The Behavioral and Physiological Response of the Caribbean Reef and Nurse Sharks to Longline Capture

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Introduction:

History:

The growth of the fishing industry has resulted in the depletion of shark populations worldwide. Sharks are K-selected, meaning they have slow growth and reproduction rates, and are being harvested at a rate faster than they are able to reproduce (Worm et al. 2012). Sharks are apex-predators and are vital for a healthy marine ecosystem (Heithaus et al. 2008). The longline fishing industry is the major contributor to shark mortality, and is accountable for approximately 52% of all shark captures each year (Worm et al. 2012). Though the longline fishing method is the most common form of shark capture around the world, the effect it has on the physiology and behavior of a shark during capture is poorly understood (Worm et al. 2012).

Stress Response:

During capture, sharks go through a physiological stress response, which is induced by stress and exhaustive exercise (See figure 1; Mandelman and Skomal 2011). Studying a species' physiological stress response is important for identifying the potential causes of at-vessel mortality and assessing the viability of sharks post release. This information is vital for the conservation of sharks. Sharks are dying during capture due to physiological stress, but the reason for why this is happening is not understood. Understanding the effects stress has on the physiology and behavior of a shark is essential for offsetting at-vessel and post release mortality, which will in turn, lead to improved regulations aiming to conserve shark species, for the benefit of maintaining a healthy, balanced marine ecosystem.

