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OCEANOGRAPHY OF THE MARMARA SEA : BIO-CHEMICAL FEATURES

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ABSTRACT

The Sea of Marmara is a small intercontinental, transitory basin between the Black Sea and the Mediterranean. These two large basins have a high surface salinity gradient resulting in the formation of a permanent two-layered stratified water mass in the Marmara Sea. The less saline Black Sea surface waters spreads into the Marmara Sea via the Bosphorus Strait and reside in the upper layer (~30 m) for 3-4 months with a mean anti-cyclonic circulation. The Mediterranean waters introduce the Marmara Sea via the Dardanelles undercurrent and travel in the intermediate and deep waters of the basin for approximately 6-7 years. The two-layered exchange flow character of the straits permit material transport between the Black and the Mediterranean Seas while creating a rare marine ecosystem in transition between them.

In the Marmara Sea, the euphotic zone, hence, the primary production is restricted with the upper layer which is renewed several times a year with nutrient rich North Western Shelf waters of the Black Sea. In addition, the nutrient budget of the Marmara upper layer includes inputs from the subhalocline waters by vertical mixing and the domestic/industial waste discharged directly into the coastal surface waters, especially by the city of Istanbul. Since primary production only occurs in the upper layer, subhalocline nutrient concentrations are as high as 8-10 (μ for nitrate and 0.8-1.2 (μ for phosphate, changing little with either depth or season. Thus, on a yearly time scale, the lower layer system approximates to a steady state. In this sense, the inputs to the subhalocline waters should be balanced with the outputs which provides a POM flux from the surface to the subhalocline waters of 0.2×10^5 tonnes phosphorus and 0.8×10^5 tonnes nitrogen per annum. The contribution of Black Sea surface waters to the POM flux is around 42% whereas the contribution of newly produced photosynthetic organic matter in the surface waters which has been activated with the vertically mixed nutrients from the subhalocline waters of the Marmara Sea is 33%. The rest is compensated with the anthropogenic nutrients including the atmospheric inputs.

The biodegradation of a major fraction of particulate organic material (80-90%) transported from the surface waters causes oxygen defficiency in the subhalocline waters. The dissolved oxygen concentrations measured at the saturation level before entering the Dardanelles Strait drops to suboxic levels during its stay of about 6-7 years in the Marmara Sea. Similarly, nutrient concentrations increase nearly 10-fold. The oxygen utilization rate in the subhalocline waters can be calculated from the $-O_2$:N:P= 178:9:1 ratio, approximately as, 1 mg L^{-1}.

The historical changes in the dissolved oxygen profiles of the Marmara Sea reveal that there has been a significant concentration decrease in ~30-300 meters for the last 40 years. In the same manner, the nutrient concentrations has increased. The long-term changes of these variables are more pronounced in the upper subhalocline and nutricline has got raised from the below of the halocline to the inner halocline. This feature is also pronounced in the coastal, shallow regions of the Marmara Sea, especially, during summer-autumn periods where the dissolved oxygen concentrations decrease to minimum levels inside the halocline sometimes being under the detection limit of the Winkler method. All these points emphasize that the microbial processes inside the halocline is more dynamic than those in the subhalocline waters and should be taken cautiously for the sake of pelagic life.

Although there is no direct measurements of POM flux in the Marmara Sea, data obtained during 1991-1996 have permitted to determine the elemental composition of seston (PON:PP) in the euphotic zone and to correlate it with the NO_3:PO_4 ratio of the subhalocline waters of the Marmara Sea. In the euphotic zone, the N:P ratio of the seston changes from 5.9 to 9.5 between the less and more productive periods. The overall Redfield ratio obtained for the seston during the period of high production is C:N:P=98:9.5:1. N:P ratios of the surface seston (9.5) and the subhalocline nutrient concentrations (9-9.3) in this period evidently shows that the POM flux in The Marmara Sea has been dominated by the biogenic material produced in the euphotic zone during the late winter-spring blooms. The relationship strongly suggests that during the whole year primary production throughout the basin and POM export to the lower layer is nitrogen-limited.

Beyond the above mentioned points, the knowledge on the ecosystem and the community structure of the Marmara Sea is limited. It is known that the dramatic changes in the Black Sea ecosystem as a result of both human and natural pressures during the last three decades paralel to the local pollution in the Marmara Sea have been adversely effecting the Marmara ecosystem. For example; decrease of fish populations and density of macrobenthos species, increase in macro algae densities are well known events. On the other hand, the role of microheterotrophs, carnivorous organisms, and of the chetonopore *Mnemiopsis leidyi* on the lower trophic levels of the Marmara Sea and on the nutrient pool is not clear.

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ABSTRACTS

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