Trace oxygen shifts nitrogen metabolism and stimulates nitrogen reduction in low-oxygen marine waters.

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The oceans are currently losing O_2 as the result of human activity, which may have dramatic effects on global climate and biodiversity. As O_2 is depleted to near anoxia, microorganisms transition from O_2-based to several possible NO_x-based metabolisms: denitrification, anammox, and dissimilatory nitrite reduction to ammonium (DNRA). These three metabolisms are differentially affected by environmental conditions, and, in turn, have different geochemical outcomes, including nitrogen loss and carbon oxidation. The net consequences of marine O_2-loss may therefore depend on which NO_x-based metabolisms engage as O_2 is depleted. The regulation of NO_x-based metabolisms under low O_2 has received little attention, however, because it is generally assumed that NO_x reduction only occurs in the absence of O_2. The threshold for anoxia is typically defined by an analytical O_2 detection limit of 1-2μM O_2, despite evidence that NO_x reduction occurs both above and below this limit. Here, we use stable nitrogen isotope (^{15}N) incubations of seawater collected from a model anoxic marine environment (Saanich Inlet, BC) to determine the rates and pathways of NO_x reduction under both anoxic conditions and within a high-resolution range of low O_2 conditions (0.1 – 10μM). We show that multiple pathways of NO_x-reduction can co-occur in the presence of low O_2, and that these pathways are differentially regulated; anammox and DNRA persist in the presence of up to 8μM O_2, while denitrification is inhibited by approximately 4μM O_2. Furthermore, we demonstrate that rates of denitrification and DNRA are highest under very low O_2 concentrations (0.1-2μM) rather than fully anoxic conditions, which is a previously unrecognized interaction between O_2 and NO_x-reduction. Additionally, we observed a trade-off between the rates of denitrification and DNRA across these very low O_2 concentrations, highlighting the importance of interactions between competing pathways that would normally be overlooked in studies with low-resolution in O_2. These findings have implications for the biogeochemical models that predict microbial metabolic responses to ocean deoxygenation and their ecological impacts.