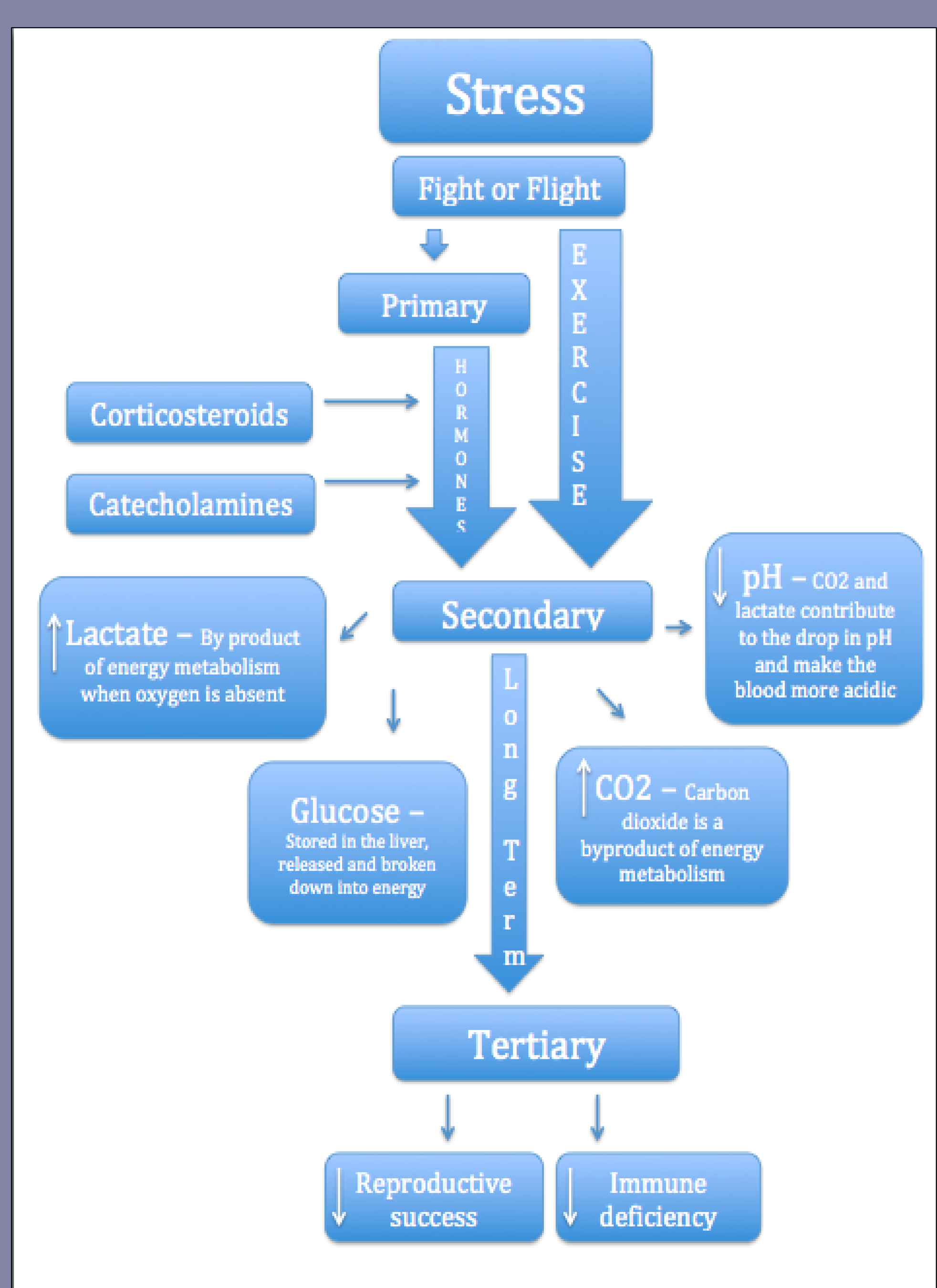

Figure 2. Stress Response Flow Chart. This chart exhibits a typical stress response. A stress response occurs when stress is induced and homeostasis is disrupted. This is exercise induced and triggers a fight or flight decision from the shark. This then leads to the primary response, which is a release of hormones such as corticosteroids and catecholamines. The fight or flight response also provokes the secondary response, which is when levels of lactate, glucose, carbon dioxide and pH all fluctuate in the blood due to physical activity. Lactate and carbon dioxide will both increase while pH will decrease. This can then lead to the tertiary response, which are the long term affect of elevated stress hormones (Skomal and Mandelman 2011).

Purpose:

To investigate how the behavioral and physiological response of the Caribbean reef and nurse sharks during longline capture makes them more or less susceptible to mortality.

Hypotheses:

1. Caribbean reef and nurse sharks will respond with a constant level of activity over the entire duration of capture.
2. As hook duration increases the physiological disturbances in lactate, carbon dioxide and pH will increase.
3. Based on dissimilar evolutionary histories, Caribbean reef and nurse sharks will have dissimilar behavioral and physiological responses to longline capture.

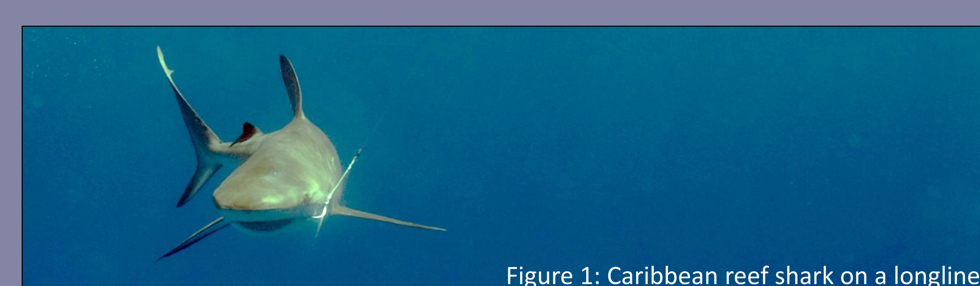

Figure 1: Caribbean reef shark on a longline

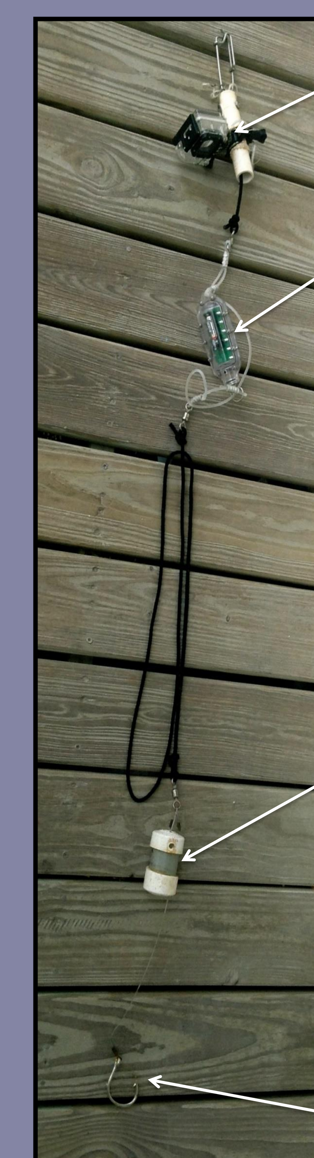

Fig 4: The Gangion
Go-Pro: records underwater footage of the sharks behavioral response to hooking.

Hook Timer: records the amount of time the shark is hooked. This allows us to categorize hooking durations into time bins and relate them to a blood analysis.

