Modeling potential effects of ocean acidification on shell formation in Pacific oyster (*Crassostrea gigas*)

Paulina Gierlak and Nicholas S. Green

Department of Ecology, Evolution, and Organismal Biology, Kennesaw State University

Contact:
pgierlak@students.kennesaw.edu
ngreen62@kennesaw.edu

Background

- As the climate changes and ocean temperatures increase, ocean waters are becoming increasingly acidified from their historical pH near 8, with a low of 7.8 expected by 2100.
- Increasing acidity interferes with the ability of many marine fauna to use calcium carbonate ($CaCO_3$) construct and maintain shells and exoskeletons.
- Ocean acidification thus poses a serious threat to many shell-forming marine species.
- We used Pacific oyster (*Crassostrea gigas*) as a model species because of its ecological and economic importance.
- **Question: How will ocean acidification affect mussels over the 21st century and beyond?**

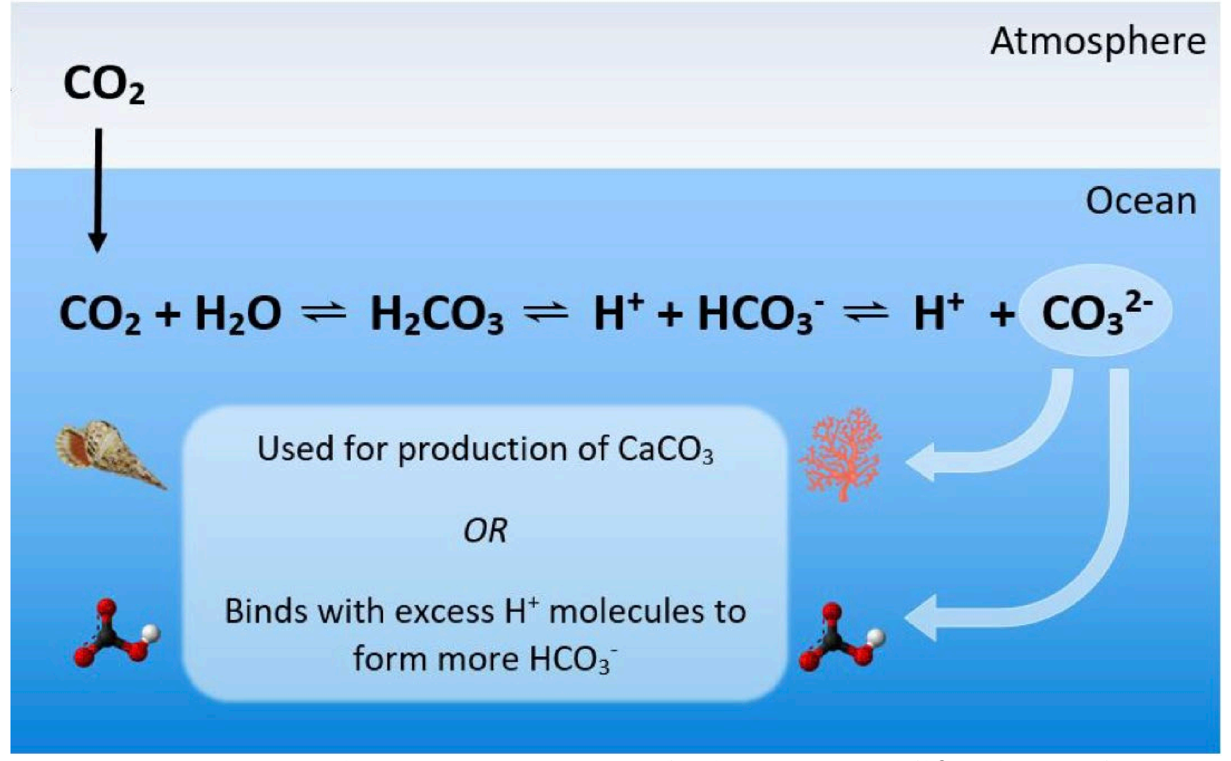

Figure source: New York City Ocean Acidification Task Force

Figure 1. Reactions of CO_2 in water. When CO_2 dissociates in water it forms carbonic acid (H_2CO_3) and carbonate (CO_3^{2-}) or bicarbonate ions (HCO_3^-), which can either be used by organisms to construct shells or taken up by excess hydrogen ions (H^+).

