10/10: Well written and a good discussion. Perhaps your answer to 7. is a touch concise but that is all that there is.

[redacted]

Research Paper Review # 1

Article:
Shovonlal Roy and S. Alam and J. Chattopadhyay, Competing Effects of Toxin-Producing Phytoplankton on Overall Plankton Populations in the Bay of Bengal. B. Math. Biol. (2006) Vol 68: 2303-2320. DOI 10.1007/s11538-006-9109-5
http://link.springer.com/article/10.1007/s11538-006-9109-5

Abstract:
The coexistence of a large number of phytoplankton species on a seemingly limited variety of resources is a classical problem in ecology, known as 'the paradox of the plankton'. Strong fluctuations in species abundance due to the external factors or competitive interactions leading to oscillations, chaos and short-term equilibria have been cited so far to explain multi-species coexistence and biodiversity of phytoplankton. However, none of the explanations has been universally accepted. The qualitative view and statistical analysis of our field data establish two distinct roles of toxin-producing phytoplankton (TPP): toxin allelopathy weakens the interspecific competition among phytoplankton groups and the inhibition due to ingestion of toxic substances reduces the abundance of the grazer zooplankton. Structuring the overall plankton population as a combination of nontoxic phytoplankton (NTP), toxic phytoplankton, and zooplankton, here we offer a novel solution to the plankton paradox governed by the activity of TPP. We demonstrate our findings through qualitative analysis of our sample data followed by analysis of a mathematical model.

Review:
1. *What is the problem being discussed?*
Many species of phytoplankton are able coexist in the Bay of Bengal despite being competing species in an environment with limited resources. These species exhibit non-equilibrium population dynamics; however, the reason for such behavior is only speculative. The exact reason for non-equilibrium populations, and therefore the ability of these species to coexist, is unknown. The authors analyze the population fluctuations of toxin-producing phytoplankton (TPP), nontoxic phytoplankton (NTP), and predator zooplankton in relation to each other under the consideration that the toxins produced by TPP are the impetus for the non-equilibrium.

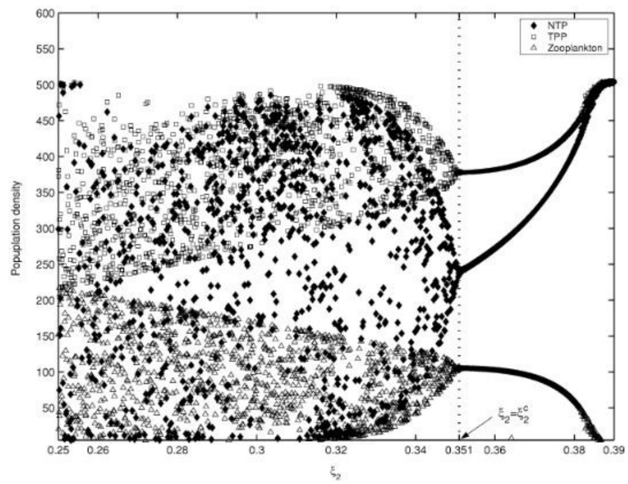
2. *What has been done before by this and/or other authors?*
Many other authors have suggested external factors to be reasons for this anomalous population behavior of competing species. For example, Hutchinson in 1961 theorized that these species of phytoplankton are able to coexist because they are not in equilibrium, and he offered unpredictable weather and seasonal cycles as the reason for population fluctuations; Huisman in 1999 proposed incomplete vertical mixing; Descamps-Julien and Gonzalez in 1995 suggested temperature changes. Furthermore, Buskey and Stockwell in 1993 showed, in a similar study, that zooplankton populations are reduced during the increase in a toxic picoplankton in the south coast of Texas, suggesting that toxins may play a role in plankton populations. Additionally, Nielsen in 1990 and Ives in 1987 have conducted both field studies and laboratory studies which further suggest that toxins may be a significant influence.

3. *What do these authors do that is new? Summarize the main results.*
These authors analyze an internal factor in contrast to previous authors who focused on factors outside of the phytoplankton themselves. They also look at a system containing three distinct types of phytoplankton: toxin-producing prey (TPP), non toxin-producing prey (NTP), and predator zooplankton. Toxins released by the TPP kill off some of the predator zooplankton when eaten; thus, these toxins act as a stabilizing agent for species of plankton by keeping the predator population in check. More importantly, TPP provide a mode of alternating plankton population dynamics from oscillation to stability and vice versa, causing overall non-equilibrium. This non-equilibrium relies on toxins and is the underlying cause for the coexistence of these phytoplankton.

4. *What tools do they use to address the problem, e.g., field studies, lab experiments, data analysis, mathematical model development, computer simulation, mathematical analysis? How do they use*

these tools?
These authors have monitored the plankton populations from the west coast of the Bay of Bengal for several years and use their data from 2000-2001. Data was gathered approximately every two weeks and taken from multiple depths of water. This field study led to the discovery of a phytoplankton that produces toxins. From this data, they proposed a three-component mathematical model relating the TPP, NTP, and zooplankton populations. They used this model to determine parameters of the system and employ bifurcation analysis which shows that the toxin production factor is a plausible reason for population oscillations.

5. *Select one important figure and summarize what it describes and what is its significance.*



The image pictured above is figure 4 which depicts a bifurcation diagram of the model system. The bifurcation parameter used is the rate of reduction in zooplankton due to toxin consumption from feeding on TPP, ξ_2. Above a certain value of ξ_2, the populations of TPP and zooplankton are negligible; however, the NTP still survive. This shows that as the TPP are eaten, the zooplankton population also diminishes, which enables other species to continue surviving. The different rates of killing zooplankton by toxin ingestion affect the population dynamics: any change in ξ_2 changes the dynamics of the entire system. This figure supports that toxins are the reason for the non-equilibrium state of the phytoplankton population.

6. *What are the open questions and/or what is their plan for the future?*
Open questions include if there are still other significant factors outside of toxicity, and future work could apply this model to similar biological systems to see if the model holds.