Bottom Layer Oxygen Depletion - An Increasing Problem in the Adriatic Sea ?

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Low dissolved oxygen (DO) or hypoxia (levels below 3 ppm) and anoxia resulting in mass mortalities of benthic organisms is a problem that appears to be in rise in many coastal areas (*Officer et al., 1984; Westernhagen et al., 1986*). The magnitute of hypoxia/anoxia problem is spreading also in some Mediterranean coastal water bodies (*Friligos, 1982*), among others also the Northern Adriatic Sea. Severly hypoxic and even anoxic conditions have been documented in this area several times during last three decades and most recently in November 1989 (*Smodlaka, pers. comm.*).

Although the general processes which govern the bottom water DO levels have been identified and extensively studied there are still uncertainties about the relative importance of individual processes leading to oxygen depletion as well as the role of anthropogenic influences. The most important events in the development of the seasonal anoxia are considered to be the "bottom-sealed-by-pycnocline" phenomenon (*Tolmazin, 1985*), incresed organic loading either from *in situ* production or from allochtonous sources, reduced vertical mixing and lateral exchange. Increased eutrophication, which is blamed for more frequent and more intensive phytoplankton blooms, has also been related to hypoxia/anoxia problem.

The debate on oxygen defficiency and other eutrophication problems intensified during the last decade also in the countries around the Adriatic Sea, where environmental problems have substantial economic significance.

The Gulf of Trieste, the northernmost and the shallowest part of the Adriatic Sea, shows varying degrees of seasonal (late summer-autumn) oxygen depletion in its deeper waters (> 20 m). The annual cycle shows that DO in bottom waters normally declines during mentioned period to a minimum concentration in late August-September. Critically low DO levels and anoxic bottom waters leading to localized benthic mortalities have been observed in 1974, 1980, 1983 and 1987, the areal extent being the largest in September 1983 when about 1/6 of the Gulf's bottom waters were infected. In order to determine the causes and effects of oxygen depletion, a massive sampling programme has been carried out during 1986-89. We studied physical processes affecting bottom DO levels, especially seasonal development of water column stratification, oxygen sources and sinks in the bottom layer as well as sediment biogeochemical processes.

Our estimates indicate (*Malej et al., submitted*) that even during summers not characterized by critically low oxygen levels (like 1986 and 1988), the oxygen demands of the water column above the bottom and sediments in the Gulf of Trieste were large enough to exceed the supply available from *in situ* pelagic (the below pycnocline water column) and bottom (benthic micro algae) photosynthesis, therefore physical mechanisms affecting oxygen resupply must have contributed to slower deep water oxygen depletion.

According to our measurements done during 1986-89 severe hypoxic patches can be expected almost any summer-autumn with unfavourable meteorological conditions in the Gulf of Trieste. The general pattern of observations suggest the central part of the Gulf of Trieste to be most vulnerable and the spreading of hypoxic waters towards the coasts. However, *Faganeli et al. (in press)* who studied paleoenvironmental conditions from a deep 40-m core could not confirm an accelerated rate of organic matter deposition recently. They concluded that past biogeochemical processes in the Gulf of Trieste were not markedly different from those of the present day. Therefore, it seems that anoxic events in the Gulf of Trieste are not of recent origin.

While human activities may still be very important sources of oxygen-demanding loadings to the Gulf, the quantities of some natural sources have not yet been estimated, especially the role of lateral advection, plankton dynamics during the stratified conditions and sediment regeneration. Therefore it would be advisable to:

- monitor DO levels and rates of decline in bottom waters as well as relevant physical properties especially the degree of stratification
- assess quantitatively the man-made and natural oxygen-demanding loadings
- develop a predictive model and long-term trends using available data
- improve our understanding of the dynamic processes in the coastal waters and in meantime
- try to diminish oxygen-demanding loadings which will reduce the likehood of severe hypoxia and anoxia events.

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