Accelerometer: measures triaxial acceleration in g-force per second. This allows us to associate different behaviors with energy use.

Circle Hook: hooks shark in the corner of the jaw only.

Methods:

Sharks were caught using experimental longlines. The line consisted of six gangions which were checked every 30-35 minutes. Gangions consisted of a line with a GoPro camera, a hook timer, an accelerometer, and a circle hook. The entire work up was done by leaning over the boat, so the shark never left the water. After the species was identified, the shark was flipped into tonic immobility, the sex was recorded, and blood was taken. Then, the shark was flipped back over, length measurements were taken, the shark was tagged, and then released. Two types of blood analyses were performed, one on the boat and one in the lab. Glucose was measured with an Accu-Chek meter, and pH, lactate, and carbon dioxide were measured with an iStat point of care device. In the lab, centrifugation was used to spin out constituents in the blood, and then plasma was sent off to a lab for further analysis. Data was tested for normality with a Shapiro-Wilkes test. Depending on whether the data has a normal or non-normal distribution, either a Kruskal-Wallis or ANOVA test is used. The level of significance was set at $p < 0.05$.

Fig 3: (Left to right) Syringe with blood, Accu-Chek, and Istat.

Results:

Blood was taken from 38 sharks (19 *C. perezi* and 19 *G. cirratum*) and acceleration data was gathered every second for the first 2 hours of the capture event, from 22 sharks (10 *C. perezi* and 12 *G. cirratum*). Of the 38 sharks that had blood data collected, 9 of each species had a hook duration of 30 minutes or less and 5 of each species were in both the 120-150 and 240-270 minute hook duration. Dissimilar letters indicate a statistically significant difference within a population. Error bars indicate mean blood chemistry values ± 1 standard error.

