RELATIVE CONTRIBUTION OF EUTROPHICATION AND HYDROMORPHOLOGY TO BOTTOM OXYGEN DEFICIENCY: THE CASE OF THE MEDITERRANEAN AND BLACK SEAS

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Abstract

As hydromorphology plays a key role in isolating bottom waters from vertical and horizontal supply of oxygen, its contribution to bottom oxygen deficiency is discussed relatively to eutrophication (oxygen sink). If nutrient over-enrichment of margins is largely responsible of cultural eutrophication and seasonal hypoxia or anoxia (northern Adriatic Sea and north-west Black Sea), permanent stratification leads to anoxia rather independently of the trophic conditions (deep Black Sea). In case climatic changes favour a decrease of the hydrodynamics, and particularly when stratification is reinforced in its extension or duration, the contribution of hydrology to bottom oxygen deficiency would significantly increase.

Keywords: oxygen deficiency, hydromorphology, eutrophication, Mediterranean Sea, Black Sea

Eutrophication is defined [1] as 'an increase in the rate of supply of organic matter to an ecosystem'. Besides this main direct effect and the causative factors, e.g. nutrient enrichment, a holistic assessment of eutrophication should include the supporting environmental factors, e.g. hydromorphological conditions, and the indirect effects, e.g. oxygen deficiencies or changes in benthic community structure. We propose here to investigate the influence of bathymetry and hydrology on bottom oxygen deficiency in the Mediterranean and Black Seas. The monthly mean data is extracted from 3D physical models based on climatology (or a mean of several years).

Bottom hypoxia is mainly controlled by the load of particulate organic matter (POM) that reaches the bottom and the physical capacity of the system to renew the near bottom oxygen [2].

These enclosed seas are mostly characterized by an important water column in which the POM degradation mainly occurs. However, in two important continental shelves, i.e. the northern Adriatic Sea and the north-west Black Sea, a significant fraction of the POM fuelled by the Po and Danube rivers reaches the sea bottom of the continental shelf. In both cases, poor hydrodynamical conditions limits the vertical (mixing) and horizontal (transport) oxygen supply to the bottom waters leading to seasonal hypoxia/anoxia. The summer stratification favours in these areas the primary production as nutrient and light are available near the surface. The stratification, together with low bottom friction (not shown), isolates bottom waters from the vertical supply of oxygen. The low advection near the sea bed (Fig. 1) contributes in reducing the horizontal supply of oxygen.

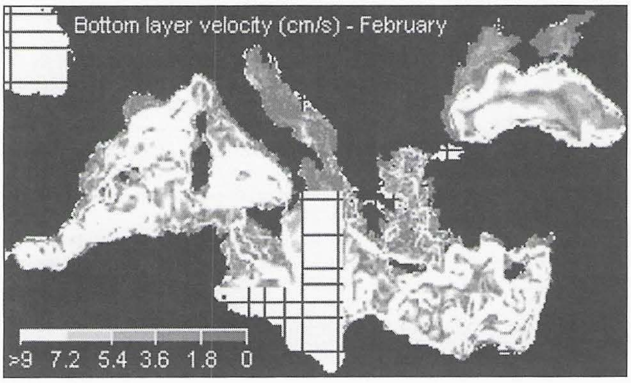

Fig. 1. Mean bottom advection of the benthic layer (cm s^{-1}) for August in the Mediterranean and Black Seas. Dark colours represent unfavourable conditions as regards to oxygen deficiency. Striped areas are regions not covered by the models.

The gathering of these unfavourable hydromorphological conditions in both continental margins of the Adriatic and Black Seas increases the effect of nutrient over-enrichment leading to seasonal oxygen deficiencies. In areas where the margin extension is small, the eutrophication-induced risk of hypoxia is limited in case the stratification is seasonal. The permanent halocline encountered in the Black Sea (Fig. 2) increases tremendously the physical sensitivity to oxygen deficiency. The bottom waters are permanently isolated and the oxygen bulk is consumed progressively even when the surface productivity is relatively low. It is thus suggested that the deep Mediterranean Sea is protected from oxygen deficiency by the absence of permanent stratification.

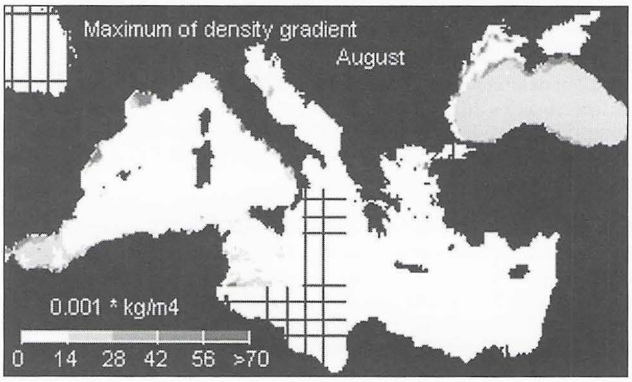

Fig. 2. Mean stratification intensity (kg m^{-4}) for February in the Mediterranean and Black Seas. Dark colours represent unfavourable conditions as regards to oxygen deficiency. Striped areas are regions not covered by the models.

Beside the nutrient loads from rivers, the impact of eutrophication is therefore largely controlled by the morphology of the receiving coastal area (semi-enclosed or open and water depth) and the regional hydrology (stratification, bottom friction, transport). In case of permanent stratification, anoxia can occur rather independently of the trophic condition. It is concluded that climatic changes which would lead to a decrease of the hydrodynamics, and particularly those which would reinforce the stratification either seasonally or permanently, would increase the sensitivity to bottom hypoxia and alter consequently the ecosystem functioning.

References

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