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Heme b distributions through the Atlantic Ocean: in situ identification of iron limited phytoplankton

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Heme *b* is an iron-containing cofactor in hemoproteins that participates in the fundamental processes of photosynthesis and respiration in phytoplankton. Heme *b* concentrations typically decline in waters with low iron concentrations but due to lack of field data, the distribution of heme *b* in particulate material in the ocean is poorly constrained. Within the framework of the Helmholtz Research School for Ocean System Science and Technology (HOSST) and the GEOTRACES programme, the authors compiled datasets and conducted multidisciplinary research (e.g. chemical oceanography, microbiology, biogeochemical modelling) in order to test heme *b* as an indicator of *in situ* iron-limited phytoplankton. This study was initiated in the North Atlantic Ocean and expanded to the under-sampled South Atlantic Ocean for comparison of the results considering the different phytoplankton populations. Here, we report particulate heme *b* distributions across the Atlantic Ocean (59.9°N to 34.6°S). Heme *b* concentrations in surface waters ranged from 0.10 to 33.7 pmol L^{-1} (median=1.47 pmol L^{-1}, n=974) and were highest in regions with a high biomass. The ratio of heme *b* to particulate organic carbon (POC) exhibited a mean value of 0.44 µmol heme *b* mol^{-1} POC. We identified the ratio of 0.10 µmol heme *b* mol^{-1} POC as the cut-off between heme *b* replete and heme *b* deficient phytoplankton. By this definition, the ratio heme *b* relative to POC was consistently below 0.10 µmol mol^{-1} in areas characterized by low Fe supply; these were the Subtropical South Atlantic gyre and the seasonally iron limited Irminger Basin. Thus, the ratio heme *b* relative to POC gave a reliable indication of iron limited phytoplankton communities in situ. Furthermore, the comparison of observed and modelled heme *b* suggested that heme *b* could account for between 0.17-9.1% of biogenic iron. This range was comparable to previous culturing observations for species with low heme *b* content and species growing in low Fe (≤0.50 nmol L^{-1}) or nitrate culturing media. Our large scale observations of heme *b* relative to organic matter suggest the impact of changes in iron supply on phytoplankton iron status.