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TITLE: Oxygen- and capacity-limitation of thermal tolerance: a matrix for integrating climate-related stressor effects in marine ecosystems

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ABSTRACT:

The concept of oxygen- and capacity-dependent thermal tolerance in aquatic ectotherms has successfully explained climate-induced effects of rising temperatures on species abundance in the field. Oxygen supply to tissues and the resulting aerobic performance characters thus form a primary link between organismal fitness and its role and functioning at the ecosystem level. The thermal window of performance in water breathers matches their window of aerobic scope. Loss of performance reflects the earliest level of thermal stress, caused by hypoxaemia and the progressive mismatch of oxygen supply and demand at the borders of the thermal envelope. Oxygen deficiency elicits the transition to passive tolerance and associated systemic and cellular stress signals like hormonal responses or oxidative stress as well as the use of protection mechanisms like heat shock proteins at thermal extremes. Thermal acclimatization between seasons or adaptation to a climate regime involves shifting thermal windows and adjusting window widths. The need to specialize on a limited temperature range results from temperature-dependent trade-offs at several hierarchical levels, from molecular structure to whole-organism functioning, and may also support maximized energy efficiency. Various environmental factors like CO(2) (ocean acidification) and hypoxia interact with these principal relationships. Existing knowledge suggests that these factors elicit metabolic depression supporting passive tolerance to thermal extremes. However, they also exacerbate hypoxaemia, causing a narrowing of thermal performance windows and prematurely leading the organism to the limits of its thermal acclimation capacity. The conceptual analysis suggests that the relationships between energy turnover, the capacities of activity and other functions and the width of thermal windows may lead to an integrative understanding of specialization on climate and, as a thermal matrix, of sensitivity to climate change and the factors involved. Such functional relationships might also relate to climate-induced changes in species interactions and, thus, community responses at the ecosystem level.

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