Geophysical Research Abstracts
Vol. 13, EGU2011-9346, 2011
EGU General Assembly 2011

Seasonal variability of the Black-Sea ecosystem: A modelling study

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Seasonal variability of contrasting coastal versus open basin Black-Sea ecosystems is studied with the combination of a three-dimensional physical-biogeochemical model and observations. The circulation model has high spatial resolution capable of simulating both large-scale circulation in the basin and mesoscale eddies. The ecological module of the model includes two groups of phytoplankton, two groups of zooplankton, the opportunistic heterotrophic dinoflaggelate Noctiluca scintillans, gelatineous carnivores (Aurelia auritia, Mnemiopsis leidyi), bacteria, dissolved and suspended organic substances, nitrate, and ammonium. The application of the eddy-resolving circulation model in the Black Sea enabled us to qualitatively reproduce the processes of vertical entrainment of deep-sea waters rich in biogenic elements into the upper layer and the transport of coastal waters into the open part of the sea. Our numerical experiments demonstrate that the model reproduces the observed seasonal dynamics of phytoplankton in the Black Sea. In addition, the model reproduces the response of biogeochemical variables to the mesoscale features of circulation.

The northwestern shelf and the west coast of the Black Sea are characterized by the observed elevated bioproductivity mainly because of the inflow of biogenic elements via river discharge. Model results suggest that although the temporal variability of nutrients are similar because of high biomass of the invasive ctenophore Mnemiopsis leidyi, longer periods of small and large phytoplankton blooms occur in these coastal areas compared to the open basin. This indicates severe regulation of the ecosystem by the upper levels of the food chain. As a result, three consecutive maxima of phytoplankton biomass (in winter, spring, and summer) occur in the coastal waters and the extensive winter phytoplankton bloom is a new element in the annual cycle of the ecosystem. In the coastal waters, under the influence of Mnemiopsis leidyi, the developments of microzooplankton and Noctiluca scintillans at the end of autumn are suppressed. In the absence of grazing pressure by zooplankton, phytoplankton blooms can start as early as January, earlier than in open basin where the Mnemiopsis leidyi biomass is an order of magnitude less.