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Stable H and O isotope signals to define the provenance and transformations of marine suspended organic matter

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The processes that determine the reactivity of marine organic matter (OM) and thereby the balances of carbon fluxes, energy, and climate have been elucidated by chemical fingerprints that are encoded during OM transformation. The formation of North Atlantic Deep Water (NADW) provides a useful starting point to assess such transformations, as dissolved and suspended OM (SOM) is exported from productive surface waters into the bathypelagic, where it is respired by microbial communities over timescales of years to centuries. Considering that production and mineralization fluxes should alter not only the carbon (C) content of SOM, but also organically bound hydrogen (H) and oxygen (O), we hypothesized that stable H and O isotope composition of SOM may encode signatures of its provenance and transformation. We isolated SOM via solid phase extraction of N. Atlantic waters (5-10 L; 10 – 4100 m; n = 72) in summer 2023, following the subduction of NADW along a north-south transect, and determined the fraction of exchangeable (f_{ex}) H and O, and stable isotope ratios of non-exchangeable H and O ($\delta^{18}O_n$ and $\delta^{2}H_n$) via Uniprep-IRMS. $\delta^{2}H_n$- and $\delta^{18}O_n$-SOM values showed relatively high variability ranging from -180 to -167 ‰ and +15.5 to +20.7 ‰, respectively, while $\delta^{13}C$ values ranged from -24.1 to -21.8 ‰. $\delta^{2}H_n$ values were typically lowest in the surface ocean (-178 ± 2 ‰), particularly at the lower latitudes, while $\delta^{18}O_n$ values typically exhibited a subsurface minimum at 100 m (+17.8 ± 1.0 ‰) and maximum in mesopelagic waters (650 – 1200 m; +19.5 ± 0.8 ‰). Collectively, the novel stable isotope signals of non-exchangeable H and O have begun to identify site-specific factors (e.g., surface production and photo-oxidation) and conserved trends (subsurface oxidation) that govern SOM distribution and reactivity in the marine environment.