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Hotspots of methane formation – a response to melting sea ice in nitrate stressed Polar surface water

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The Arctic Ocean is one of the regions in the world where climate change is mostly pronounced. Increased summer melting has been considered to amplify biological production as a consequence of the shift from an ice-covered to an open water Arctic Ocean. However, stronger water stratification during sea ice melting generally limits nutrient availability in near-surface water, which in turn hampers the enhancement of primary production and creates oligotrophic conditions in near-surface water after a spring bloom. Because the Arctic Ocean receives water from the Atlantic and the Pacific Ocean and surface water from both oceans differ in their N: P ratio, different stages of oligotrophy are established in Atlantic and Pacific derived Arctic water respectively.

Here we report on hotspots of methane formation in the central Arctic Ocean and in the western Fram Strait, which were detected exclusively in Pacific derived water but not in the adjacent Atlantic derived water. We show that nitrate exhaustion is a primary requirement for methane production in aerobicwater. A second pre-condition in the high latitudes is the phosphate excess, which is utilized as a P source by bacteria. Where phosphate is available as a source of P, methylated compounds like DMSP and its degradation products may serve as the bacterial C source. During a regenerated production, when a combination of these conditions exists, methane may be a metabolic by-product and its production could yield energy even under aerobic conditions ([O2] ∼ 400 [U+F06D]M). The metabolic activity (respiration) of unicellular organisms explains the presence of anaerobic conditions in the cellular environment. The limiting conditions for the maintenance of a reduced niche inside a cell within an aerobic environment are discussed in terms of a theoretical Model. Methane production may occur as a rapid response to environmental perturbations during the shift from a phytoplankton bloom to an oligotrophic system and is directly linked to the N, P and C cycles. Thus, feedback effects on cycling pathways of the climatically relevant biogases methane and DMS are likely, with DMSP catabolism in high latitudes possibly contributing to a warming effect on the earth's climate through increasing production of the greenhouse gas, methane.