Widespread deoxygenation of temperate lakes

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The concentration of dissolved oxygen in aquatic systems helps to regulate biodiversity1,2, nutrient biogeochemistry3, greenhouse gas emissions4, and the quality of drinking water5. The long-term declines in dissolved oxygen concentrations in coastal and ocean waters have been linked to climate warming and human activity6,7, but little is known about the changes in dissolved oxygen concentrations in lakes. Although the solubility of dissolved oxygen decreases with increasing water temperatures, long-term lake trajectories are difficult to predict. Oxygen losses in warming lakes may be amplified by enhanced decomposition and stronger thermal stratification8,9 or oxygen may increase as a result of enhanced primary production10. Here we analyse a combined total of 45,148 dissolved oxygen and temperature profiles and calculate trends for 393 temperate lakes that span 1941 to 2017. We find that a decline in dissolved oxygen is widespread in surface and deep-water habitats. The decline in surface waters is primarily associated with reduced solubility under warmer water temperatures, although dissolved oxygen in surface waters increased in a subset of highly productive warming lakes,

probably owing to increasing production of phytoplankton. By contrast, the decline in deep waters is associated with stronger thermal stratification and loss of water clarity, but not with changes in gas solubility. Our results suggest that climate change and declining water clarity have altered the physical and chemical environment of lakes. Declines in dissolved oxygen in freshwater are 2.75 to 9.3 times greater than observed in the world's oceans6,7 and could threaten essential lake ecosystem services2,3,5,11

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