Sea, which increased thereafter (see Figure 7 in Chatterjee et al., 2024).

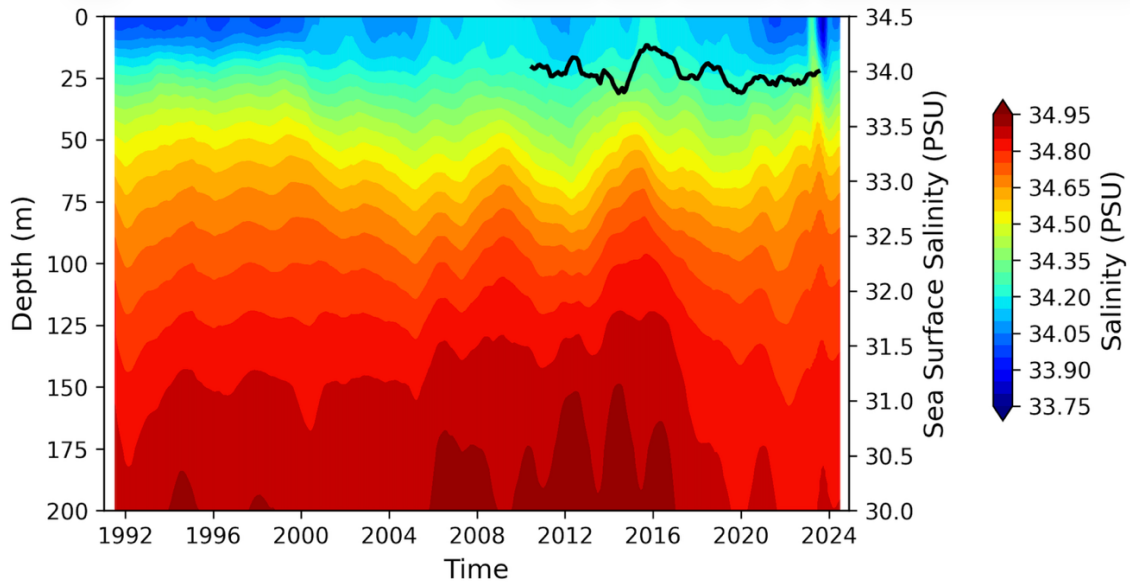


Figure 4. 12-month running mean of monthly salinity in the upper 200m from TOPAZ reanalysis (colour) and sea surface salinity from ESA CCI (black line, right Y-axis) averaged over the northern Barents Sea (76°-80°N, 20°-60°E).

3.3. Downstream effects

In the following, we investigate the downstream effects of the changes in the salinity of the Barents Sea on the dense outflow waters exiting the Barents Sea into the Nordic Seas and the central Arctic. Figure 6 shows the annually averaged temperature and salinity of the densest 5% of the water masses in sections crossing the outflow of dense water from the Barents Sea into the Nordic Seas and into the central Arctic respectively at BSO and St. Anna Trough respectively (SAT; see Fig 1 for locations). At BSO, the increase in temperature during the 2000s was partly offset in terms of density change by an increase in salinity. In the last ten years, however, the drop in salinity has further reduced density to levels unprecedented within the 1993–2024 record (Fig 6a,c). At SAT (Fig 6b,d) the variability of the density of dense waters is in general dominated by temperature, however, in recent years the sharp drop in salinity contributed to form record low density. The cooling of the AW en route through the Barents Sea has been reported to decline in recent decades (Skagseth et al., 2020). A warming trend is also reflected in our model results, with the temperatures of the densest water being below 0° C before 2005 and around or above 0° C in all years after 2005 (Fig. 6b).

