Stochastic advection-reaction-diffusion model for phytoplankton colonies in a 2D spatial domain

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Phytoplankton lies at the base of the food chain of seas and oceans, and it is responsible for about 80% of the total *chlorophyll a*. As a consequence, phytoplankton determines the trophic structures of marine ecosystems, while influencing the total abundance and the spatial distributions of marine biological species, e.g. fish populations. Thus the study of spatio-temporal dynamics of phytoplankton populations and the development of models which predict the trend of primary production become of paramount importance to understand and forecast the dynamics of biological species within marine ecosystems.

Here it is presented a two-dimensional advection-reaction-diffusion model to describe the dynamics of four phytoplankton populations in a real ecosystem located in the Channel of Sicily (South Mediterranean Sea). Light intensity and nutrient concentration represent the limiting factors for the phytoplankton growth. Specifically, due to the characteristics of the marine ecosystem analyzed, i.e. a transect consisting of twelve marine stations between Cape Passero (Sicily) and Misurata (Libya) [1], the limiting nutrient component is phosphorus.

Phytoplankton abundances are first obtained by solving numerically a system of deterministic partial differential equations and then converted in *chlorophyll a* concentrations [2], whose spatial distributions are compared with those obtained from field data collected in the twelve marine stations [3]. Statistical checks based on the χ^2 test indicate a good agreement between theoretical and experimental distributions of *chlorophyll a* concentration.

Deterministic models however can not fully describe the nonlinear dynamics of a real ecosystem continuously exposed not only to deterministic but also to random perturbations coming from the environment. To take into account the random fluctuations of the environmental variables, the deterministic model is modified by inserting in the equations Gaussian noise sources [4]. As confirmed by checks based on the χ^2 test, the distributions of *chlorophyll a* concentration obtained by the stochastic model fit the field data better than those calculated by the deterministic model.

It is worth noting that in this study real values for physical and biological variables were used. Specifically, the analysis exploits hydrological and nutrients data acquired *in situ*, including intraspecific competition for limiting factors.

The study and the results discussed here indicate the effectiveness of this approach for reproducing real spatial distributions of *chlorophyll a* concentration. Moreover we note that the stochastic advection-reaction-diffusion model presented in this work can be extended to different marine ecosystems and used as a global model to forecast eventual decreases in the abundance of primary production and to prevent the consequent decline of fish species.

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