Measuring Atlantic Stingray (*Hypanus Sabinus*) Thermal Performance Using Metabolic and CTmax Studies

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Background

As climate change intensifies, ocean surface temperatures have reached unprecedented levels, causing uncertainty in how fish will adapt and respond to current and future temperature changes. As ectotherms, the energy use of the Atlantic Stingray (Dasyatis sabina) is subject to thermal change, however, the sensitivity of energy use across activities and energetic budgets is currently unknown. Atlantic stingrays are coastal benthic associated elasmobranch species and are known to move with seasonal temperature change. Our research focused on the metabolic and energetic impacts that rising ocean temperatures will have on Atlantic Stingray. Studying this will help biologists project fishes' responses to rising ocean temperatures and shifts in viable habitat in reference to climate change. Using respirometry to directly measure fish oxygen consumption and Critical Themral Maximum (CTmax) trials across starting temperatures of acclimation, this research used metabolic and behavioral challenges to identify temperature sensitivity and thermal limits of Atlantic Stingrays, known to influence fish behavior and viable habitat. Measurements of resting and maximum energy use allowed us to investigate changes in the energy scope for life activities and the sensitivity of this metric to temperature change, as well as to identify a limiting upper temperature where survival is compromised and how this changes with starting temperature.

Methods

- Defined Metabolic Terms
  - ***Intermittent Respirometry*** *– measures how much oxygen aquatic organisms consume*
  - ***MO2*** *– metabolic rate of oxygen consumption*
  - ***MMR*** *– Maximum Metabolic Rate - highest metabolic rate measured*
  - ***SMR*** *–Resting Metabolic Rate – lowest rate needed to sustain conscious organism at rest*
  - ***AS (Aerobic Scope)*** *represented as the difference/quotient of MMR and SMR, energetic scope for all life activities*
  - *CTmax - critical thermal maximum, critical thermal limit where survival is threatened*

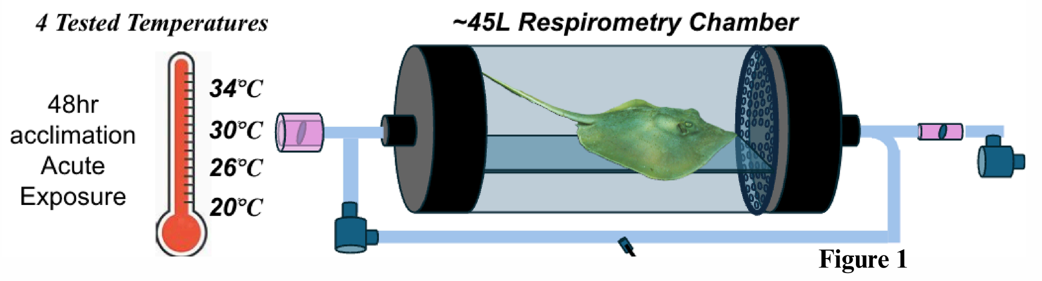


Figure 1

- Intermittent respirometry was used to measure oxygen consumption in each respirometry chamber over 10 min closed measure periods
- MMR after stimulating rays was measured, followed by undisturbed rest in chamber for 24 hours
- SMR was found by taking the average of lowest 10% of MO2 measures after first 5 hr of trial
- Slope of linear regression (O2 vs Time) used to calculate MO2 for each 10 min closed measure in MMR-SMR- PcSMR trial
- Thermal sensitivity (E) calculated of via Arrhenius relationships for all metrics