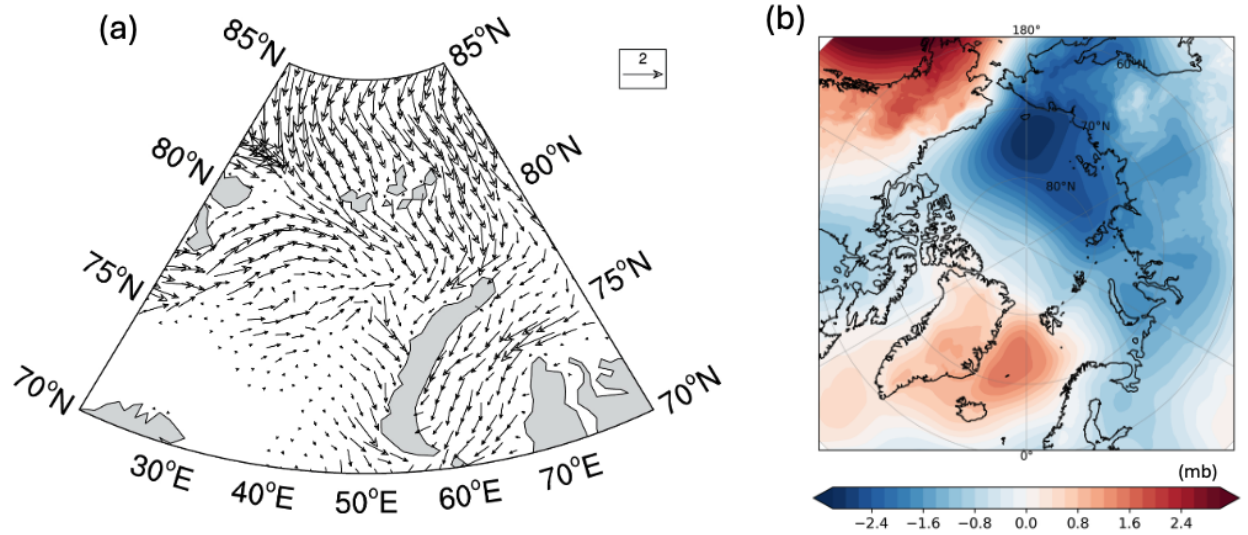


Figure 5. a. TOPAZ4b reanalysis derived winter mean (NDJFM) sea ice drift velocity (cm/s) difference during the two time periods (2016-2024) and (1993-2015). b. Same as (a) but for MSLP difference from ERA-5.

