Deoxygenation and coastal eutrophication drive distinct benthic nutrient dynamics in the hypoxic Marmara Sea and oxic northeastern Mediterranean Sea

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Seafloor biogeochemistry and benthic fluxes can dramatically shift in response to deoxygenation and eutrophication-driven organic carbon production. In such conditions, biogeochemical cycling of key nutrients (N, P) can be highly coupled to oxygen concentrations and metal (Fe, Mn) redox cycles, often leading to the increase in dissolved P and Fe concentrations in the deep-water column. This study reports, for the first time, impacts of deoxygenation and coastal eutrophication on the sedimentary biogeochemical processes in the deoxygenating Marmara Sea and the oxic Northeastern (NE) Mediterranean (Cilician Basin), two previously unexplored, but rapidly changing environments under the pressure of anthropogenic impacts. We have conducted water column and sedimentary biogeochemical surveys using R/V Bilim-2, CTD rosette sampling and multicorer operations in several campaigns between 2016 and 2019. In the hypoxic Marmara Sea, dissolved oxygen concentrations in the deep waters (>900 m) decreased from 70.7 μM in 1995 to 7.3 μM in 2019, indicating a rapid deoxygenation during the last two decades. As a result, hydrogen sulfide started to accumulate at levels of 2.6-2.9 μM in Marmara's Eastern Basin, as detected during the 2016 and 2019 field surveys, suggesting a switch from oxic respiration to denitrification and sulfate reduction in the water column. The porewater geochemistry in the rapidly deoxygenated Marmara Sea ecosystem is firstly reported in this study, yielding markedly high concentrations of ammonia and dissolved reactive phosphate. These suggest high rates of organic matter decomposition and limited trapping of nutrients in the benthic interface, which would further enhance eutrophication in the Marmara Sea, analogous to benthic 'vicious cycle' in the much shallower Baltic Sea. In contrast, in the NE Mediterranean Sea, porewater phosphate (PO_4), nitrate (NO_3), nitrite (NO_2), ammonium (NH_4) and reactive silicate (Si) concentrations throughout the sediment column ranged between 0.06 and 2.30 μM for PO_4, 1.40 and 67.62 μM for NO_3, 0.06 and 6.75 μM for NO_2, 0.45 and 120.55 μM for NH_4 and 1.22 and 154.30 μM for Si, respectively. These data from the NE Mediterranean shelf indicated organic matter degradation processes took place in the first 3-4 centimeters of the sediment column. The decrease in the porewater nitrate concentrations suggested the preliminary denitrification process in the eutrophic coastal zone though no apparent decrease was recorded in the core samples obtained from the oligotrophic offshore regions.