Thermal Niche Preference of the Southern Stingray, *Dasyatis americana*

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Introduction

Temperature:
Temperature is one of the most important environmental variables affecting marine organisms. Stingrays are ectotherms, which means the environment around them regulates their body temperatures. Therefore, changes in water temperature affect physiologic processes such as stingrays' gestation periods and digestion efficiency (Wallman & Bennett, 2006). Previous research shows that elasmobranchs exhibit thermal preferences which impacts seasonal migration and drives sexual segregation (Wallman & Bennett, 2006, Speed et al. 2012). Stingray species are known to partition resources along ecological axes such as food (Pardo et al. 2015) and it is has been proposed that changes in temperature may also cause animals to partition resources (Speed et al. 2012).

Ecological Importance:
Stingrays are ecosystem engineers because they alter their habitat chemically, physically, and biologically through the process of bioturbation. Bioturbation occurs when stingrays beat their pectoral fins during foraging. This process results in nutrient suspension and re-oxygenation of sediments (Figure 1, O'Shea et al., 2012). Stingrays are mesopredators, meaning they are in the middle of the food chain, linking apex predators such as sharks, and primary producers such as smaller invertebrates which they prey upon. This study focuses on the southern stingray, *Dasyatis americana*, which resides in shallow, coastal flats throughout the Caribbean.

Climate Change:
Climate change may have large impacts on stingrays if temperature is a determining factor in habitat use. As ocean temperatures rise (Figure 2), southern stingrays may change their habitat choice to find environments with their preferred temperature, leaving a gap in the biotic pyramid of their old habitat.

Purpose:
This study seeks to determine whether the southern stingray demonstrates a thermal niche preference and how that preference causes habitat partitioning between males and females, as well as adults and juveniles. This research will help to determine the possible impacts of climate change and quantify how this might affect the habitat preference of *D. americana.*

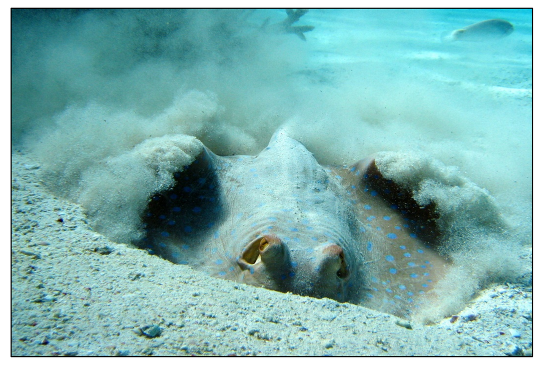

Figure 1. Blue spotted fantail ray bioturbating.

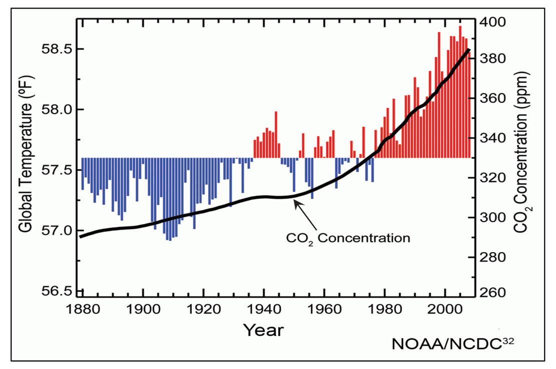

Figure 2. Raise in global temperature as a result of increasing atmospheric CO2 admissions.

Figure 3. Southern stingray swimming in the waters of Wood Cay.

Method and Materials

Southern stingrays were collected from the shallow waters of the Schooner Cays, and the Marker Bar (Figure 4) off of the coast of Cape Eleuthera, The Bahamas in which environmental loggers were placed to monitor ambient temperatures. The stingrays were captured with a seine net and two handheld dip nets. Once captured, a series of morphometric measurements were taken. Females were assessed as mature or immature based upon disc width-- a width of 700 mm was the threshold of maturity (O'Shea, personal communication). Males' maturity was established by the calcification of claspers and presence of gametes.

An archival temperature tag (DS1921H-F5 High Resolution Thermochron, Maxim Integrated) was attached to the base of each stingray's tail (Figure 5). A backing plate was tied to the temperature logger with steel wire, the two ends of the wires were inserted through the tail with two 18-gauge hypodermic needles before being secured to a second backing plate. All rays captured were fitted with an external ID tag (Figure 6) and a PIT (Passive Integrated Transponder) tag to allow identification of individual rays. The thermal loggers recorded the ambient water temperatures the rays were exposed to (in degrees Celsius) every 15 minutes for a seven to 21 day time period. The loggers were removed when the ray was recaptured and the data was downloaded.

