Investigating the Interspecific Stress Responses of Sharks to Longline Capture

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Background and Introduction

Shark populations are declining globally due to anthropogenic exploitation, with an estimated 97 million sharks killed in 2010 (Ransom and Worm 2003; Worm et al. 2013). Longline fishing is one of the biggest contributors to this decline; it is the method used for approximately 80% of the reported sharks caught annually (Ransom and Worm 2003; Worm et al. 2013). In commercial fisheries, sharks are often left on the longline for substantial periods of time, which can result in physical and physiological disruption that may affect post-release survivorship (Skomal 2007). The physiological effects are reflected by changes in the blood chemistry. A shark's body mass is 30% muscle tissue and issues are directly shown in the blood (Skomal 2007). Very little information is known about sharks' response to the stress of longline capture (Mandelman and Skomal 2011). A better understanding of the physiological and behavioral effects of stress is important because this population decline has the potential to cause unpredictable cascading effects throughout the ecosystem, as sharks are vital to maintaining balance in the marine environment (Heithaus et al. 2008).

Purpose

This project fits into a multi-species study comparing nurse sharks (*Ginglymostoma cirratum*) and Caribbean reef sharks (*Carcharhinus perezi*), which represent distinct evolutionary lineages. The goal of this study is to understand how life history characteristics (ex. respiratory traits) may influence a species' response to longline capture. By quantifying and analyzing behavioral and physiological responses to anthropogenic stress, our research will work to fill gaps in our knowledge of species-specific responses to stress. Hopefully these findings will be used in the future when designing and implementing effective conservation and management strategies for shark populations.

Hypothesis

The stress induced by longline capture will cause a greater physiological disruption in the Caribbean reef shark than the nurse shark.

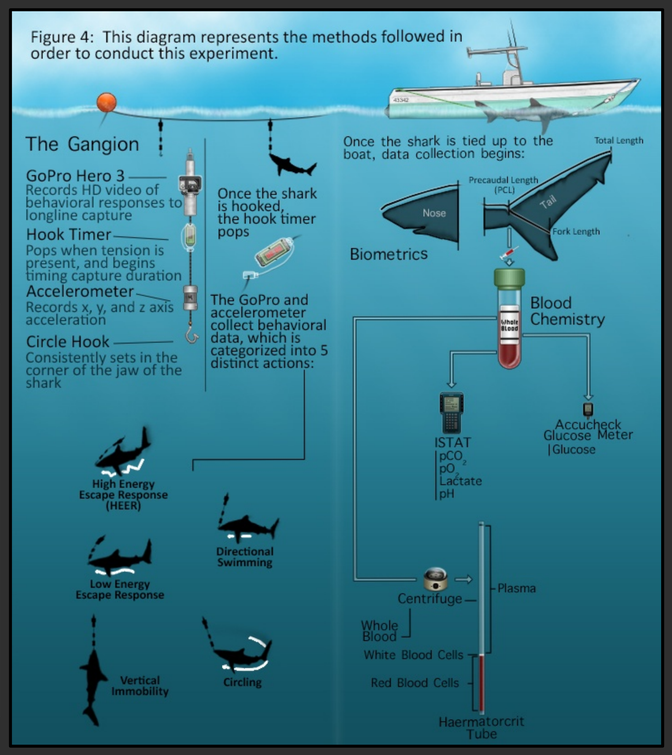
Figure 1: A nurse shark next to the boat.

Figure 2: A Caribbean reef shark next to the boat.

Methods

The methods required to conduct this experiment are represented by Figure 4. A 120m longline is set with six gangions spaced along its length in the study area seen in Figure 3. The parts of the gangion are detailed, as well as the behavioral categories used to classify actions seen in the accelerometer data and GoPro footage. The line is checked every hour for a catch once it is set so that we can accurately control the duration of capture. Once the shark is alongside the boat, the process of taking biometrics and blood begins. This operation is detailed in the second half of the figure.

