Deterministic and Stochastic Modeling of Plankton Interactions

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We propose a deterministic mathematical model of interactions between non-toxic phytoplankton (NTP), toxin producing phytoplankton (TPP), and zooplankton to explore the role of TPP on population interaction. To simulate the seasonal forcing, we extend the autonomous system by incorporating periodic toxin production of TPP into the toxin liberation rate. In these models, mutual interference between zooplankton and avoidance of TPP by zooplankton are considered. Sufficient conditions based on the model parameters are derived for which the three interacting populations can coexist. Our analytical findings indicate that mutual interference of the zooplankton can stabilize the interactions. Numerical simulations with parameter values taken from the existing literature are performed to illustrate complexities of the population interactions and to validate our analytical findings. We then construct parallel models of continuous-time Markov Chain and Itô stochastic differential equations to study the effects of randomness of birth and death. Our results illustrate that variabilities of the population interactions depend on the size of the spatial domain and also on the birth and death rates formulated.

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