Optimality based models of phytoplankton size structure in the North Pacific

*Bingzhang Chen[1], Sherwood Lan Smith[1]

1.Japan Agency for Marine-Earth Science and Technology

Phytoplankton size structure is an important factor determining trophic transferand export production in the ocean. To model phytoplankton size structure,conventional ocean models usually discretize the phytoplankton community intoa number of size classes, which is usually computing extensive. In addition, theflexible behaviors of phytoplankton physiology such as flexible intracellularnitrogen-to-carbon ratios and chlorophyll-to-carbon ratios should be alsoconsidered. Here we present a new ecosystem model which combines theflexible behavior of phytoplankton physiology and an innovative approach ofmodeling the mean and variance of a continuously distributed phytoplanktonsize. The key features of the new type of ecosystem model include: 1) A tradeoffexists phytoplankton photosynthesis and nitrogen uptake. Phytoplankton cellsare assumed to optimize the energy allocation between light harvesting andnitrogen uptake. 2) By assuming a continuous lognormal distribution ofphytoplankton size, key phytoplankton physiological parameters such asnutrient uptake rate, photosynthesis rate, minimal nutrient quota, etc. followvalidated size-scaling laws. Then the net growth rate of the bulk phytoplanktoncommunity can be expressed as a function of the net growth rate at mean log sizeand the second derivative of net growth rate evaluated at the mean log sizebased on moment closure approximations. 3) A killing-the-winner strategy isadopted to maintain phytoplankton size diversity. This model is coupled with a3D regional ocean circulation model (ROMS) in the North Pacific and canreproduce the large-scale patterns of oceanic circulation, temperature, andsalinity, nitrate and chlorophyll fields. As expected, nutrient concentration is themajor factor controlling distributions of phytoplankton mean size and sizevariance. Sensitivity analysis suggests that the ecosystem model is very sensitiveto the type of grazing functions and zooplankton mortality closure terms.

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