Poleward Shift in Ventilation of the North Atlantic Subtropical Underwater (STUW)

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Problem: The subtropical high pressure of the descending branch of the Hadley circulation is located between 20° and 40° of both north and south latitudes. Within the zone, a pool of sea surface salinity maximum (SSS-max) exists in responding to the excess of evaporation over precipitation. This study is to report that the sea-surface salinity maximum (SSS-max) in the North Atlantic has poleward expanded in recent decades, and that the expansion is a main driver of the decadal changes in subtropical underwater (STUW) —a high-saline water mass in the upper 50–300 m.

Key Findings: The STUW ventilation zone (marked by the location of the 36.7 isohaline) has been displaced northward by 1.2 ± 0.36° latitude for the 34-year (1979-2012) period (Fig.1). As a result of the redistribution of the SSS-max water, the ventilation zone has shifted northward and expanded westward into the Sargasso Sea (Fig.2). The ventilation rate of STUW has increased, which is attributed to the increased lateral induction of the sloping mixed layer (Fig.3). STUW has become broader, deeper, and saltier, and the changes are most pronounced on the northern and western edges of the high-saline core (Fig.4).

Figure 1

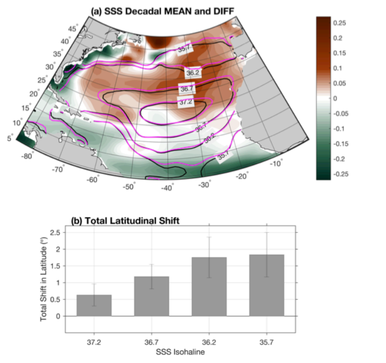


Fig 1. Mean SSS in the 1980s (black) & 2000s (magenta) with the SSS mean differences between the two decades in the background (colors). (b) Total shift in the positions of the selected isohalines located north of 25°N. Error bars denote the 95% confidence interval estimates.

Figure 2

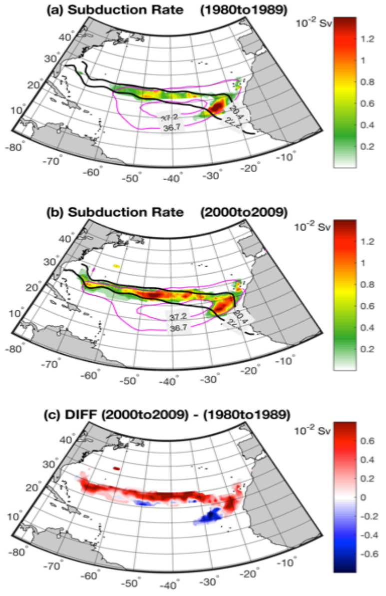


Fig 2. Mean subduction rate (colors) in (a) the 1980s, (b) the 2000s, and (c) the differences between the two decades. In (a)-(b), black (magenta) contours denote the 20.4 and 22.2°C outcrop isotherms (36.7 and 37.2 outcrop isohalines) in March for the respective decade.

Figure 3

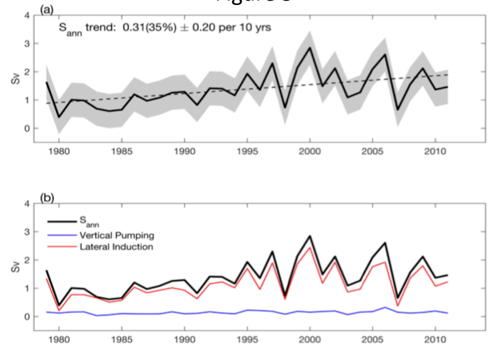
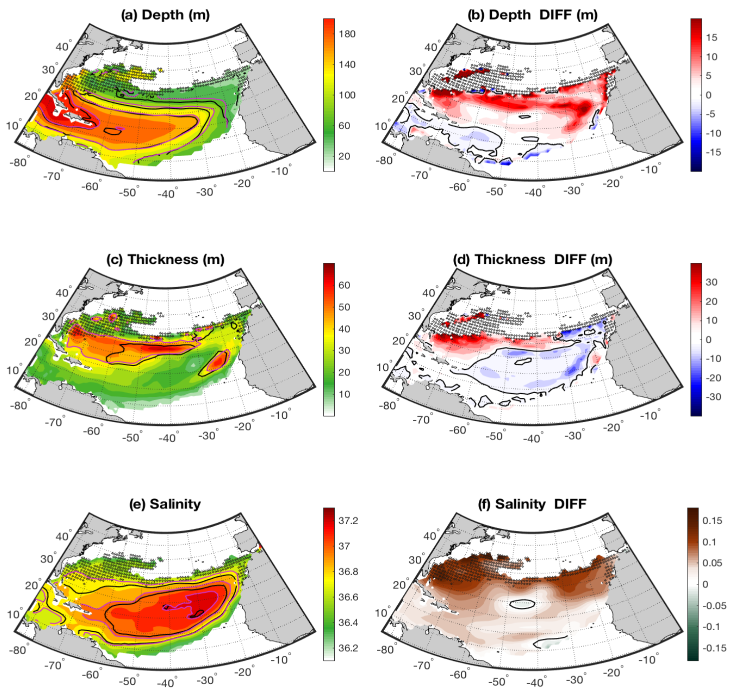


Fig 3. Time series of (a) annual-mean subduction rate with trend estimate, and (b) annual-mean subduction rate (black) and the respective contributions from vertical pumping (blue) and lateral induction (red).

Fig 4. Mean properties of STUW in the 1980s (black contours) and the 2000s (colors and red contours): (a) depth, (c) layer thickness, and (e) salinity. The 2000s-minus-1980s difference anomalies in the properties of STUW: (b)depth, (d) layer thickness, and (f) salinity. In (a)-(f), the stippled areas denote the areas exiting only in the 2000s as a result of the STUW expansion.

Figure 4



Significance: This study shows that the increase of SSS-max in the North Atlantic is due to the poleward expansion of the SSS-max center in association with the widening of the tropics, which is different from the "dry-gets-drier and wet-gets-wetter" paradigm. The expansion has shifted the ventilation zone poleward, leading to an increased production of the STUW. The change in STUW could have profound impacts on both the equatorial thermocline and the North Atlantic Deep Water, as the STUW propagates into the tropical and subpolar regions via interior pathways.

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