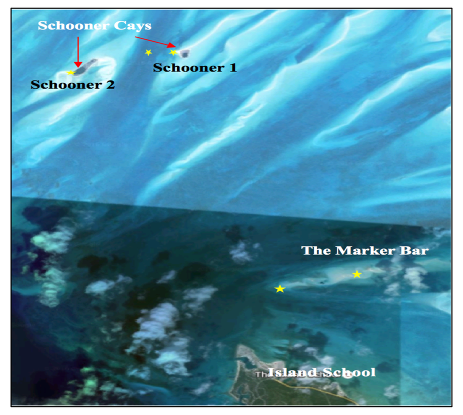

Figure 4. Study locations in relation to The Island School. Stars represent position of environmental loggers.

Figure 5. CEI researchers tagging an archival temperature tag on the base of a the stingray's tail.

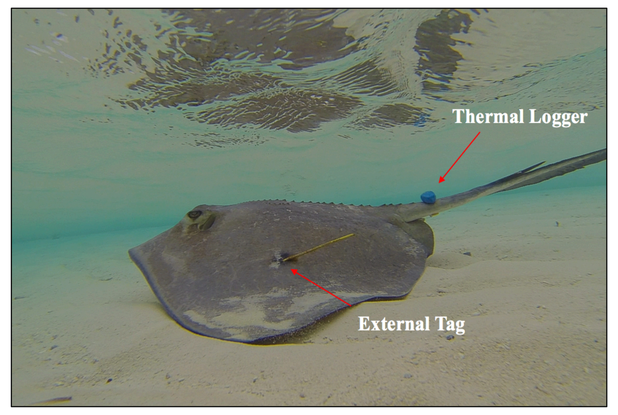

Figure 6. Southern stingray with external and archival temperature tag.

Results

In total, 38 thermal loggers (Table 1) were deployed on stingrays at both the Schooner Cays (nine deployed at Wood Cay, 21 deployed at Water Cay) and Marker Bar (8 deployed). Of the 38 tags put out, 12 were on immature females, 17 on mature females, and nine mature males. To date, seven thermal loggers have been retrieved (six mature females, one immature female) with time deployed ranging from five days to 21 days.

Table 1. Stingrays used in data chart

Ray Number	Gender	Capture Site	Maturity	Days of Data
677	Female	Water Cay	Mature	21
682	Female	Wood Cay	Mature	21
S - 1613	Female	Wood Cay	Immature	21
2268	Female	Water Cay	Mature	5
2302	Female	Marker Bar	Mature	21
2312	Female	Marker Bar	Mature	15
466	Female	Marker Bar	Mature	13

The stingrays showed statistically significant variances in median water temperatures experienced (Figure 2, Kruskal-Wallis, $H=374.28$, $d.f.=6$, $p<0.01$). Overall, stingrays were divided into three distinct groups. Group one (Rays 0682, 2302 and 0466) exhibited the highest temperatures (median = 26.13 +/- 6.25) compared to Group two (Rays S-1613, 0677 and 2312, median = 25.88 +/- 5.5) and Group three (Ray 2268, median = 25.38 +/-3.875).