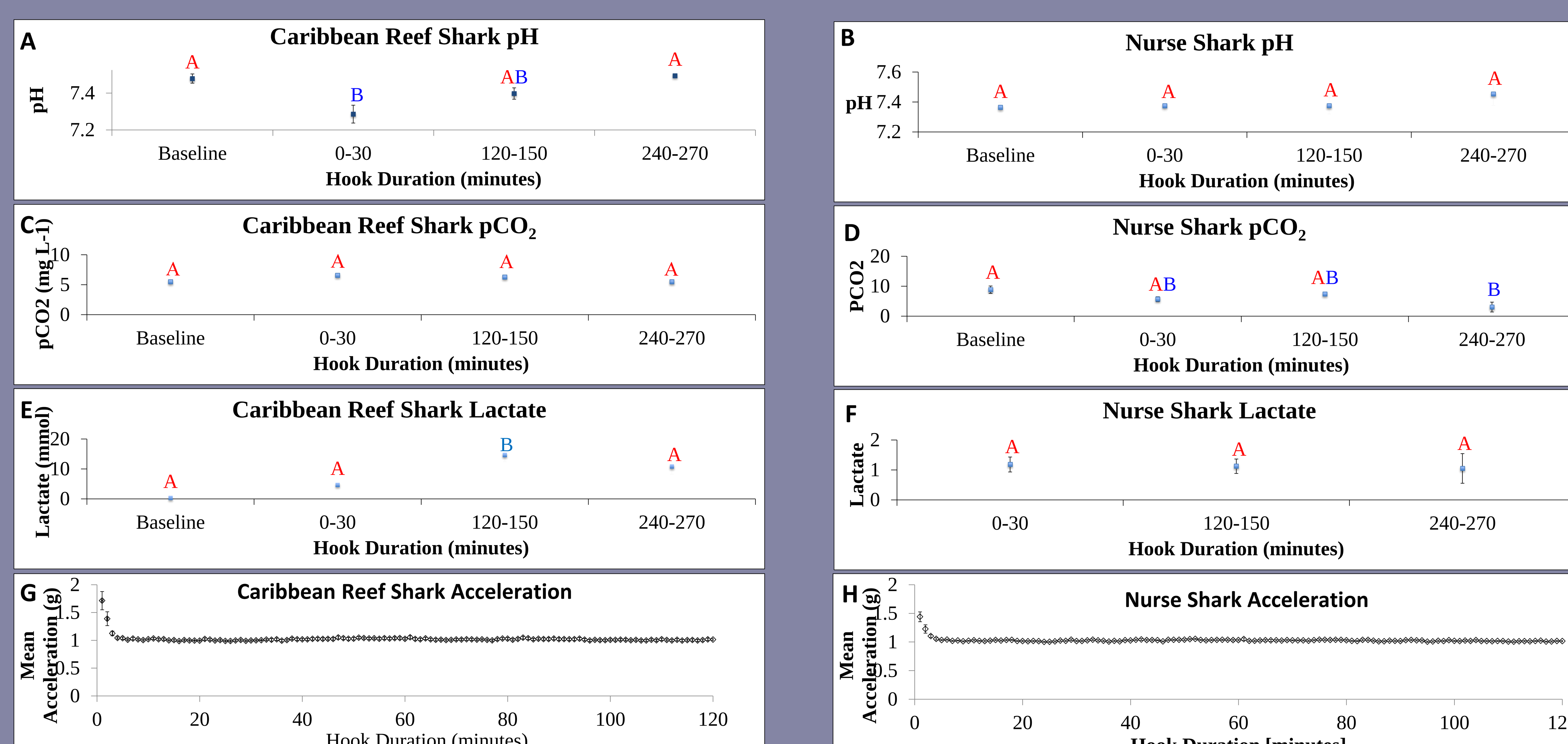

Figure 6: Results Graphs: A highlights a decrease in pH in Caribbean reef sharks within the first 30 minutes of capture but a full recovery within the 4 hours. B suggests no significant change in pH within capture duration for nurse sharks. C portrays that Caribbean reef sharks have no significant response to carbon dioxide when captured. D indicates a significant difference in the levels of carbon dioxide within nurse sharks within the first 30 minutes and they did not make a full recovery within the 4 hours. E highlights that Caribbean reef sharks had a significant difference in response to lactate during 120-150 minutes but made a full recovery within the 4 hours. F indicates that nurse sharks had no significant change in lactate in response to capture. G portrays the acceleration response of Caribbean reef sharks. There was a more exaggerated stress response within the first 5 minutes of capture for Caribbean reefs than nurse sharks.

Discussion:

Acceleration

All previous literature has suggested that energy levels stay constant throughout the capture event, but our research has shown trends that indicate that is not true. On a minute by minute average, we found a significant decrease in acceleration in the first five minutes with the values decreasing from the first minute (see fig 6 G and H). This suggests that most of the exhaustive exercise happens very early in the escape response, while it is not expending much energy after the initial response. All of the blood parameters we measured to quantify the secondary stress response except for glucose change as a result of physical activity, so understanding what part of the stress response is causing that fluctuation is useful to understanding the stress response overall.

Blood Analysis

We found that Caribbean Reef and nurse sharks are able to recover back to near baselines in the parameters we measured as capture duration increases. That suggests that the species we studied are able to recover from the physical activity that happens as a result of longline capture. While they do recover, they do not recover from all. This warrants further research to determine what exactly is causing these sharks to die.

Interspecific Difference

We found that there is a variation in the behavioral and physiological disturbances in the Caribbean reef and nurse sharks to longline capture, with a generally higher response suggested in the Caribbean reef shark which reflects the life history characteristics of the two species.

Fig 5: Blood is drawn from the caudal vein of a shark in tonic immobility

Literature Cited

- Brooks, E. J., Mandelman, J. W., Sloman, K. A., Liss, S., Danylchuk, A. J., Cooke, S. J., Skomal G. B., Philipp, D. P., Sims D. W., Suski C. D. (2011). They Physiological response of the Caribbean reef shark (*Carcharhinus perezi*) to longline capture. *Comparative Biochemistry and Physiology, Part A 162*, 94-100.
- Gallagher, A. J., Frick, L. H., Bushnell, P. G., Brill, P. G., & Mandelman, J. W. (2010). Blood Gas, Oxygen Saturation, pH, and Lactate Values in Elasmobranch Blood Measured with a Commercially Available Portable Clinical Analyzer and Standard Laboratory Instruments. *Journal of Aquatic Animal Health 22*, 229-234.
- Heithaus, M. R., Frid A., Wirsing A. J., Worm B. (2007). Predicting ecological consequences of marine top predator declines. *Trends in Ecology and Evolution 23*, 202-210.
- Skomal, G. B., & Mandelman, J. W. (2011). 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*, 146-155.
- Worm, B., Davis, B., Kettemer, L., Ward-Paige, C. A., Chapman, D., Heithaus, M. R., Kessel S. T., Gruber S. H. (2012). Global catches, exploitation rates, and rebuilding options for sharks. *Marine Policy, 40*, 194-204.

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