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Effect of hypoxia on benthic nutrient fluxes in the northwestern Black Sea

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The western Black Sea shelf has been affected by eutrophication from the 1960s to the mid 1990s. A combination of increased nutrient loads from the major inflowing rivers Danube, Dniester and Dnepr and favourable climate conditions led to high productivity regimes. As a consequence, increased oxygen consumption due to decomposition of organic matter caused recurrent seasonal bottom water hypoxia for more than 20 years. In addition, recycling of nutrients from organic matter settling to the seafloor along with tight benthic-pelagic coupling represents an important internal source for productivity, hence internally supporting eutrophication. From the 1970s to 1990s, the benthic and pelagic systems deteriorated and ecosystem structure and functioning changed. Following the collapse of the centrally planned economies in the eastern European countries during the 1990s, the riverine nutrient input decreased, and the ecosystem, now slowly responding, shows signs of recovery; e.g. by a decrease in hypoxic events.

In this study, benthic nutrient flux data from in-situ and ex-situ experiments during the 1990s on the Danube-influenced north-western Black Sea shelf and data from the 2000s, including the EU-FP7 HYPOX experiments, are analysed to reveal the effect of hypoxia on benthic nutrient fluxes. Mann-Whitney statistical tests have been applied to demonstrate the significance of differences in fluxes due to varying oxygen conditions in the water.

During the 1990s experiments, bottom water hypoxia was encountered in all locations, while during the 2000s hypoxia has been met only during summer in the Danube Prodelta area and near the Dniester mouth. Indeed, bottom water oxygen in the 1990s has been statistically significantly lower than in the 2000s while benthic oxygen consumption was higher during eutrophication-induced hypoxia. The benthic nutrient fluxes in the 1990s and the 2000s however do not differ significantly. During hypoxia, despite ceasing eutrophication, ammonia release from the sediments has been significantly higher than in oxic conditions, while no significant differences were detected in nitrate effluxes. This may be explained by dissimilatory reduction of the nitrate stored in large sulphate reducing bacteria like Beggiatoa (DNRA) leading to high fluxes of ammonia. DNRA might be an important recycling pathway of nitrogen during hypoxia on the Black Sea shelf. Hypoxia triggers also phosphate efflux from the sediment, the flux being marginally significantly higher than during oxic conditions where phosphate adsorbs to iron and manganese oxihydroxides. No clear pattern has been found in the N:P ratios of the nutrient efflux.

This study shows that hypoxia supports higher ammonia and phosphate effluxes from the sediment than oxic conditions, making the sediment to a larger source of nutrients for benthic and pelagic productivity. Avoiding man-made hypoxia or anoxia in coastal seas is crucial for maintaining a balanced and functioning ecosystem.