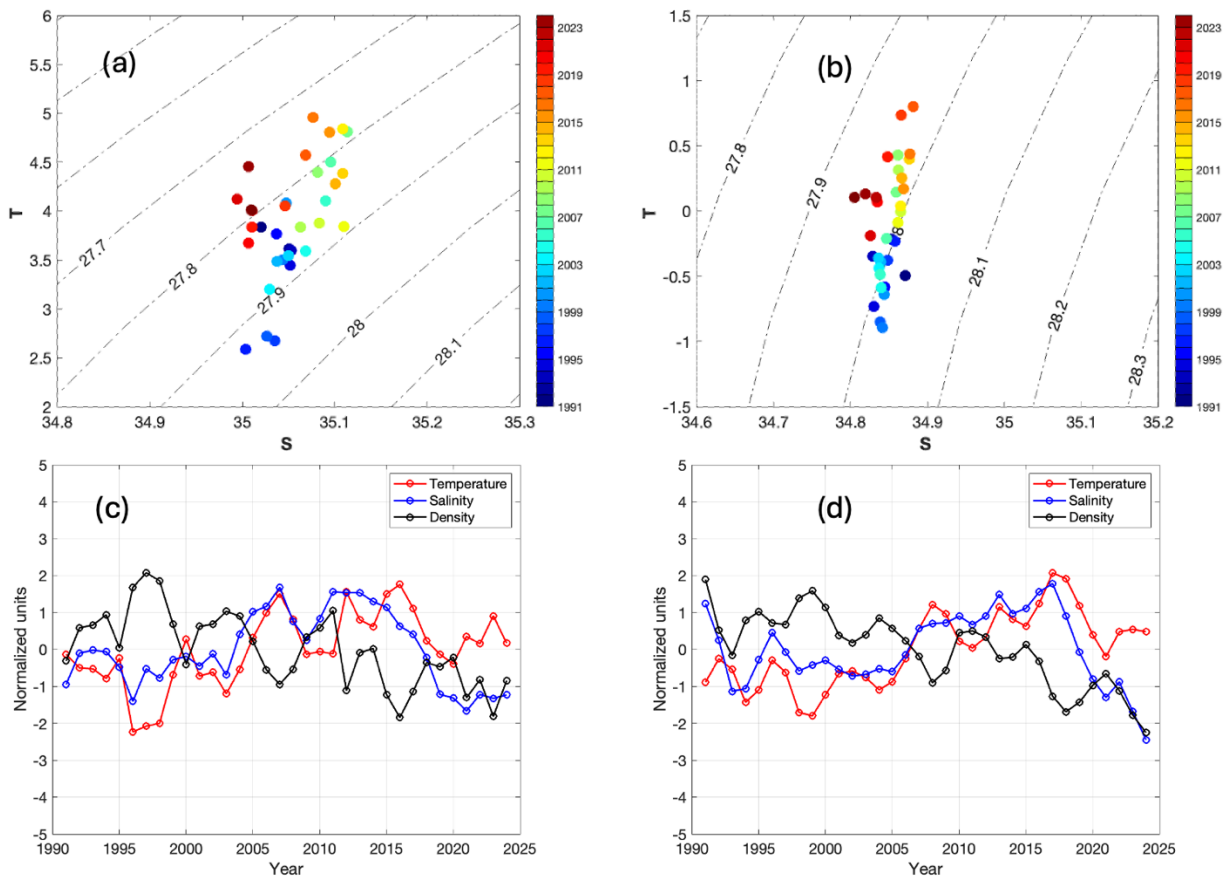


Figure 6. Temperature-salinity diagram showing the hydrographic properties of the densest 5% of the water masses in a) BSO and (b) SAT. The data represent TOPAZ reanalysis annual averages. Color denotes the year of the annual average. The temporal evolution of temperature, salinity and density, shown in panels a and b are presented in panels c and d respectively.

4. Summary and Discussion

In this study, we present the evidence of the recent freshening in the Barents Sea resulting from the unprecedented salinity anomaly observed in the northern North Atlantic during 2012-2016 (e.g., Holliday et al., 2020). The recent salinity anomaly transported into the SBS differs from previous low salinity anomalies (late 1970s and 1980s). During the recent salinity event, the temperature remained relatively high, whereas the temperature and salinity previously covaried (e.g., Furevik, 2001; Mork et al., 2019). A possible mechanism for the positive correlation between temperature and salinity was proposed by Sundby & Drinkwater (2007), suggesting that atmospheric conditions favoring (working against) increased flow along the Norwegian coast push the temperature and salinity gradients downstream (upstream), causing both temperature and salinity to locally increase (decrease). However, the most recent salinity anomaly was caused by lower salinity entering the Nordic Seas from the North Atlantic. This is further underpinned by the observation that while the 2012-2016 salinity anomaly in the North Atlantic was unprecedented for the last 120 years, direct hydrographic observations from the BSO (Blindheim and Loeng, 1981; González-Pola et al., 2020) dating back to the late 1970s, show that the negative salinity anomaly in the Barents Sea during 1977-1979 was even stronger (Fig. 3). Moreover, although relatively colder AW has intruded into the Norwegian Sea from the North Atlantic since the mid-2000s, a reduced heat loss from the ocean surface has helped in sustaining the temperature anomalies and thereby decoupling the temperature and salinity signal in the Nordic Seas (e.g Skagseth et al., 2020, Mork & Skagseth et al., 2019, Chatterjee et al., 2024).

The salinity variability in the NBS is found to be more complex and is influenced by both the sea ice import from the central Arctic as well as the as the AW salinity variability transported from the SBS. The reduction in sea-ice import into the NBS, and associated weakened stratification and increased penetration of AW to the surface has been found to increase the salinity of the region during the time period 2003-2016 (e.g., Lind et al., 2018). Our study showed that the positive trend in the salinity of the NBS no longer exists after 2016; in fact, the salinity of the region has shown a rapid freshening since then. In addition to low saline waters from SBS, this drop in the salinity variability is also linked to the increased transport of sea ice into the region, an opposite scenario to that reported by Lind et al. (2018). During this time period after 2016, anomalous northwesterly geostrophic winds are found to favour increased sea ice import from the central Arctic to the NBS. An increased sea ice import and associated enhanced stratification of the upper ocean in NBS inhibits penetration of AW to the surface, pausing the Atlantification trend, and in turn favors a more direct downstream impact of SBS salinity anomaly through lateral advection (Fig 7). Whereas, with reduced sea ice import during 2003-2016, as reported in Lind et al., (2018), the weakened stratification in the NBS region favours local vertical mixing, which may play a larger role in

driving the NBS salinity over the lateral transport from SBS, as also confirmed by the weaker correlation between BSO and NBS salinity variability during 2003-2016.