Figure 3: A map of the area where the longlines were set for this experiment



Results and Discussion

Species	Total Sharks	Capture Date	Sex	Range TL (cm)
G. cirratum	8	15-Feb-13 to 1-May-13	6F, 2M	183-236
C. perezi	5	10-Apr-13 - 25-Apr13	4F, 1M	124-190

Table 1: Our research group collected a total of 13 sharks, 5 reef and 8 nurses, in 2013. The data above shows biometric measurements including mean and range of total lengths for each species of sharks we caught.

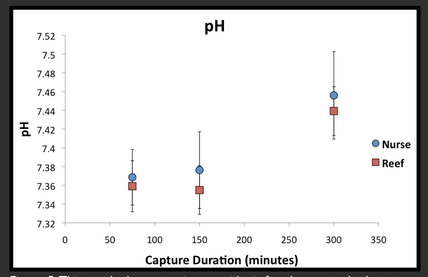


Figure 5: This graph shows maximum acidosis for the nurse shark at one hour, and the Caribbean reef shark at two hours. Both species show signs of recovery within four hours. Nurse sharks have a higher pH than reef sharks, which suggests they recover faster than reef sharks.

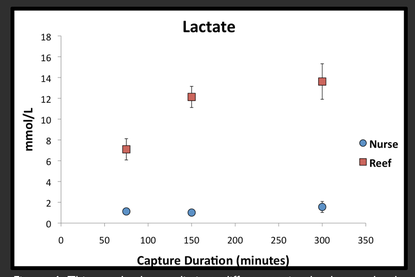


Figure 6: This graph shows distinct differences in the lactate levels between nurse and reef sharks. Lactate levels are directly influenced by increased muscle movement and energy expenditure. Reef sharks have a higher increase in lactate than nurse sharks, suggesting that reef sharks are more active throughout longline capture.

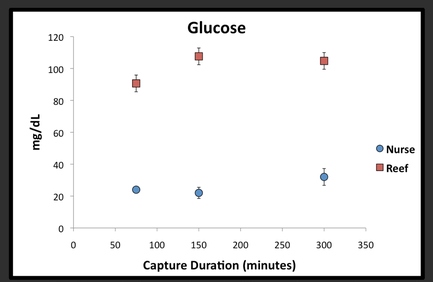


Figure 7: This graph shows a dramatic difference between glucose levels with respect to time. A higher glucose level is due to the mobilization of glycogen, which occurs in a more active shark. This data suggests that reef sharks are significantly more active on longlines than nurse sharks because their glucose levels are higher.

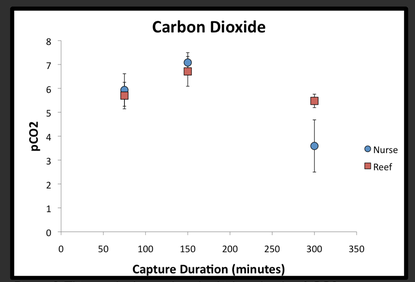


Figure 8: This graph shows that the highest levels of CO2 are at two hours, and both species show signs of recovery within four. CO2 levels are directly influenced by respiratory rates. The nurse shark has a lover carbon dioxide level as time increases, suggesting that it recovers faster than reef sharks.

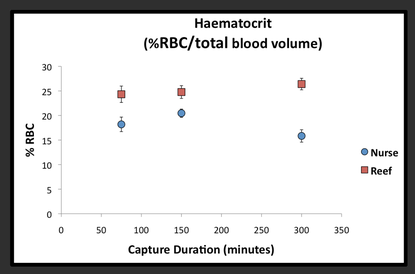


Figure 9: This graph shows the two species' data for haematocrit, which is the percentage of red blood cells per total blood volume. Haematocrit is important in determining energy expenditure because red blood cells are carriers of oxygen. The more red blood cells a shark is producing indicates an increase in oxygen consumption and respiratory rate, which suggests increased stress. The reef shark's haematocrit levels continue to increase with time while the nurse shark's ability to recover from the initial increase is consistent with the resting behavior.

Figure 10: Shark research team holding a nurse shark in tonic immobility.

