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Effect of bottom water oxygenation on oxygen consumption and benthic biogeochemical processes at the Crimean Shelf (Black Sea)

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Hypoxia occurs where oxygen concentrations fall below a physiological threshold of many animals, usually defined as <63 μmol L-1. Oxygen depletion can be caused by anthropogenic influences, such as global warming and eutrophication, but as well occurs naturally due to restricted water exchange in combination with high nutrient loads (e.g. upwelling). Bottom-water oxygen availability not only influences the composition of faunal communities, but is also one of the main factors controlling sediment-water exchange fluxes and organic carbon degradation in the sediment, usually shifting processes towards anaerobic mineralization pathways mediated by microorganisms.

The Black Sea is one of the world's largest meromictic marine basins with an anoxic water column below 180m. The outer shelf edge, where anoxic waters meet the seafloor, is an ideal natural laboratory to study the response of benthic ecosystems to hypoxia, including benthic biogeochemical processes. During the MSM 15/1 expedition with the German research vessel MARIA S. MERIAN, the NW area of the Black Sea (Crimean Shelf) was studied. The study was set up to investigate the influence of bottom water oxygenation on, (1) the respective share of fauna-mediated oxygen uptake, microbial respiration, or re-oxidation of reduced compounds formed in the deeper sediments for the total oxygen flux and (2) on the efficiency of benthic biogeochemical cycles. During our study, oxygen consumption and pathways of organic carbon degradation were estimated from benthic chamber incubations, oxygen microprofiles measured in situ, and pore water and solid phase profiles measured on retrieved cores under oxic, hypoxic, and anoxic water column conditions.

Benthic oxygen fluxes measured in Crimean Shelf sediments in this study were comparable to fluxes from previous in situ and laboratory measurements at similar oxygen concentrations (total fluxes -8 to -12 mmol m-2 d-1; diffusive fluxes: -2 to -5 mmol m-2 d-1) with oxygen penetrating less than 5 mm into the seafloor. In total oxygen uptake by the seafloor, the fraction of the diffusive flux, which comprises microbial consumption plus re-oxidation of reduced compounds, increased with declining oxygen concentrations. Measurements and modeling of penetration depths and fluxes of the electron acceptors nitrate, iron- and manganese oxides, sulfate suggest that as long as oxygen is available in the oxic and the hypoxic zones of the Crimean shelf, the largest fraction of oxygen is consumed directly during aerobic mineralization of organic matter and re-oxidation processes play only a minor role. Furthermore, the combination of rapid and strong fluctuation of bottom water oxygen concentration and low sedimentation rates appear to repress anaerobic organic matter degradation.

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