Heart Function in *Homarus americanus:* the Effect of Pressure and Stretch
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When a heart contracts, it generates pressures that alter cardiac output, which is needed to deliver oxygen and nutrients to the body. In the lobster heart, the cardiac ganglion (CG) controls the frequency and amplitude of heart contractions. The CG output may in turn be altered by information from stretch receptors, which are influenced by pressure changes due to stretch on the wall of the heart.

In the Johnson Lab, Pietro *et al.* (2017) investigated the effects of preload stretch, or the mechanical stretch on the wall of the heart prior to contraction, and afterload pressure, or the back pressure in the arteries that the heart must pump against, on the cardiac system of the American lobster. They found that heart rate often decreased in response to increased afterload (i.e. arterial) pressures, which is similar to the mammalian baroreceptor reflex for maintaining blood pressure homeostasis. In crustaceans, this reflex has only been reported in the crab *Carcinus maenas* (Wilkens & McMahon, 1994).

This summer, I continued to investigate lobster baroreceptor-like responses by systematically changing preload stretches and afterload pressures of the lobster heart to determine their combined effects on cardiac output (volume per time of blood exiting the heart), diastolic and systolic arterial pressure, frequency and amplitude of the heart beat, and the passive and active forces exerted by the heart. I found that arterial diastolic (relaxation) pressures were independent of preload stretches, but increased with increasing imposed afterload pressure (Fig. 1). These results are consistent with the hypothesis that the posterior artery valve isolates arterial pressure from heart pressure by preventing hemolymph backflow into the heart.

Frequency was also affected by imposed changes in afterload pressure; however, this response varied between lobsters and preload stretches. For example, in one case, the frequency at the lowest preload stretch (blue in Fig. 2) decreased with increasing imposed afterload pressure, which is consistent with the baroreceptor reflex. In contrast, when stretched to the highest preload level (red in Fig. 2), the frequency at the lowest afterloads decreased such that frequency was relatively independent of increasing afterload pressure. Thus, while there was often a clear pattern within a given lobster, as seen here, the variation in responses suggests a dependence on the state of several integrated factors.

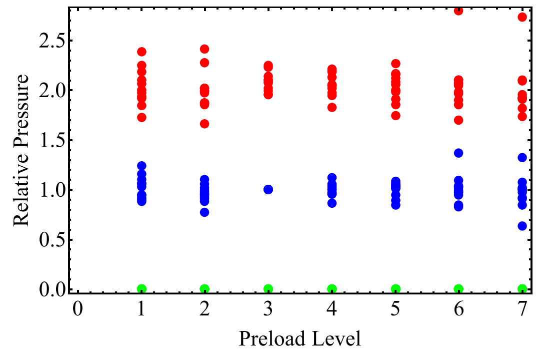

Figure 1. Relative diastolic (relaxed) pressures as a function of different levels preload stretch (1 = 0.2 g force, each increase is by 0.1 g) at three different imposed afterload pressures (green = 0 cm H2O, blue = 4.5 cm H2O, red = 9 cm H2O). Relative diastolic pressure was independent of preload stretch at a given imposed afterload pressure. However,

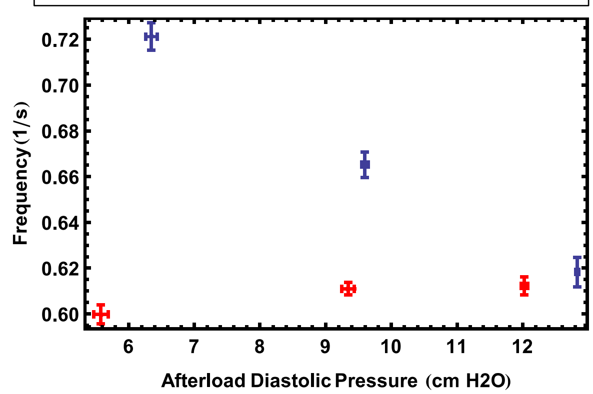

Figure 2. Heart beat frequency as a function of imposed afterload pressures at two different preload stretch levels (blue= 0.2 g preload force, red=0.8 g preload force). At a low preload stretch, frequency decreased as pressure increased, but at a high preload stretch, frequency at low pressures decreased so that overall frequency increased with increases in pressure. Error bars represent one standard error.

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References cited:

Pietro, Fickera, Johnson, Ellers 2016. Quantifying the Effects of Elastic Arteries, Stretch, and Pressure on the American Lobster Heart. President's Summer Research Symposium poster presentation.

Wilkens, J.L., McMahon, B.R. (1994). Cardiac performance in semi-isolated heart of the crab *Carcinus maenas*. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology, 266: R781-R789.