Temperature effects on gait of the sea stars *Asterias rubens* and *Asterias forbesi*
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Off the coast of southern Maine, the sea star *Asterias forbesi* has recently surpassed in abundance the sea star *Asterias rubens*. Since *A. rubens* has a more northern distribution and a lower survival and growth rate at higher temperatures (Pratt 2006), the Johnson lab is searching for a link between locomotion speeds in these sea stars and temperature. In nature, speed is essential for an organism's fitness, because it allows them to escape predation or capture food. The Johnson lab discovered that sea stars can increase their speed by switching from a slower, crawling gait to a faster, oscillating gait (Ellers et al. 2014, Ellers et al. 2021). In general, many aspects of the physiology and locomotion of ectotherms (animals whose body temperature is the same as their environment, including sea stars) increase with temperature, often until they reach a plateau beyond which performance declines. These changes across temperatures are modeled through thermal performance curves (TPCs) (Schulte et al. 2011). In her Honors project in the Johnson Lab, Emma Bertke established a thermal performance curve for the maximum speed of *A. forbesi* that shows increasing maximum speed with increasing experimental temperature, with no difference between 13°C and 18°C (Bertke 2020). Thus, given the north/south distribution of *A. forbesi* and *A. rubens*, it was predicted that *A. rubens* would peak at a lower temperature (Figure 1). Results from last summer supported that hypothesis, but only at 12.2°C (Figure 2; Ashby et al. 2022). However, the hypothesis that there would be a difference between the species at warmer temperatures and that both species would plateau at higher temperatures was not supported, so I repeated previous methods at a larger range of temperatures to determine the location of the plateau and whether the peak and plateau temperatures differ between the two species.

I began this summer by collecting the experimental sea stars of both species from the Rockland Breakwater in Rockland, ME and acclimating them for eleven days at 12.8°C. Data collection entailed filming each star moving across a clear tank at six experimental temperatures, ranging from 7.8°C to 22.8°C. Since we used maximum speed as the measurement of their performance, we instigated their faster, oscillatory gait by placing them in the tank on their back and letting them right themselves. Once they moved, we would orient them in the right direction. If they moved too far towards or away from the camera, determined by moving off the runway we put under the tank, we would stop the video and move them back to the start. We repeated this for each sea star until we had 5-7 usable films for each sea star or until the sea star had been in the filming tank for 25 minutes. We used DeepLabCut to extract the maximum speeds.

Our results showed that the maximum speeds of both sea stars align with the thermal performance curve model. Their maximum speeds increased rapidly from 7.8° until 13.8°C when the performance began to plateau for both species. At 22.8°C, the performance of both species declined. This indicates that when acclimated to 12.8°C, the sea stars' optimal performance range lies around 14-20°C, with decreased performance in temperatures warmer and cooler than those. Overall, the *A. rubens* had faster maximum speeds than *A. forbesi*. These results indicate that as ocean temperatures continue to rise, the sea stars' maximum speeds will decline, possibly leading to further changes in the sea stars' distributions.

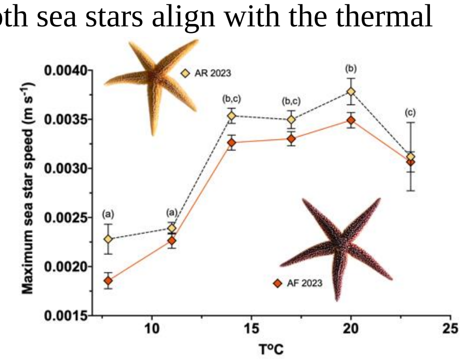

Figure 1. Maximum speed of both sea star species increased from 7.8 to 13.8°C, then plateaued. Maximum speed decreased from 20°C to 22.8°C. *A. rubens* overall maximum speed was higher than *a. forbesi*. Means with shared letters are not significantly different (Two-way ANOVA, p>0.05)

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