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Temporal variability of hypoxic zones

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Oxygen is a critical constraint on marine ecosystems. As oceanic O_2 falls to hypoxic concentrations, habitability for aerobic organisms decreases rapidly. We show that the spatial extent of hypoxia is highly sensitive to small changes in the ocean's O_2 content, and that this sensitivity is strongest at suboxic concentrations, where anaerobic metabolisms predominate. In model-based reconstructions of historical oxygen changes, the world's largest suboxic zone, in the Pacific Ocean, varies in size by two-fold. We investigate the causes and mechanisms behind these changes on seasonal and decadal time-scales. Small changes in the depth of the tropical and subtropical thermocline driven by Pacific climate are the primary cause of low-O_2 variability on decadal time-scales because thermocline depth has a multiplicative effect on the export of organic matter from surface waters and the fraction of it that is respired within the uplifted waters. These results imply even larger fluctuations in the rate of nitrogen removal via denitrification, creating a link between decadal climate oscillations and the nutrient limitation of marine photosynthesis.