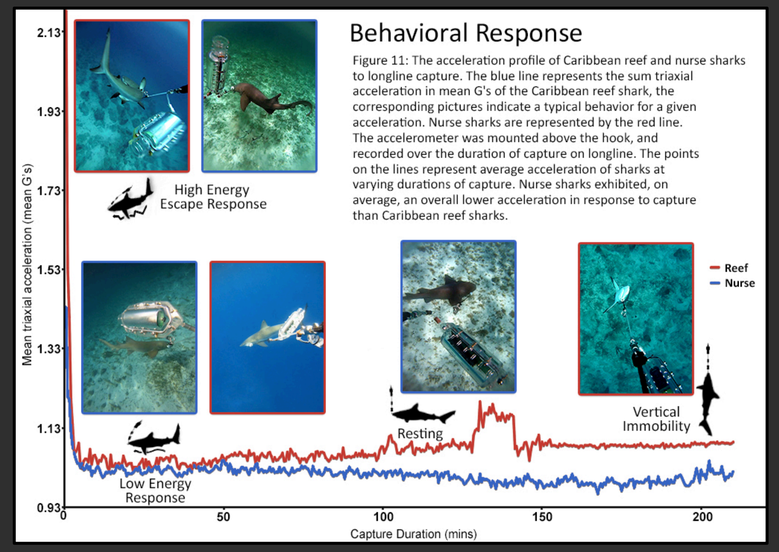


Figure 12: A Caribbean reef shark tied to the side of the boat.

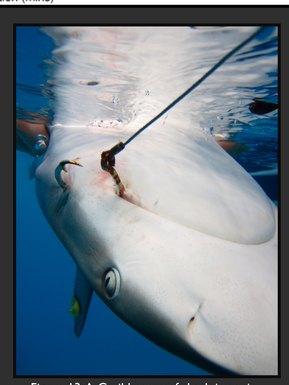


Figure 13: A Caribbean reef shark in tonic immobility.

Conclusion

The data shows a distinct difference between the nurse and Caribbean reef sharks' physiological and behavioral responses to longline capture. Although there is some recovery in parameters such as pH, CO2, and haematocrit, better baselines are required for a more thorough comparison. Baselines are challenging to get because the nature of taking blood is innately stressful. It was seen in the data that the reason the two species have such distinct physiological responses is because of their distinct evolutionary lineages and life history characteristics, more specifically, their respiratory traits. Nurse sharks are strong buccal pumpers (they do not need to swim to breathe), which seems to allow them to recover better than Caribbean reef sharks, which are weak buccal pumpers.

The emerging field of conservation physiology focuses on the importance of studying the physiological response of declining species in order for conservation strategies to be successful. With our project, which analyzes nurse sharks as a model for benthic species and reef sharks as a model for reef associated species, we are contributing to the understanding of sharks physiological response to longline capture. **Overall, it was found that Caribbean reef sharks (seen in Figure 11 and 12) are more susceptible to longline induced stress than nurse sharks and are therefore more negatively affected by longlines. The data collected will help inform policy makers on how to develop effective conservation and management strategies that regulate the use of longlining worldwide.**

Citations:

Chapman, D., Davis, B., Gruber, S.H., Heithaus, M.R., Kettemer, L., Kessel, S.T. , Ward-Paige, C.A., Worm, B. Marine Policy. 2013. Global catches, exploitation rates, and rebuilding options for sharks. Marine Policy 40: 194-204.
Frid, A., Heithaus, M.R., Wirsing, A.J., Worm, Boris. 2008. Predicting Ecological consequences of marine top predator declines. Trends in Ecology and Evolution. 23: 202-210.
Myers, Ransom A., Worm, Boris. 2003. Rapid worldwide depletion of predatory fish communities. Nature 423: 280-283.
Skomal, Gregory B. and John W. Mandelman. 2012. The physiological response to anthropogenic stressors in marine elasmobranch fishes: A review with a focus on the secondary response. Comparative Biochemistry and Physiology. Part A 162: 146–155.
Shepard, E. L.C., Wilson, R.P., Quitana, F., Laicha, A.G., Liebsch, N., Albareda, D.A., Halsey, L.G., Gleiss, A., Morgan, D.T., Myers, A.E., Newman, C., Macdonald, D.W. 2008. Identification of animal movement patterns using triaxial accelerometry. Endangered Species Research 1-14.