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Phytoplankton coexistence based on niche differentiation studied by an OGCM

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Oceanic phytoplankton have high diversity. Observational studies estimate that there are over 70,000 phytoplankton species. In mechanisms which enable the high diversity, we focused on niche differentiation, and inspected it by using an oceanic general circulation model (OGCM). We also explored effects of advection and diffusion on the phytoplankton diversity.

Based on NEMUEO and MEM, we developed a marine ecosystem model which can express a few hundred phytoplankton species and combined it to a physical oceanic model, MRI.com. The physical field represents idealized subpolar and subtropical gyres in a rectangular model domain of 30 by 30 degrees. To explore effects of advection and diffusion, an offline model (hereafter 0D model) is also developed, in which only concentration of phytoplankton and zooplankton are prognostic variables, and advection and diffusion of the two variables are set to be zero.

We seeded 240 phytoplankton species which have different trait for temperature, light and nutrient, and 31 species survive. In the 0D model, the same experiment results in 85 surviving species, in which only one species survives in one grid box. Therefore advection and diffusion increase alpha diversity but decrease gamma diversity.

We divided a surviving species into 8 species, in which optimum temperature is slightly different. As a result of competition of 248 (31∗8) species, 125 species survive. This is not considered to be the upper limit of niche differentiation, and further differentiation would be possible. We found coexistence of two species which differ only 0.1 degrees in optimum temperature. The fact that slight difference of niche enables coexistence is considered to be significant to explain the high diversity of oceanic phytoplankton.

Keywords: Phytoplankton diversity, marine ecosystem model, OGCM