Study on Generation of Oxygen-Depleted Water Based on Stochastically-Changing Weather Conditions

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Eutrophication is now a social problem and a widespread phenomenon in lakes, rivers and coastal zones all over the world, and various works have been attempted to restore water quality in many eutrophic water areas. In addition, the awareness of environmental management on habitats has increased recent years. Hakata Bay, located in western Japan, has been recognized to be an important sea area for birds and aquatics: Wajiro tidal flat and the peripheral sea area, located at the head of the bay, is planned to be designated as a Wildlife Special Protection Area by the Environment Agency in Japan. Dissolved oxygen (DO) in sea water and sediments is essential for the habitation of aquatics, and the generation of oxygen-depleted water would cause serious damages to benthos and fishery resources; hence the prevention of the generation of oxygen-depleted water is the major subject for the proper management of the aquatic environment in such a sea area.

To examine the generation probability of oxygen-depleted sea water in Hakata Bay, possible 20 time-series of different hourly-solar-radiation intensities were generated stochastically using the random numbers, and a three-dimensional numerical simulation on dissolved oxygen was carried out for each time-series during the period when the probability of oxygen-depletion was potentially high. The Sediment-Water Interaction Model (SWIM), developed by the present authors, was used for the DO simulations. The SWIM consists of two submodels, a hydrodynamic model and a biological model, and they were calibrated with the tidal current data and water quality data observed in the bay. The hourly-solar-radiation intensities were generated at random using the first order autoregressive model after cumulative frequency distribution curves of the daily clearness index were obtained from the historical data over 9 years.

The results of the model calibration followed the seasonal variation of observed water quality well, and generated cumulative-frequency-distribution curves of daily solar radiation agreed well with the observed ones. The simulation results indicated that the exchange of sea water would have a great influence on the DO concentration, and that the concentration could change more than 1 mg/L in a day. If plenty of weather conditions were generated stochastically, the frequency distribution of minimum DO concentration would be obtained by the simulations with the conditions, and the generation probability of oxygen-depleted water could be discussed. This prediction method seems to be an effective way to examine a solution to minimize fishery damages when DO is depleted.