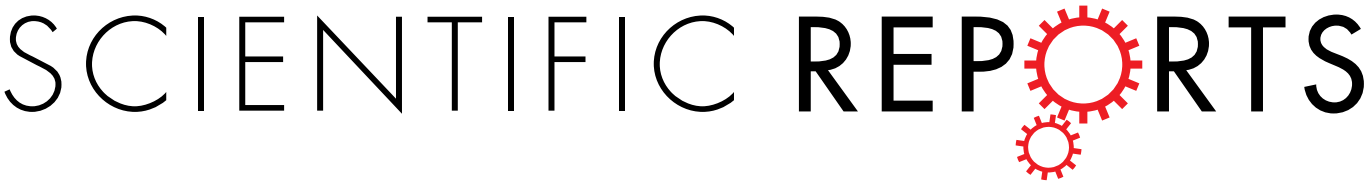

OPEN

Received: 30 August 2016
Accepted: 7 February 2017
Published online: 16 March 2017

Spatio-temporal dynamics of a planktonic system and chlorophyll distribution in a 2D spatial domain: matching model and data

Davide Valenti[1], Giovanni Denaro[2], Rosalia Ferreri[2], Simona Genovese[2], Salvatore Aronica[2], Salvatore Mazzola[2], Angelo Bonanno[2], Gualtiero Basilone[2] & Bernardo Spagnolo[1,3]

Field data on chlorophyll distribution are investigated in a two-dimensional spatial domain of the Mediterranean Sea by using for phytoplankton abundances an advection-diffusion-reaction model, which includes real values for physical and biological variables. The study exploits indeed hydrological and nutrients data acquired *in situ*, and includes intraspecific competition for limiting factors, i.e. light intensity and phosphate concentration. As a result, the model allows to analyze how both the velocity field of marine currents and the two components of turbulent diffusivity affect the spatial distributions of phytoplankton abundances in the Modified Atlantic Water, the upper layer of the water column of the Mediterranean Sea. Specifically, the spatio-temporal dynamics of four phytoplankton populations, responsible for about 80% of the total *chlorophyll a*, are reproduced. Results for phytoplankton abundances obtained by the model are converted in *chlorophyll a* concentrations and compared with field data collected in twelve marine sites along the Cape Passero (Sicily)- Misurata (Libya) transect. Statistical checks indicate a good agreement between theoretical and experimental distributions of chlorophyll concentration. The study can be extended to predict the spatio-temporal behaviour of the primary production, and to prevent the consequent decline of some fish species in the Mediterranean Sea.

During the last decades, the study of the spatio-temporal behaviour of phytoplankton abundance assumed a role of fundamental importance to predict the effects induced by physical and hydrological changes on the fish abundances in marine ecosystems[1–5]. In particular, field observations focused on the spatial distribution of chlorophyll concentration, which is the main marker of the phytoplankton populations[2,4–9]. These represent the base of the marine food web, and are used to estimate the biomass primary production in all aquatic ecosystems[4,10].

Theoretical models for population dynamics allowed to reproduce the spatio-temporal distributions of phytoplankton groups in a one-dimensional spatial domain by considering the effects of heterogeneity of the limiting factors along the water column[4,5,11–19]. On the other side, some authors introduced two- and three-dimensional models[20,21], in which the habitat of planktonic groups is considered homogenous for the nutrient and the environmental parameters are fixed constant in the whole ecosystem. In particular, these assumptions are connected with the lack of experimental data, whose availability is crucial for the estimation of some environmental variables[16,18], such as the light intensity, the velocity field of marine currents, the horizontal and vertical turbulent diffusivities. Moreover, unlike some one-dimensional models[4,5,15–18], the numerical results for phytoplankton abundances are not converted in chlorophyll concentration, and therefore the comparison between theoretical results and experimental data can not be performed. For these reasons, the theoretical chlorophyll concentration obtained by the phytoplankton abundances has been never reproduced in the vertical water plane of the marine ecosystems. In general, the analyses are usually carried out on the horizontal water plane by using the remote

[1]Dipartimento di Fisica e Chimica, Università di Palermo, Group of Interdisciplinary Theoretical Physics and CNISM, Unità di Palermo, Viale delle Scienze, Ed. 18, I-90128, Palermo, Italy. [2]Istituto per l'Ambiente Marino Costiero, CNR, U.O.S. di Capo Granitola, Via del Faro 3, I-91020, Campobello di Mazara, TP, Italy. [3]Istituto Nazionale di Fisica Nucleare, Sezione di Catania, Italy. Correspondence and requests for materials should be addressed to D.V. (email: davide.valenti@unipa.it)