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## It's not just oxygen: Understanding and managing a multiple stressor world

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Deoxygenation does not occur in isolation. Anthropogenic nutrient enrichment, acidification, fisheries, rising temperatures, and other consequences of human activities can all influence the process of deoxygenation and alter physiological and ecological consequences of oxygen decline. The effects of multiple stressors can depend on the timing and order of exposures as well as severity; interactive effects can occur at levels of organization ranging from physiology to landscapes. The difficulty of clearly predicting combined effects of multiple stressors complicates our ability to project futures under a variety of scenarios, and to develop and implement effective management strategies.

This talk will focus on recent and new ideas on the general issue of multiple stressors, and especially the combined effects of oxygen and other stressors in coastal systems and semi-enclosed seas. Proximity to large human populations results in these systems being altered by activities within their local watershed, airshed and waters. In addition, they are strongly affected by global consequences of increased greenhouse gas emissions, and are warming and becoming more acidic as well as more oxygen-depleted as a result. Although the large temporal and spatial variation in physical characteristics of these systems may have already selected for species with wide physiological tolerances, both experiments and models show that the combined effects of multiple stressors can strongly affect both individual organisms and food webs. Rising temperatures, deoxygenation and acidification are especially tightly linked; warming and nutrient enrichment increase respiration, which depletes oxygen and releases CO<sub>2</sub>. Some stressors, such as increased temperatures, can make animals more sensitive to low oxygen, while others such as high mortality rates due to fisheries, may mask oxygen effects. Development of a framework for understanding effects of multiple stressors will require us to consider processes across life stages, generations and landscapes, as well as how behavioral responses to hypoxia can determine exposure to other stressors.

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