Comparing Metabolic Rates and Acceleration to Understand the Effects of Commercial Longlining on Sharks

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Introduction

Longlining

Since the 1950s, mortality rates of sharks have been steadily increasing globally due to several human-induced factors, such as longlining (Figure 1). Although longlining is illegal in The Bahamas, it is not very well regulated globally, resulting in unintentional capture of sharks, or bycatch. The combination of physiological stress and physical trauma experienced during longline capture can potentially lead to mortality either during capture or sometime after release.

Measuring Metabolic Rates

Calibrating metabolic rate against a measure of activity level in the lab can be used to measure metabolic rates in wild animals. Metabolic rate can be measured indirectly via oxygen consumption. Activity level can be measured through acceleration via overall dynamic body acceleration (ODBA), which states that body acceleration is caused by muscle contraction. ODBA has been shown to be an excellent proxy for VO2 in many species, including sharks (Gliss et al. 2010).

Lemon Sharks

Lemon sharks are an excellent model species for this study due to these factors:

• Locally abundant in South Eleuthera (Murcich et al. 2010)
• Remain in the same location for most of their juvenile life (Jennings et al. 2006)
• Lower hook-and-line capture mortality (Danyshuk et al. 2014)
• Easy to transport and do not need to swim to breathe (Figure 3)

Methods

Field Work

• Sharks were caught at various creeks along South Eleuthera (Figure 4) in seine nets (Figure 5)
• Placed in holding tanks at the Cape Eleuthera Institute (Figure 6)
• Fed two percent of their body mass daily
• Forty-eight hours prior to experiment, food was withheld

Figure 4. Lemon sharks were captured at various creeks along South Eleuthera.

Figure 5. Sharks were placed in holding tanks at the Cape Eleuthera Institute.

Swim Tunnel Experiment

Accelerometers were attached to the shark’s first dorsal fin (Figure 7). Sharks were placed in a swim tunnel respirometer for a six-hour acclimatization period at a low swimming speed (Figure 8). Swimming speed was increased in 10 cm s−1 increments every 15 minutes until the shark reached its critical swimming speed, or the maximum speed a shark can maintain before it becomes exhausted. The rate of oxygen consumption was measured at every velocity increment for the first ten minutes. To analyze the relationship between VO2 and ODBA, a standard least squares model was used with individual shark as a random effect, and an alpha value of 0.05.

Figure 7. Accelerometer on the dorsal fin of a lemon shark recording its acceleration.

Figure 8. Acceleration data from the data logger graphing a decrease in oxygen concentration in the swim tunnel over time.

Results

A total of nine juvenile lemon sharks (seven male and two female) were tested. The mean total length of the nine juvenile lemon sharks was 65.01 ± 1.40 cm. The mean mass of the sharks was 1.41 ± 0.10 kilograms. The average water temperature in the swim tunnel was 27.4 ± 0.11 °C.

For each shark, VO2 was calculated along with ODBA at each swimming speed (20, 30, and 40 cm s−1). Of the nine sharks tested, only four swam to exhaustion, while the remaining five did not seem to exhaust, or did not swim at all. The standard least squares model showed that there was no statistically significant relationship between ODBA and VO2 (p>0.05). Figure 10. However, the random effects model showed that there was a significant difference for the intercepts between curves for individual sharks (p=0.001; Figure 10).

Figure 9. Correlation between overall dynamic body acceleration and oxygen consumption of individual lemon sharks. Only three sharks were used at 2 result of insufficient data.

Discussion

The relationship between ODBA and VO2 was not statistically significant, which is surprising because ODBA and VO2 have been shown to correlate very well in many other species, including another shark (Gliss et al. 2010). Although a low sample size was tested, a study correlating dynamic body acceleration with VO2 produced statistically significant data with a sample size of only three juvenile hammerhead sharks (Gliss et al. 2010).

Figure 11. Similar to Lowe (2001), it is possible that Metabolic-related factors may contribute to a higher VO2 value at lower swimming speeds.

Non-continuous swimming

On occasion, sharks would become uncooperative and rest in the rear of the swim tunnel (Figure 13). Lemon sharks can passively pump water over their gills and do not need to continuously swim to breathe. A full set of data could not be recorded from sharks that would not swim continuously for the duration of the experiment.

Future Objectives

In the future, both an energetic cost of capture and a daily energy budget of juvenile lemon sharks will be measured. A daily energy budget will show the amount of energy a juvenile lemon shark uses throughout its daily activities. Measuring energetic costs of capture will help obtain a broader understanding of a shark’s energy expenditure during capture. An understanding of how a shark uses energy during capture relative to its overall daily energy expenditure can be derived by comparing both of these. These results could potentially persuade governments to regulate commercial fishery practices to help conserve shark populations worldwide.

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Citations


