

Population dynamics under the climate change: catastrophes, extinctions, and long transients

Prof. Sergei Petrovskii
School of Mathematics and Actuarial Science
University of Leicester, Leicester, United Kingdom

Abstract

The effect of climate change on population dynamics is widely recognised, usually with many adverse effects, often resulting in species extinctions and biodiversity loss. Population dynamics can also have feedback on the climate; however, this issue remains poorly understood. In my talk, I will focus on the effect that the global warming can have on plankton, in particular, on phytoplankton ability to produce oxygen. It is estimated that more than one half of the total atmospheric oxygen is produced in the oceans due to the photosynthetic activity of phytoplankton. Any significant decrease in the net oxygen production by phytoplankton is therefore likely to result in the depletion of atmospheric oxygen and in a mass mortality of animals and humans. However, the rate of oxygen production depends on water temperature and hence can be affected by the global warming. I address this issue theoretically by considering a novel model of a coupled plankton-oxygen dynamics where the rate of oxygen production changes with time to account for the ocean warming [1]. I first prove that the model, albeit being simple or “conceptual”, provides an upper bound for a class of complex realistic models of ocean(bio)dynamics [2,3]. I then show that, when the temperature rises sufficiently high, a regime shift happens: the sustainable oxygen production becomes impossible and the system’s dynamics leads to plankton extinction and oxygen depletion. I also consider a scenario when, after a certain period of increase, the temperature is set on a new higher yet apparently safe value, i.e. before the oxygen depletion disaster happens. I show that in this case the system dynamics may exhibit a long-term quasi-sustainable dynamics that can still result in the regime shift but only after a considerable delay: the phenomenon known as long transient dynamics [4,5]. Finally, I will argue that this catastrophe of the global oxygen depletion might have been the factor that resulted in a few mass extinctions in the Earth geological past.

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