Preliminary Simulation Results

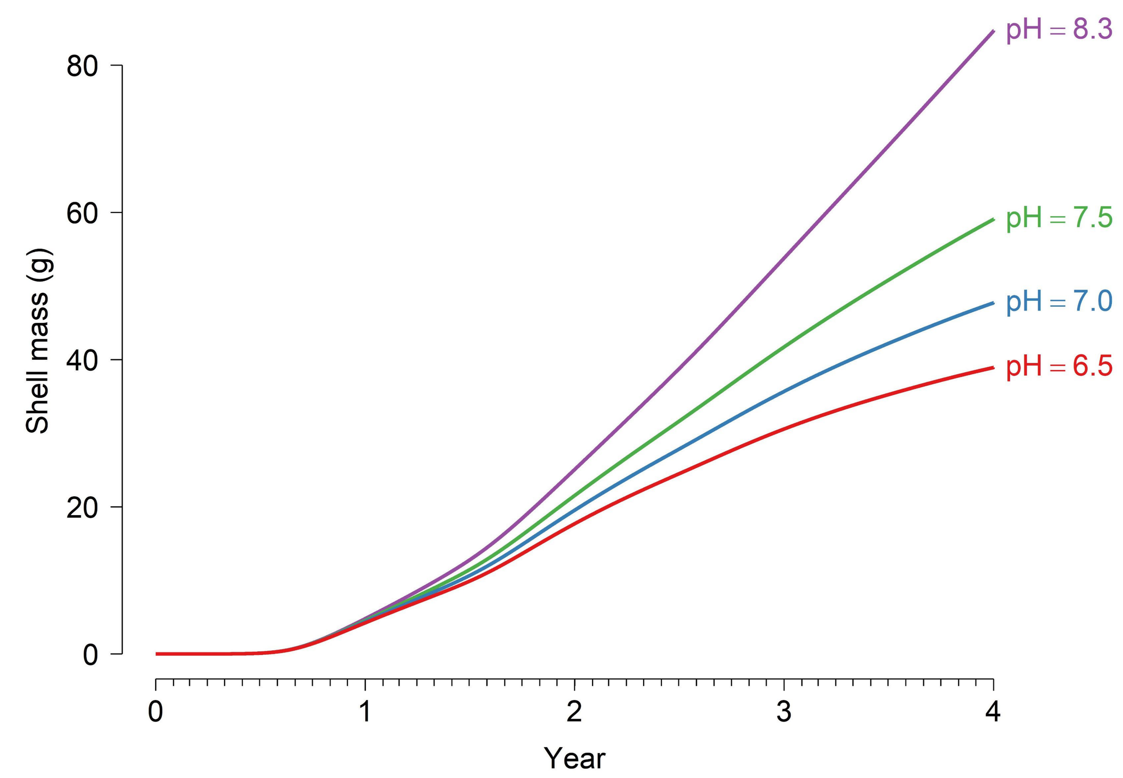

Figure 2. Mean shell mass per oyster increased over time in all treatments, with slower growth and lower overall shell mass projected under more acidic conditions (i.e., lower pH). Curves show median and 95% quantile interval of 100 replicate simulations.

