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Was the Atlantic a predominantly Polar Ocean during the last glacial?

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The Last Glacial Maximum (LGM) is marked by significant cooling of the global ocean, which was recently estimated to 2.6°C using noble gases trapped in ice cores (1). This cooling is not equally distributed throughout the world oceans, since global ocean circulation models predict regional temperature anomalies during the LGM of up to 7°C (annually and zonally averaged) when compared to modern interior ocean temperature (2). The oceans deep interior thus became haline stratified (3) due to the drop in temperature to near freezing and the global increase in salinity from ice sheet growth. In contrast to a deepening of the modern thermocline as a result of anthropogenic global warming, cooling causes the thermocline to rise in the sub-tropics as more polar waters enter the mid-depth ocean.

Here we present glacial thermocline temperature reconstructions since the LGM based on the Li/Mg ratio in aragonite skeletons of precisely dated cold-water corals. Corals have been collected from 300-1000m water depths from sites in the northern and southern Atlantic (62°N to 25°S) and demonstrate synchronous 5 - 7°C glacial cooling, and a dramatic shoaling of the thermocline. Through the deglaciation the warming of the upper thermocline ocean occurs early in the southern hemisphere followed by fluctuating warming and thermocline deepening in the northern Hemisphere, which supports the oceanic climate seesaw proposed by Stocker and Johnson in 2003 (4). We thus propose dramatic changes in export of polar waters towards the Equator and augmented subsurface ocean stratification leading to a mostly polar Atlantic with a shallow permanent thermocline. This shoaling possibly increased the rate of nutrient recycling causing higher biological surface ocean activity and the cooling promoted carbon storage. During the

glacial, we assume an atmospheric forcing, such as equatorward displacement of the Hadley circulation, to steer the glacial polar water advance as mid-depth boundary currents in the northern and southern hemisphere to effectively spread the cold water through the entire mid-depth Atlantic.

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