Light-dependent aerobic methane oxidation reduces methane emissions from seasonally stratified lakes

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Freshwater lakes represent large methane sources, which contribute significantly to methane emissions to the atmosphere. However, microbial methane oxidation, an important methane sink, remains poorly constrained in stratified water columns. Despite numerous reports of microbially-mediated methane oxidation occuring in anoxic hypolimnia, involved bacteria and electron acceptors remain largely unidentified.

Here we investigated biological methane oxidation in the water column of the seasonally stratified Lake Rotsee, Central Switzerland. A zone of methane oxidation extending from the oxic/anoxic interface into anoxic waters was identified by chemical profiling of oxygen, methane and $\delta^{13}C$ of methane. Incubation experiments with ^{13}C-methane yielded highest oxidation rates within the oxycline, and comparable rates were measured in anoxic waters. Despite predominantly anoxic conditions within the zone of methane oxidation, known groups of anaerobic methanotrophic archaea were conspicuously absent. Instead, aerobic gammaproteobacterial methanotrophs were identified as the active methane oxidizers. In addition, continuous oxidation and maximum rates always occurred under light conditions. These findings, along with the detection of chlorophyll α and measured primary production rates, suggest that aerobic methane oxidation is tightly coupled to light-dependent photosynthetic oxygen production both at the oxycline and in the anoxic bottom layer. It is likely that this interaction between oxygenic phototrophs and aerobic methanotrophs represents a widespread mechanism by which methane is oxidized in lake water, thus diminishing its release into the atmosphere.