Figure 2

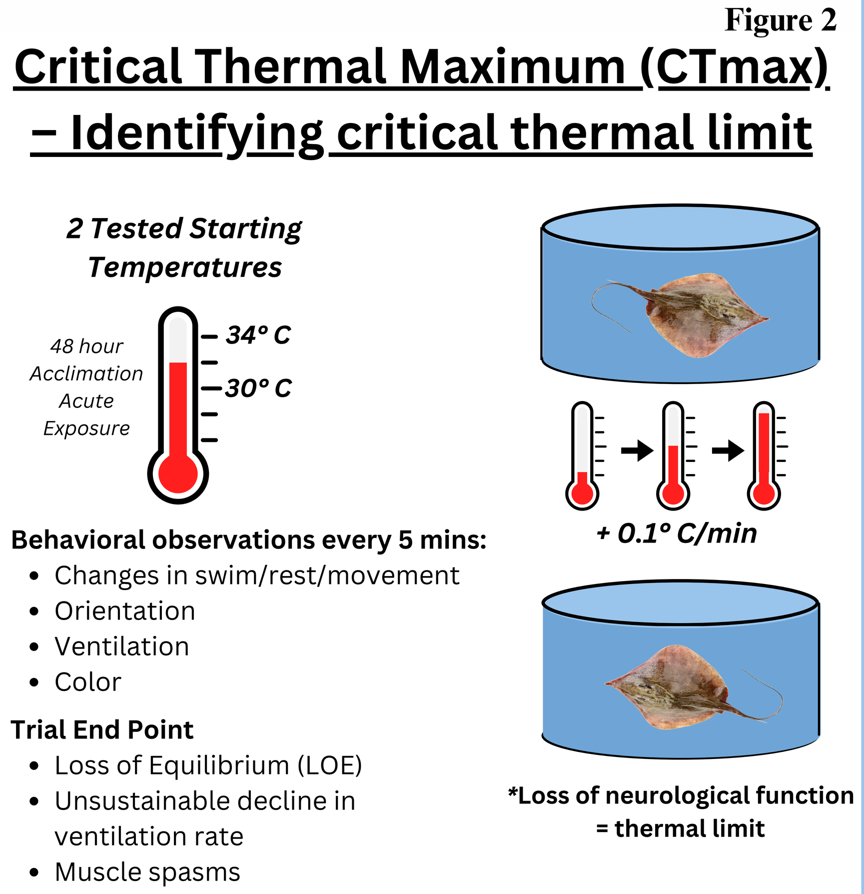


Fig. 3: Box and Whisker plot denoting min, max, median, and quartiles of disorientation and endpoint across temperature. Letters denote statistical significance, with different letters denoting statistical difference, and groups with letters in common denoting groups that are not statistically significant. "**" denotes marginal significance.

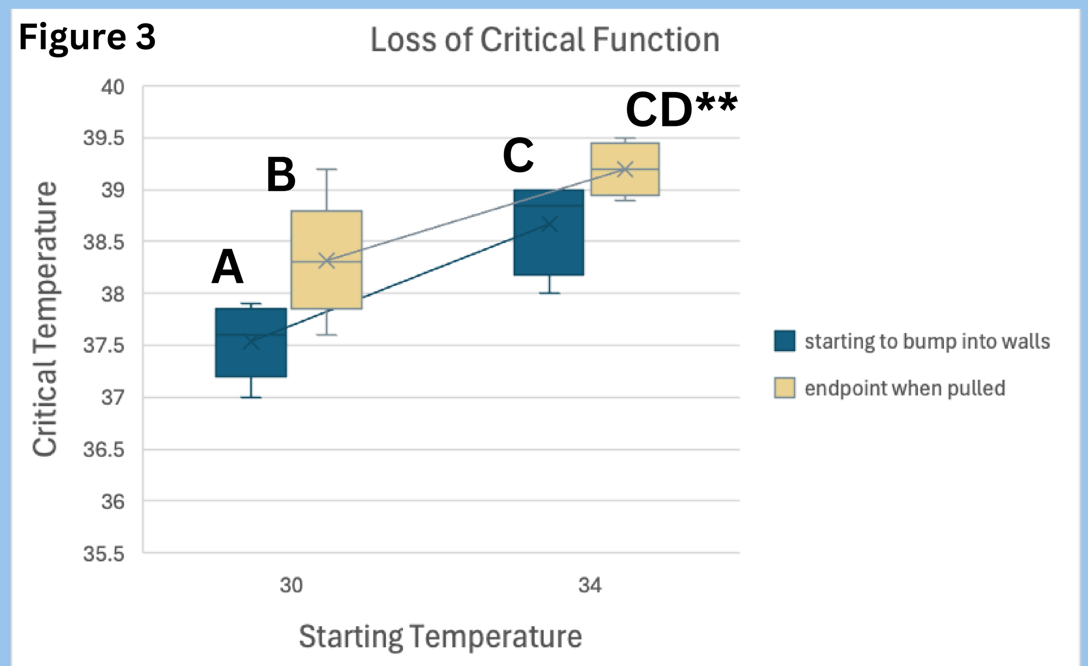


Fig. 4: Horizontal Bar diagram denoting differences in disorientation temperature between rays acclimated to 34° C over a 48 hour period versus rays acclimated to only 30° C.