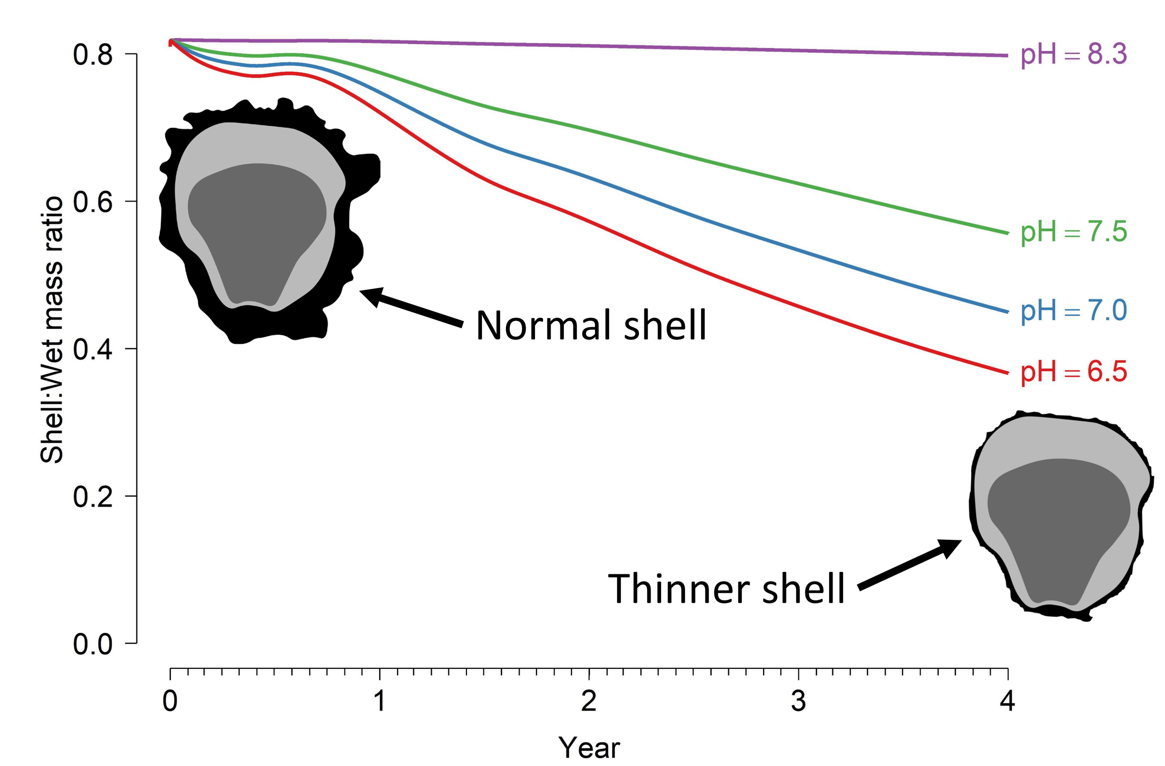

Figure 3. Shell-to-wet mass ratio decreased over time in all treatments, with a faster decrease in scenarios with more acidic conditions (i.e., lower pH). Curves show median and 95% quantile interval of 100 replicate simulations.

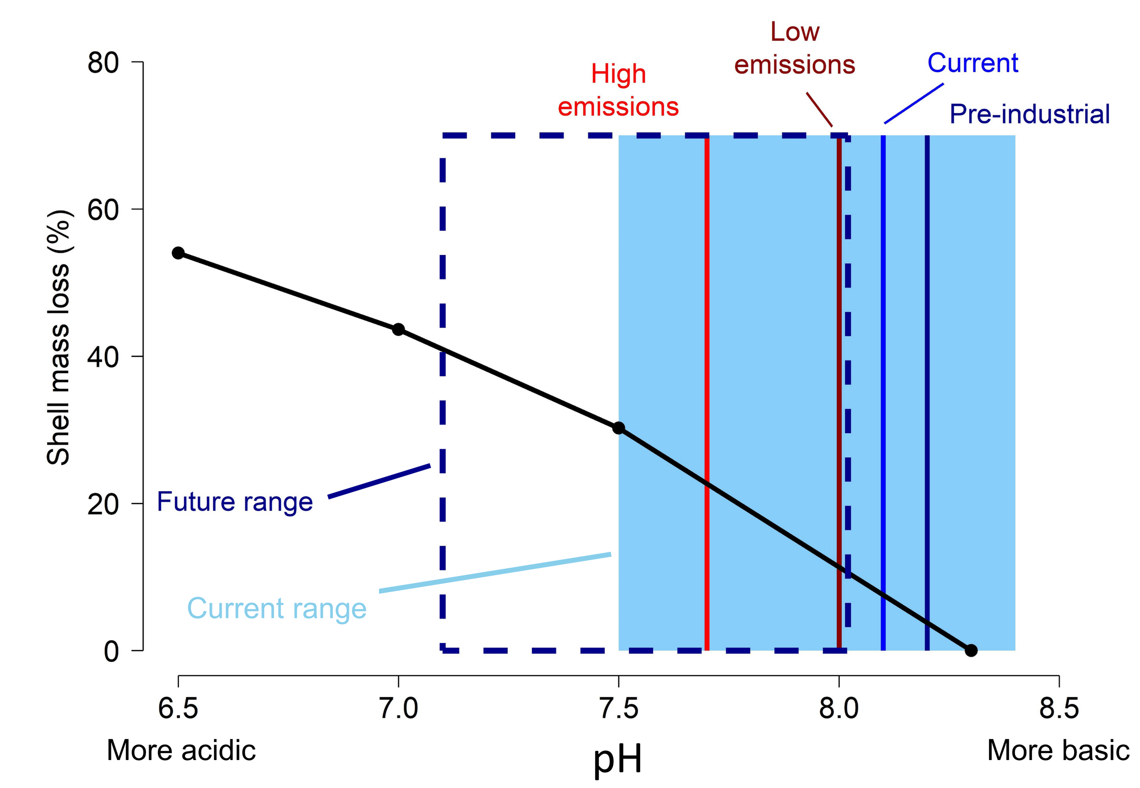

Figure 5. Scenarios with lower pH showed greater shell loss relative to the control pH of 8.3. Estimated pH for pre-industrial, current, and two emissions scenarios are shown, along with pH range under current conditions and high-emissions scenario.