Our model results (Fig 6) show that in both outflow regions from the Barents Sea, the densest water masses were warming from the start of our model period in 1993 to 2016 (BSO) and 2018 (SAT). Concurrent with the warming, the salinity was also increasing, partly offsetting the density decrease due to the warming. Then, during the most recent years, the temperature has declined, but a strong decline in salinity offset the increase in density from the cooling, resulting in the density being at the lowest for the full model timeseries. These hydrographic changes are in agreement with findings based on observations both in the BSO (Skagseth et al., 2020) and the SAT (Zabudkina et al., 2025). Moreover, our results indicate that the trends in the hydrographic properties of the dense water exiting the Barents, in either end, to a large degree reflect the trend in the hydrographic properties of the AW initially entering through the BSO, despite the internal water transformation processes. Historical records, however, indicate this not to always be the case. In the proximity of the Novaya Zemlya Bank, where polynya activity causes strong cooling and sea-ice formation and subsequent brine release, dense water with high salinity may form in winter (Knipowitsch, 1905; Nansen, 1906). Indeed, during the period of unprecedented low salinity of the inflowing AW in 1978-79 (Fig. 3b), water with salinity exceeding 35.1 was observed near the bottom in the northeastern Barents Sea, yielding densities $\sigma_\theta > 28.2$ (Midttun, 1985). In 2008, during the period of maximum AW salinity in the BS, no brine-enriched bottom water was observed close to the Novaya Zemlya Bank and the maximum observed density of $\sigma_\theta = 28.09$ (Lien and Trofimov, 2013) was less than the $\sigma_\theta > 28.2$ observed in 1979 (Midttun, 1985). These observations suggest that in today's warmer climate with strongly reduced sea-ice formation in the Barents Sea, the density of the bottom water in the Barents Sea is likely insufficiently large to contribute to intermediate and deep-water renewal during periods of anomalously low salinity.

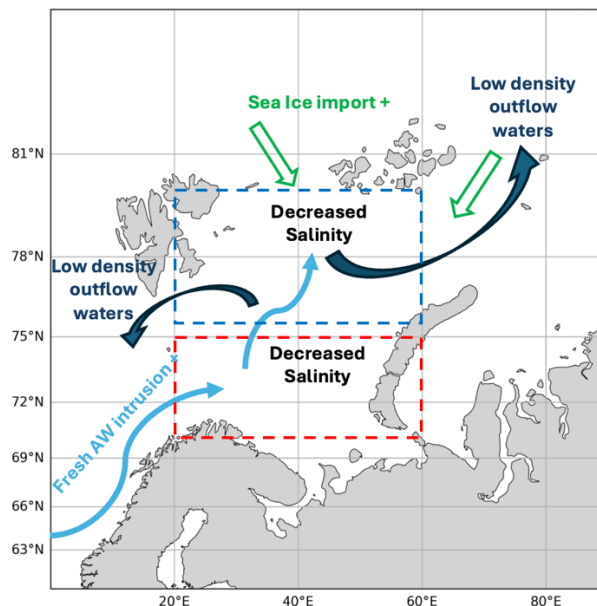


Figure 7. Summary diagram of the mechanisms involved in the recent freshening in the NBS (dashed blue box) and SBS (dashed red box) and its implications on the outflow waters. The figure summarizes the influence of fresh water intrusion into the SBS and NBS via the BSO, the increased sea ice import into the NBS from the central Arctic that in turn effects the stratification and the dampens the surfacing of AW thereby affecting the salinity of the region.

Table 2. List of acronyms and definitions used in this study.

Acronyms	Definitions
AW	Atlantic Water
AMOC	Atlantic Meridional Overturning Circulation
BS	Barents Sea
BSO	Barents Sea Opening
CCI	Climate Change Initiative
ESA	European Space Agency
ERA5	ECMWF Reanalysis Version5
ICES	International Council for the Exploration of the Sea
MSLP	mean sea level pressure
NAO	North Atlantic Oscillation
NBS	Northern Barents Sea
NwAFC	Norwegian Atlantic Front Current
NwASC	Norwegian Atlantic Slope Current
SAT	St. Anna Trough
SBS	Southern Barents Sea
SMAP	Soil Moisture Active Passive
SMOS	Soil Moisture and Ocean Salinity
SSS	Sea surface salinity

Author contribution: RR, VSL, SC were involved in the initial study design, analysis, discussion and writing the manuscript. SS was involved in the analysis, while AB and LB were involved in discussions and the writing phase.

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