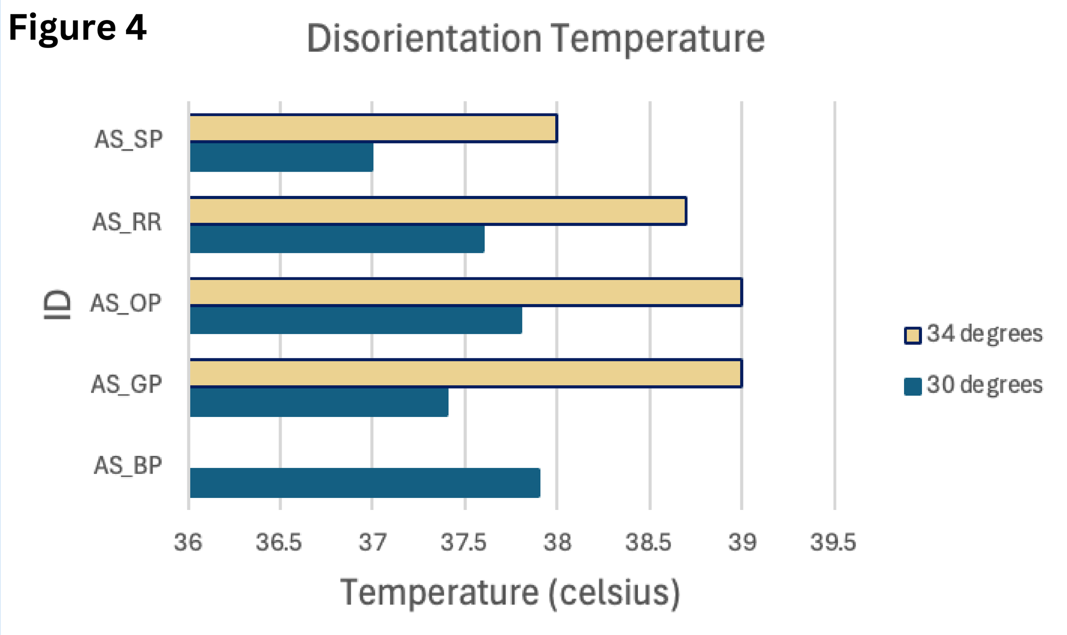
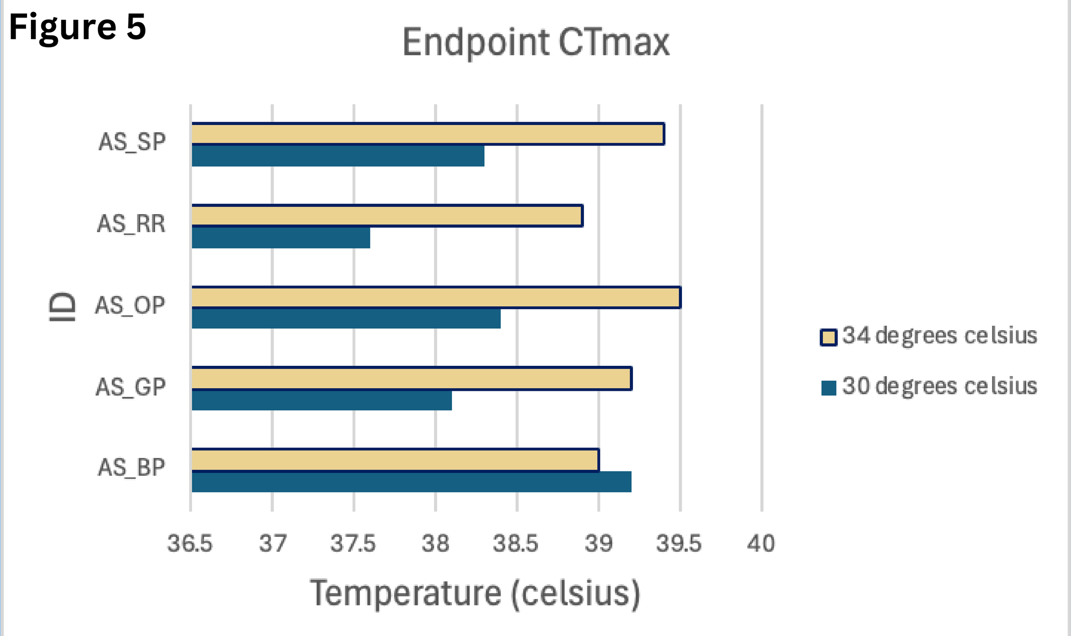


Fig. 5: Horizontal Bar diagram denoting differences in Endpoint temperature between rays acclimated to 34° C over a 48 hour period versus rays acclimated to only 30° C.



Results

- **Temperature of disorientation and the temperature of CTmax endpoint demonstrated statistically significant differences between the two acclimation temperatures.**
- **The temperature at which CTmax occured was significantly higher than the disorientation temperature for the 30 degree acclimation group;.**
- **The difference in disorientation and CTmax endpoint for the 34 degree acclimation group demonstrated only marginal statistical significance.**
- **Greater samples sizes are needed to interpret results with certainty.**
- **Analysis of energetic data is still ongoing**

Conclusions

- **CTmax is sensitive to temperature of short term acclimation, increasing with increased temperatrue of acclimation**
- **Increasing average summer temperatures has potential to prime/increase threshold for critical thermal impacts to neurological performance up to a point: critical temperature thresholds are also known to be impacted by the length and severity of thermal exposure and increased length of thermal exposure at temperature extremes may also negatively alter CTmax and critical population limits.**
- **More data is needed!**
- **Importantly, disorientation occurred at temperatures below CTmax, suggesting that stingrays begin to lose neurological and motor function before reaching their critical thermal maximum. This indicates that animals may be limited at temperatures below CTmax in the wild, which could affect their survival and behavior in changing thermal environments.**
- **Analysis of energetic data is still ongoing but initial resutls suggest energy needs increase with temperature for the Atlantic stingray across all activity levels, but that different levels of activity demonstrate different thermal sensitivity.**

References

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