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**Topic:** Critical drivers for ocean salinity science and applications and the future need for high-resolution technologies

**Title:** Coupled Salinity–Temperature Extremes and Upper-Ocean Stratification During Marine Heatwaves in the Northwest Atlantic

**Abstract:** Marine heatwaves (MHWs) have intensified in both frequency and magnitude worldwide, with especially pronounced impacts in western boundary current regions such as the Gulf Stream (GS). In these highly dynamic environments, variability in ocean circulation strongly shapes upper-ocean stratification and regulates the storage and redistribution of heat. This study focuses on salinity variability during MHWs in the Northwest Atlantic, examining how salinity anomalies evolve in tandem with changes in surface and subsurface temperature.

We integrate satellite observations of sea surface temperature (SST) and sea surface salinity (SSS) with high-resolution ocean reanalysis products to resolve the spatial distribution and vertical structure of MHWs during recent years marked by heightened activity. A uniform, threshold-based methodology is employed to detect anomalous conditions in temperature and salinity and to evaluate their interaction. To further investigate dynamical drivers, a largest-contour eddy tracking technique applied to satellite-derived sea surface height and reanalysis data is used to assess connections among Gulf Stream eddy properties, salinity anomalies, and MHW characteristics.

Our analysis indicates that surface freshening strengthens upper-ocean stratification, limits vertical mixing, and supports MHWs that are intensified near the surface and persist for extended periods. In contrast, episodes of elevated salinity associated with Gulf Stream advection and warm-core ring activity reduce stratification, facilitate enhanced vertical exchange, and contribute to MHWs that penetrate deeper into the water column with pronounced subsurface signatures. Notably, substantial shelf freshening observed in 2023 occurred simultaneously with extensive and long-lasting MHW conditions, emphasizing the importance of salinity in governing event evolution. Furthermore, an inverse relationship emerges between MHW spatial extent and peak intensity, consistent with the differing prevalence of events occurring within cool-core versus warm-core rings.

Overall, these results underscore the critical influence of salinity variability and Gulf Stream mesoscale dynamics in shaping the vertical structure, magnitude, and duration of MHWs in the Northwest Atlantic. By extending established MHW detection approaches beyond SST to include sea surface salinity, this work demonstrates that coherent salinity extremes accompany and actively modulate marine heatwave development.

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