Exploring the combined effects of pathogen-induced stress, temperature, and food scarcity on the bioenergetics of *Pinna nobilis*

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The endangered fan mussel (*Pinna nobilis*) has historically declined due to overfishing, habitat destruction from trawling and anchoring, pollution, and seagrass meadows degradation. More recently, the species is facing severe population declines due to mass mortality events linked to pathogens such as *Haplosporidium pinnae, Mycobacterium* spp, and *Vibrio* spp. Climate change-induced temperature increases and food scarcity pose additional threats by affecting physiological responses, immune functions and survival. To prevent extinction, conservation efforts should focus on habitat protection and disease mitigation. Furthermore, a better understanding of *P. nobilis* bioenergetics in response to its environment could inform recruitment strategies. This study extends a DEB model for *P. nobilis* to assess the combined effects of pathogen infection and environmental stressors, such as temperature increase and food scarcity, on growth, maturation, and reproduction. The model successfully reproduces observed growth patterns in length and weight, clearance rate and oxygen consumption across a range of temperatures. Additionally, it accurately predicts ages and sizes at developmental transitions between life stages. The exact mechanism of the effect of pathogens on the energy flows is not yet fully understood. Experimental results indicate that pathogens affect the mechanisms of cell homeostasis and immunity maintenance. We hypothesize that the pathogen mode of action is to increase rates of somatic and maturity maintenance through a stress parameter. By exploring how these stressors impact key processes, this study provides critical insights to support conservation efforts for this keystone species.