

Changes in salinity and temperature affecting the cardiac response of the American lobster, *Homarus americanus*

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Lobsters are most abundant in coastal waters and play a vital role in the cultural and economic fabric of the Gulf of Maine region. In addition to providing important commercial fisheries, lobsters play a key role in the maintenance of healthy and diverse marine life in Northern Atlantic ecosystems. However, according to the Gulf of Maine Research Institute, the Gulf is warming faster than 99.9 percent of the world's oceans. Changes in salinity and temperature outside of normal conditions caused by global perturbations such as climate change may impact the physiological functioning of the lobster, including its cardiac system.

Central pattern generators (CPGs) are neural networks that produce rhythmic patterned behaviors such as walking, breathing, and chewing. The cardiac system consists of the whole heart and the cardiac ganglion (CG). The heartbeat of the lobster is regulated by CG, which is a CPG that consists of a simple network of nine neurons: four generate the rhythm of the heartbeat, and the other five are motor neurons that signal for the cardiac muscles to contract and cause a heartbeat. Variations in heart contractions can result from changes to the heart caused by global perturbations like temperature and salinity. Although lobsters can adapt to short-term exposure to changing salinity levels, long-term exposure may leave deleterious effects on the system's physiological function. Furthermore, temperature increases of the system from 2°C to 20°C result in an increase in heart rate, and as temperatures exceed 20°C, the heart rate rapidly decreases until the system stops functioning.

Although previous studies have shown the effect of various temperatures on the heart, the combinatorial effects of changing temperature and salinity are not understood. The goal of this project was to measure how these factors simultaneously affect the whole heart of the lobster as it would function under the stressors of climate change. To understand these effects, I first measured the impact of changing salinity alone on the heart. I dissected the heart out of the lobster and then cannulated the posterior artery while continuously perfusing various concentrations of saline through and over the heart, including 1x (which is the concentration of saline in normal conditions), 0.75x and 1.25x, which are saline concentrations 25% lower and 25% higher than 1x saline, respectively. I tied the anterior arteries to a force transducer with suture silk to measure heart contractions, which were recorded using Spike2 software. I allowed the heart to acclimate in normal saline, then applied differing saline concentrations. The heart recovered in normal saline conditions in between each application.

I characterized the impact of changing salinity on the heart by its amplitude and frequency. If the heart “crashes,” it will stop functioning and produce fewer than 2 beats per 30 seconds; to be considered a crash, the heart must recover and continue to function when returned to normal saline. The heart is seen to have recovered if it reaches an amplitude and frequency similar to its original state after a saline application. Because the heart was able to continue functioning under 0.75x and 1.25x salinities, I was able to measure the combinatorial affects of changing salinity and temperature.

With increasing temperatures, heart contractions appeared to be more robust and crash temperatures were generally higher in lower concentrations of saline compared to higher concentrations. In 0.75x saline, whole hearts showed amplitude and frequency patterns relatively similar to those in 1x saline, although with increasing temperatures, frequencies were typically greater in 0.75x saline than in 1x saline, and crash temperatures in 0.75x saline were similar to those in 1x saline. Conversely, amplitude and frequency patterns and crash temperatures were generally lower in 1.25x compared to 1x saline, implying that the heart is typically not able to withstand higher concentrations. Additionally, the heart often failed to recover in normal saline applications at the end of experiments after treatment with high saline concentrations.

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