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River-born and climate drivers of hypoxia on the NW Black Sea Shelf

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The Black Sea receives major freshwater inputs mainly from the Danube, Dnieper and Dniester rivers, discharging into the broad and shallow north-western shelf. This freshwater input, along with usually warm and calm summers leads to strong thermohaline stratification, restricting ventilation of the bottom water layer and making the north-western shelf prone to oxygen deficiency near the seafloor during summer. During autumn and winter, the thermohaline stratification is eroded by frequent storms, and the water column is re-oxygenated. During the second half of the 20th century, these rivers transported large amounts of nutrients from wastewater of more than 100 million people, from agriculture and from industries to the Black Sea, triggering eutrophication on the shelf. The increased oxygen consumption of the eutrophication-born organic matter caused widespread recurrent seasonal seafloor hypoxia during stratification. Combined effects of overfishing and climate forcing lead to an ecosystem collapse on the shelf during the 1970s to the mid-1990s. The reduction in anthropogenic nutrient inputs since the 2000s lead to a slow recovery of the shelf ecosystem, and to a decrease in spatial and temporal extent of seasonal bottom-water hypoxia.

To better understand drivers of and the dynamics behind the seasonal bottom water hypoxia formation and water column re-oxygenation on the north-western shelf, a mooring was deployed in 2010 and 2016 during summer and autumn, for three and six months, respectively. The mooring, consisting of an Aanderaa SEAGUARD sensor package attached to an acoustic release, was deployed in 30 m water depth in the Portita region – north of Constanta and south of the Danube River Mouths. The in-situ time series of seafloor oxygen, temperature, turbidity, salinity, and current velocities and directions, combined with CTD profiles, benthic oxygen consumption rates based on ex-situ incubations of sediment cores, and pelagic oxygen respiration rates, and meteorological data and Danube River data provide a set of information that allows river-born, climatological and biological controls on bottom-water hypoxia to be identified.

The results reveal that bottom-water hypoxia is still occurring between mid-July and mid-October intermittently on the north-western shelf, despite recovery from eutrophication. A current strong climate driver for seasonal bottom water hypoxia is the duration of thermohaline stratification on the shelf, controlled by summer warming and calm weather. Earlier onsets of stratification and warmer summers may intensify hypoxia on the shelf in the future. A current strong river-born driver is the freshwater inflow by the large rivers Danube, Dniester and Dnipro, also driving stratification, and the trophic state of the north-western shelf, largely driven by river-born nutrients. If river-born nutrient input increases again due to industrial agriculture in the catchments in the future, hypoxia is likely to intensify. In conclusion, the north-western Black Sea shelf is very sensitive to climate change (warming), and the effects of human-induced eutrophication, which may likely intensify the spatial and temporal extent of seasonal bottom-water hypoxia.
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