Shaping coral reef growth. The role of nutrient diffusion and erosion

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Coral reefs are some of the most biodiverse and productive ecosystems in the world, providing habitats for a vast array of marine species and supporting the livelihoods of millions of people [1]. However, coral reefs are facing increasing threats from climate change, pollution, and overfishing [2]. Understanding how these ecosystems grow and function is crucial for effective conservation efforts.

One key aspect of coral reef ecosystems is their spatial patterns, which can provide important insights into how these ecosystems form and persist [3]. Remote sensing data and satellite imagery have revealed that coral reefs often exhibit distinct patterns in their morphology, such as the arrangement of coral colonies and the formation of reef structures [4]. These patterns can reflect a combination of biological and physical processes, including water flow, nutrient availability, and competition among coral colonies and reefs [3].

To better understand the mechanisms underlying coral reef pattern formation, a range of theoretical and numerical models based on reaction diffusion equations have been used to explore the roles of competition, predation, and other ecological factors in shaping coral reef communities [5]. Other models have focused on the physical processes that influence reef growth, such as hydrodynamics and sediment transport [6]. However, many of these models have limitations in terms of their ability to capture the complexity of coral reef ecosystems. While some of them overlook the importance of specific ecological interactions or physical processes, others are overly simplified, ignoring the heterogeneity of coral reef habitats or assuming uniform conditions across the reef.

We will propose a novel model that aims to address some of actual limitations by incorporating both biological and physical factors into a single framework. Specifically, we will focus on the role of nutrient diffusion and erosion in shaping the spatial patterns of coral reefs.

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[1] D. R. Bellwood et al. *Confronting the Coral Reef Crisis*, Nature **429**, 827-33 (2004).

[2] T. P. Hughes et al. *Global warming and recurrent mass bleaching of corals*, Nature **543**, 373-377 (2017).

[3] T. P. Hughes et al. *Global warming impairs stockrecruitment dynamics of corals*, Nature **568**, 387-390 (2019).

[4] P. Mumby and R. S. Steneck, *Coral reef management and conservation in light of rapidly evolving ecological paradigms*, Trends in Ecology & Evolution **23**, 555-563 (2008).

[5] N. Shigesada et al. *Modeling Stratified Diffusion in Biological Invasions*, The American Naturalist, **146**, 229-250 (1995).

[6] L. Alvarez-Filip et al., *Shifts in coral-assemblage composition do not ensure persistence of reef functionality*. Scientific Reports, **3** 3486 (2013).