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Trace metal distributions in the Labrador Sea reveal water alteration processes and iron and nitrogen colimitation

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The Labrador Sea is a climatically important and physically complex region, as the meeting place for highly modified southbound Arctic waters, northward flowing Atlantic waters, and freshwater inputs from sea ice and glacial melt off Greenland. A greater understanding of water mass alteration processes is required to discern this region's response to a changing climate. Additionally, despite significant study of trace metal biogeochemistry in adjacent regions, the role of metal micronutrients in driving biological productivity in the Labrador Sea has been poorly constrained. Here we leverage dissolved trace metal concentrations in Labrador Sea surface waters (< 300 m) in May 2025 to gain a greater understanding of water alteration processes in the subpolar North Atlantic and to illuminate the role of trace metals in controlling primary productivity. Iron (Fe), manganese (Mn), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), cadmium (Cd), and lead (Pb) have distinct signatures across the sea due to differing source waters from west to east. Southward flowing Arctic-origin waters, carried by the Labrador Current, have been modified by the shallow shelves and freshwater inputs of the Canadian Arctic Archipelago and are more concentrated in Mn, Fe, Co, Ni, and Cu. Conversely, Atlantic-origin Labrador Sea waters have enhanced concentrations of Zn and Pb. Shelf input from the Canadian Atlantic coast further modifies the waters west of 54°W, resulting in high concentrations of trace metals. However, rapid scavenging from this shelf source exposes the eastern Labrador Sea to potential productivity limitation by Fe, as evidenced by elevated NO_3:Fe ratios, and Fe* values approaching zero. Shipboard bioassay experiments indicated episodic iron-nitrate colimitation during the spring bloom, with intensified phytoplankton growth and nutrient drawdown when Fe and nitrate were both added to the phytoplankton community. Ongoing analyses of phytoplankton abundance and protein expression changes in response to Fe and N supplementation will further elucidate the role of Fe as a productivity driver in this system. By combining geochemical, physiological and molecular explorations of this colimitation, we explore projections for changing extent of Labrador Sea Fe limitation into the future, with amplified Arctic freshwater export, increased stratification, and suppressed nutrient transport.