Impact Assessment of Global Warming on the Circulation and Ecosystem of Large Lakes

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[Abstract]

Key Words: Global warming, Large lake, Oxygen depletion, Numerical model, Ecosystem

We have developed a three dimensional physics-ecosystem coupled simulation model of Lake Biwa in order to examine how deep water ventilation, water quality, and ecosystem properties of the lake may change within the next 100 years under the scenario of global warming. Field observations and experimental assessments were also conducted to improve our knowledge regarding the key processes that were embedded in the numerical model. These processes included vertical oxygen fluxes, nutrient fluxes from the sediments, oxygen consumption in the hypolimnion, primary production, sinking fluxes of particulate matter, and responses of benthic organisms to oxygen depletion. The collected data and information were used to improve the parameterization of the simulation model. The major achievements of this project are as follows. 1) Turbulent mixing intensity monitored using a free-fall microstructure profiler TurboMAP-L during summer in Lake Biwa indicated that the supply of oxygen from the atmosphere to the deeper layer was largely suppressed by a strongly stratified water column under the surface mixed layer, in which micro-scale heterogeneities of biotic variables were generally found. 2) The data obtained using thermistor chains and current meters revealed that convective mixing and gravity currents contributed to the oxygenation of deep water in winter.3) Data on seasonal changes in sinking fluxes of particles indicated a coupling between meteorological conditions and sinking particle fluxes. 4) The experimental results obtained using sediment cores revealed that the phosphorus release from the sediment was almost doubled if the sediment surface was exposed to the anoxic condition for more than one week. 5) Results obtained from the field observations and laboratory experiments indicated that the reduction in oxygen concentration below the level of 2 mg L^{-1} might possibly result in the substantial loss of the population of endemic fish, *Chaenogobius isaza* (Isaza), in Lake Biwa. 6) Predictions derived from the numerical experiments using the three dimensional model of Lake Biwa indicated that the

circulation (winter turnover) would continue to occur even with the scenario of a 5^{o}C increase in air temperature within the next 100 years. However, the oxygen depletion in the hypolimnion at the end of stratification period could be much more pronounced under warmer conditions, which might accelerate eutrophication due to the enhancement of the internal loading of phosphorus. These results also suggest that it is highly likely that the global warming may cause a significant loss of benthic fish population in the lake.