Effects of rising sea surface temperature on the dynamics of coral-algal interactions

Sasanka Shekhar Maity*, Joydeb Bhattacharyya** and **Samares Pal***
*Department of Mathematics, University of Kalyani, Kalyani – 741235, India
**Department Mathematics, Karimpur Pannadevi College, Nadia, India.

Abstract.
Coral reef ecosystems are most vulnerable to changes in sea surface temperature (SST), a key environmental factor critical to reef-building growth. Elevated SST reduces the ability of corals to produce their calcium carbonate skeletons. Prolonged high SST results in coral bleaching owing to the uncoupling of symbiosis among corals and microalgae. Corals have narrow temperature tolerances. The skeletal growth rate of corals falls sharply to zero even at a slight increase of SST above its temperature tolerance level. Corals are also vulnerable to macroalgal toxicity. Several benthic macroalgae species are known to bring about allelopathic chemical compounds that are very harmful to corals. The toxic-macroalgae produce allelochemicals for which the survivability and settlement of coral larvae are highly affected. Toxic macroalgae species damage coral tissues when in contact by transferring hydrophobic allelochemicals present on macroalgal surfaces, leading to a reduction of corals and even coral mortality. The abundance of toxic macroalgae changes the community structure towards a macroalgae-dominated reef ecosystem. We use a continuous time model to investigate coral-macroalgal phase shifts in the presence of elevated SST and macroalgal toxicity. We have derived the conditions for locally asymptotic stability of steady states. Computer simulations have been carried out to illustrate different analytical results.

Short Introduction:

Coral reefs are the most striking and different marine ecosystems in our globe. Productive and complex, coral reefs host hundreds of thousands of species, but few are described by science. Coral reefs are very well known for their biological diversity, beauty and high productivity [1]. Coral Reefs tend to exist in alternate coral or algae-dominated states. Faster-growing macroalgae always dominate coral reefs by making less available space for the successful settlement of coral larvae [2]. Corals may die due to bleaching, and it takes decades to recover partially or completely. Most of the bleaching events occur when the temperature is at least 1^o more than the temperature threshold [3].
In the present paper, the main emphasis will be placed on the dynamic behaviour of coral reefs ecosystem due to increasing sea surface temperature.

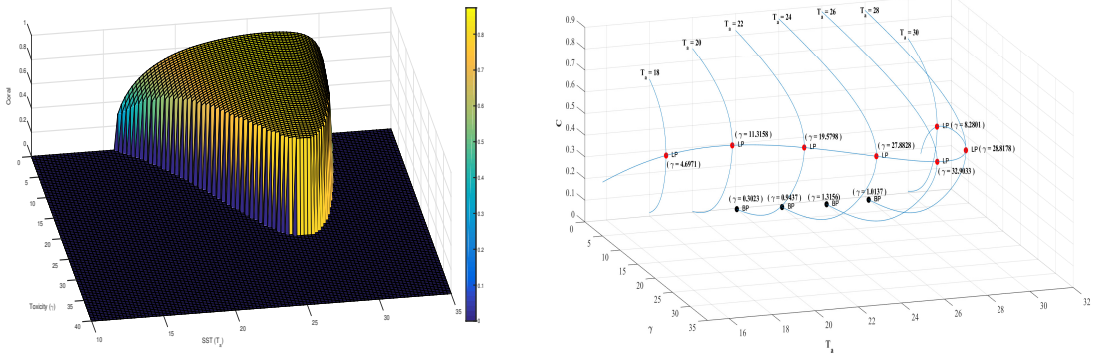

Figure 1: Bifurcation diagram of γ versus the equilibrium value of coral cover for different SST.

Results and discussion

In the tropical zone, we observed that the toxicity in coral increases due to increase of SST upto a threshold value. In case of high SST, the toxicity tolerance in coral reduces extremely and followed by coral-mortality. In the same tropical zone, we observed that higher rate of grazing of the herbivores is required for surviving corals in the system when the SST is either low or high. We observed that the difference of upper and lower SST threshold for surviving corals is maximum when they are in tropical region. The threshold difference is minimum when corals are in temperate zone and it lies between maxima and minima when corals are in subtropical zone.

References

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