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Physical and biological contributions to metalimnetic oxygen maxima in lakes

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Abstract

Many lakes have positive, heterograde vertical oxygen (O_2) profiles with a metalimnetic maximum usually assumed to be the result of biological O_2 production. However, supersaturated metalimnetic O_2 maxima are formed by biological processes (net photosynthetic production of O_2) and physical processes (warming of gasses trapped below the thermocline). Although the mechanisms contributing to supersaturated metalimnetic O_2 peaks are understood, the contribution of biological vs. physical processes is not well known in lakes. To examine these contributions, we measured O_2 and argon (Ar) saturation anomalies in the metalimnia of 17 lakes. Unlike O_2, Ar is biologically inert and, therefore, can be used to quantify physical processes. There was a positive Ar anomaly at the depth of the O_2 maximum in every lake. On average, only 14% of the O_2 maximum could be attributed solely to biological production of O_2, but this percentage varied widely among lakes. Additionally, in a subset of lakes, the relative saturation of O_2 at the metalimnetic maximum was lower than Ar due to net biological consumption, creating a weaker O_2 maximum than would be expected based on the physical processes alone. Some lakes were sampled multiple times during summer and net ecosystem production (NEP) was also calculated. There were many instances of positive NEP in the metalimnion; however, net autotrophy was usually transient instead of persistent. Overall, biological production of O_2 alone is not responsible for metalimnetic O_2 maxima as both physical and biological processes contribute substantially to the formation and persistence of O_2 maxima in lakes.