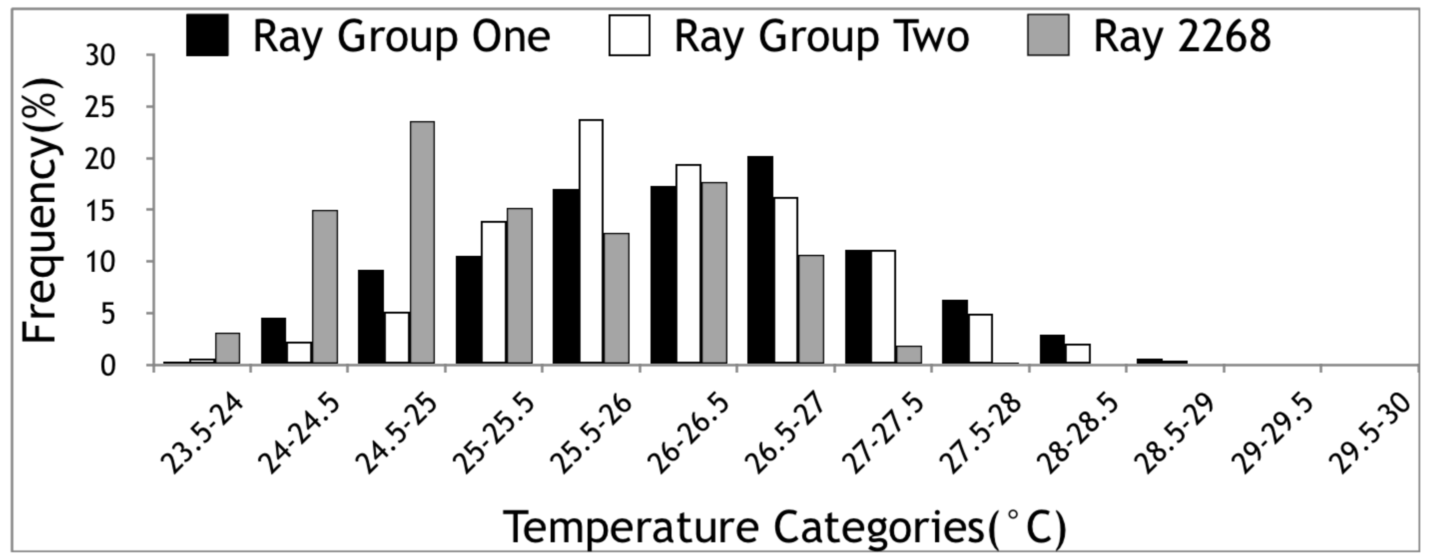

Figure 7. Frequencies of time spent in specific temperatures of ray group one, ray group two, and ray 2268.

To further analyze the different frequencies of time spent in temperature bins of 0.5°C was determined for each group (Figure 7). Frequency of time spent at each temperature range differs for each group of stingrays. Examples of daily temperature regimes for stingrays 2302 (Marked Bar) and 0677 (Schooner Cays) (Figure 8 & 9) are compared to minimum and maximum available temperatures from environmental loggers placed at each location. Both rays showed relatively similar daily patterns in temperature regimes with lowest temperatures experienced in early morning, and highest in mid afternoon. However, Ray 2302 experienced greater temperature fluctuation, as opposed to Ray 0677. This can be slightly attributed to the temperature fluctuation showcased through the environmental data of Water Cay and the Schooner channel. Stingrays appear to prefer areas with highest possible temperatures throughout the day before migrating to lowest temperatures available overnight. The greatest change in temperatures were experienced at crepuscular time periods, (dawn/ dusk).

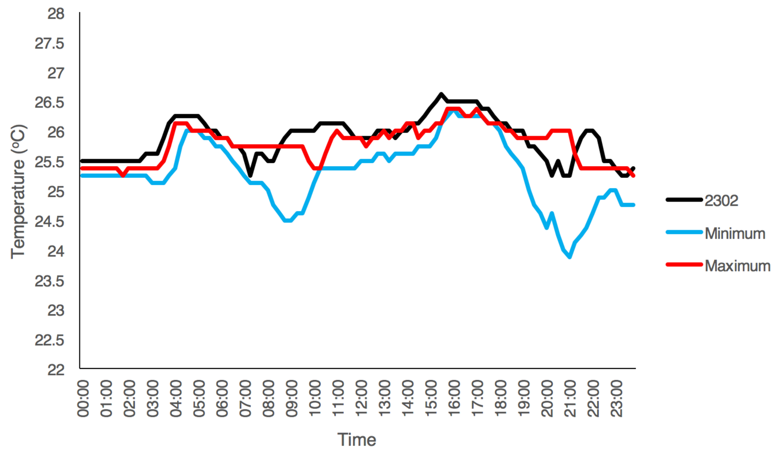

Figure 8. Temperature range of ray 2302, located at the Marker Bar, on April 10th, 2016. Also displays minimum and maximum temperatures of environmental loggers in the given area.