Modeling Approach

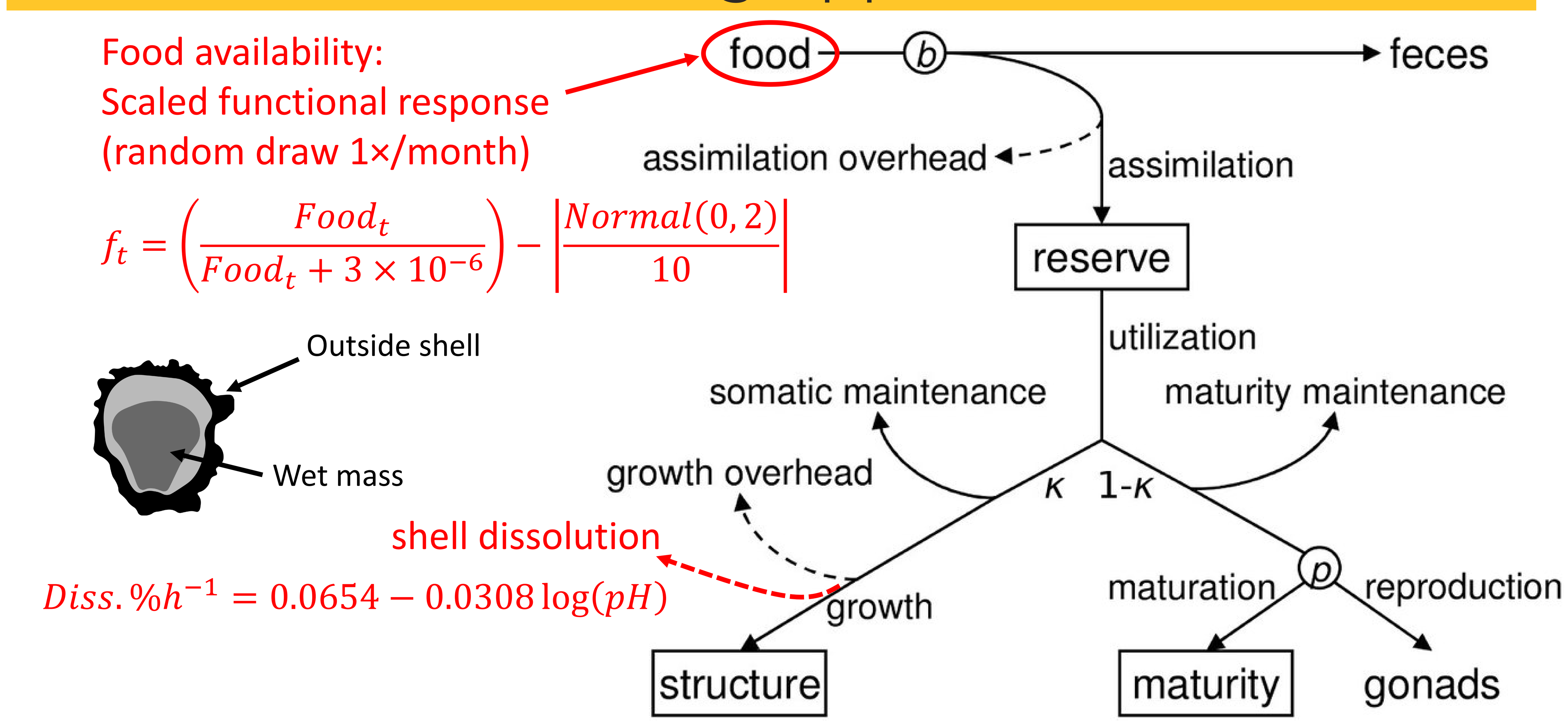

Figure 4. Schematic representation of energy flows in the standard DEB model (**black**) with our modifications shown in **red**. State variables are denoted by rectangles. Nodes ***b*** and ***p*** indicate metabolic switches at birth (onset of feeding) and puberty (onset of reproduction). Stochasticity was implemented as a random adjustment to the scaled food functional response, with a new value drawn for each month within the simulation.

Discussion

- Simulations showed that expected ocean acidification (decreasing pH) could result in significant losses in shell formation and maintenance.
- Shell dissolution due to ocean acidification will put mussels at risk for increased predation.
- Decreased shell growth rates will result in decreased somatic growth, leading to reduced reproduction, smaller harvests, and lower profits for the aquaculture industry.
- **DEBEcoMod** model implemented in **R** is readily extended to incorporate additional biological processes and environmental scenarios.
- Predictive models will be crucial for mussel conservation.