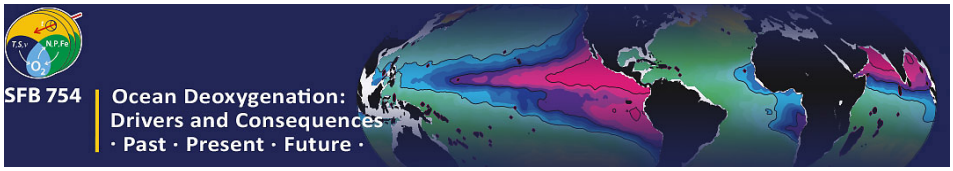

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Critical oxygen levels of marine animals and the consequences of ocean deoxygenation and warming

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Oxygen supply to the sites of cellular respiration requires a partial pressure (PO2) gradient from the environment to the mitochondria to drive diffusion. In surface waters of the ocean, as in air, the PO2 drops from 21 kPa in ambient water to less than 1 kPa at the mitochondria. In some marine environments, such as mesopelagic oxygen minimum zones (OMZ), the PO2 in the ambient water is less than 0.5 kPa. Thus, the PO2 gradient driving oxygen utilization is a mere fraction of that required for aerobic metabolism in terrestrial, and most marine, environments. While animal diversity and abundance are reduced in the OMZ core, life does thrive there. Here we review hypoxia tolerance (critical oxygen partial pressures, Pcrit) in marine animals and show that hypoxia tolerance varies widely across species. This variation is unrelated to metabolic rate, phylogeny, body mass or temperature due to the fact that O2 demand and environmental hypoxia are compensated for by evolved physiological adjustments that enable effective O2 extraction, transport, and utilization. Temperature is the primary driver of intraspecific variation in Pcrit due to effects on oxygen demand. However, because temperature increases O2 supply, the average temperature sensitivity of Pcrit is less than that for metabolic rate. Despite substantial physiological adaptation and diversity, distributions of most species appear to be constrained by oxygen supply relative to demand. We demonstrate that changes in oxygen of only a few micromolar, which may occur over very short vertical and horizontal distances, are important in structuring some mesopelagic communities, even though these ecosystems contain species with the greatest hypoxia tolerance (lowest Pcrits) of any animals measured to date. Ocean deoxygenation will reduce environmental oxygen supply while global warming will increase metabolic demand, reducing the metabolically available habitat and dramatically restructuring mesopelagic communities.

Position

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