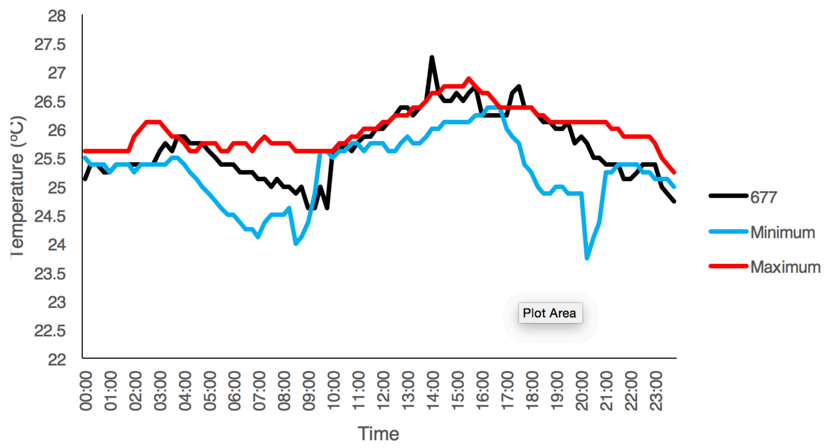

Figure 9. Temperature range of ray 677, located at Water Cay, on April 10th, 2016. Also displays minimum and maximum temperatures of environmental loggers in the given area.

Discussion

The data indicates that there are significant differences in the median temperature experienced by each of the three groups of stingrays. Differences in median temperature are not directly related to the location where the rays were tagged, date of tagging, or maturity. One possible explanation for this difference in temperature could be that stingray group one selected higher temperatures to shorten gestation time. Previous research shows that female Atlantic stingrays prefer higher temperatures during gestation (Wallman & Bennett, 2006). Our data also illustrates that stingrays prefer the highest possible temperatures available during the day and the lowest possible temperatures at night. This behavior could be a result of the rays searching for prey or escaping predators. This could mean that stingrays are entering deeper, colder water at night as a result of foraging behaviors. During the day, stingrays move to shallower, warmer waters to reduce predation risk. Similar patterns have been recorded in black tip reef shark (Figure 10, Speed *et al*., 2012).

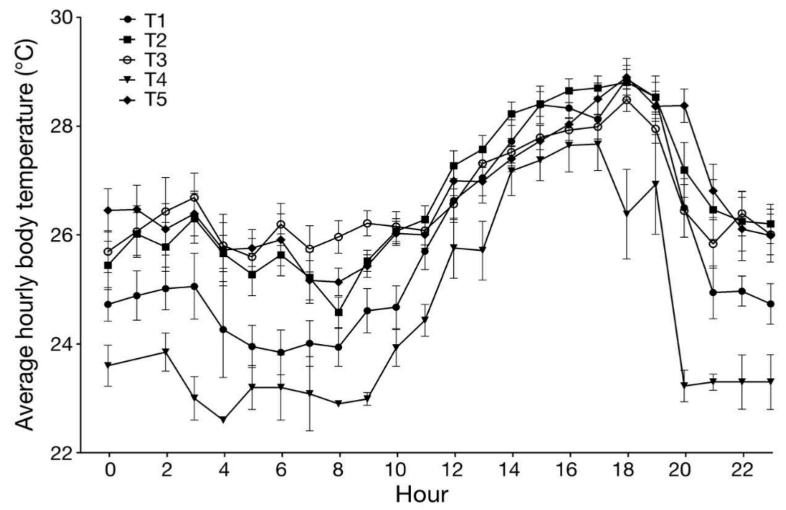

Figure 10. *Carcharhinus melanopterus*. Average (±SE) hourly body temperatures for 5 female blacktip reef sharks (tags: T1 to T5) implanted with temperature sensors at Skeleton Bay

Continuing data collection will help to determine a more specific temperature preference among stingrays. Sufficient thermal loggers have not yet been retrieved, making it difficult to enable comparisons between males and females, and juveniles and adults. With our limited data it is difficult to be certain, but the data suggests that stingrays do demonstrate a thermal niche preference and that they may exhibit differences in thermal behavior related to different life-history stages.

To improve the research, more environmental loggers will be deployed, improving the accuracy of the study. Comparing thermal niche preference from field data with temperature preference determined in experimental manipulations will provide further evidence for the importance of temperature for stingrays and their ecosystems. Increased knowledge on the impact of abiotic factors as drivers for habitat use and movement of ecologically important species will lead to improved conservation and management efforts.

References

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Acknowledgements

- Cape Eleuthera Institute
- Field Study guests
- Images courtesy of Dr. Owen R. O'Shea
- Interns: Rob Hallinan, Nicole Firing, and Katie Luniewicz
- Island School administration