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Model Extension Proposal

The paper that my group is presenting for our final project is titled "The effect of fishing on hysteresis in Caribbean coral reefs" (Blackwood et al. 2012).[1] In this paper, the authors model the impact of different levels of fishing pressure on parrotfish populations, which in turn impacts the balance between coral, macroalgae, and turf algae benthic cover in Caribbean reefs. They find that lowering the fishing pressure on parrotfish allows a reef to reach a coral-dominated stable state more quickly than systems with higher fishing pressure and therefore less grazing by large herbivorous fish.

For my model extension, I will add temperature as a variable that impacts coral cover, and therefore impacts the proportion of other benthic cover types and the carrying capacity of parrotfish by changing habitat and food availability. The goal of adding in temperature and a temperature threshold above which corals begin to bleach and die is to investigate how the model dynamics change with external controls on benthic cover rather than just the interaction of grazing and types of benthic cover with each other. I am excited about this model extension because it is directly relevant to my current research investigating how highly variable temperature regimes influences benthic community dynamics. I am also researching the regional-scale climate dynamics that control small-scale variability and will be using downscaled large ensemble climate models to analyze projected future dynamics. Experience modeling how temperature influences benthic dynamics and herbivorous fish populations will be very useful to my future research efforts, and I can imagine my work will utilize similar models to analyze the potential impact of future temperature patterns on benthic cover.

I plan to include the impact of temperature on coral by modifying the coral death rate d at each time step in the simulation. I will create a temperature vector that is the same length of the simulation and add a step to my for loop to update the coral death rate at each time step. There will be a temperature threshold above which coral starts to bleach and die. I will run simulations with three different temperature regimes: one short marine heatwave above the threshold before dropping below for the rest of the time steps, and two different scenarios of repeated marine heatwaves with long and short recovery times between spikes. I may need to increase the length of time the simulation runs, and I will try various combinations of time above and below the threshold. Depending on the results, it would be interesting to modify the temperature data set to compare the impact of different length time periods above the threshold and recovery time periods. The coral cover equation in the original model is:

[1] Blackwood, J. C., Hastings, A., & Mumby, P. J. (2012). The effect of fishing on hysteresis in Caribbean coral reefs. Theoretical ecology, 5, 105-114.

$$\frac{dC}{dt} = rTC - dC - aMC$$

I will start by modifying *d* at each time step with an *if/else* statement that tests whether the temperature value at that time step is above the bleaching threshold parameter that I set. Similar to degree heating weeks, the more time steps the temperature stays above the threshold, the higher *d* will become at the next time step. *d* will be above the baseline parameter used in the model (d = 0.44) and below 1. The death rate will not reach 1 to account for the differential bleaching and mortality responses of various coral species – some corals may survive heat stress that kills another coral.

I plan to include a time series figure of the coral, macroalgae, and turf algae percent benthic cover for the temperature-dependent simulation, as well as a time series of the parrotfish population. I would also like to create figures that illustrate temperature influence on coral cover by showing the different temperature regime time series and corresponding coral cover time series on the same figure.