Identifying effects of accelerometers on the swimming performance of juvenile lemon sharks

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INTRODUCTION

Figure 1: An adult lemon shark hooked on a longline

Globally shark populations are in decline. This is due to intentional capture (i.e. shark finning) and bycatch, all catch that is unwanted or unintentional. A large portion of bycatch comes from longlines, a method of fishing that sets out thousands of baited hooks for hours to days at a time. Many of the fish hooked on these lines die, and those who survive are often times discarded with injuries. Long-term effects from the capture event are called sublethal effects, referring to anything that harms the shark but doesn't kill it, such as physical injuries from the hook or exhaustion from fighting on the line (Wilson *et al.* 2014). Species react differently to capture as different sharks become more stressed than others (Gallagher *et al.* 2014). Immediate mortality rates of fish being discarded alive have previously been studied, but few have focused on the long-term effects of capture.

Metabolic rates are used as a metric to quantify the sublethal effects by measuring the change in activity, which can be done using accelerometers (Gleiss et al. 2010). Accelerometers are external tags placed on the dorsal fin to measure activity levels; specifically overall dynamic body acceleration (ODBA) that assumes all acceleration is fueled by energy expenditure. The metabolic rate of the sharks, which refers to all life-sustaining functions, is synonymous to the energy expenditure. Accelerometers are hypothesized to have effects on the swimming performance of sharks, which might sway data collected while using them. The purpose of the study was to identify the effects of accelerometers on the swimming performance of juvenile lemon sharks.

METHODS

Figure 2a: Using seine nets to capture lemon sharks in Kemps Creek

This study used juvenile lemon sharks as a model species for three main reasons:

1. Easily captured in local tidal creeks due to high site fidelity (Murchie *et al.* 2010)
2. Easily and safely transported back to CEI
3. High resilience to the negative effects of longline capture (Gallagher *et al.* 2014)

Accelerometers were placed on the dorsal fin of sharks to measure activity levels. Specifically, they measure Overall Dynamic Body Acceleration (ODBA), a way to measure activity levels that assumes all acceleration is fueled by energy expenditure.

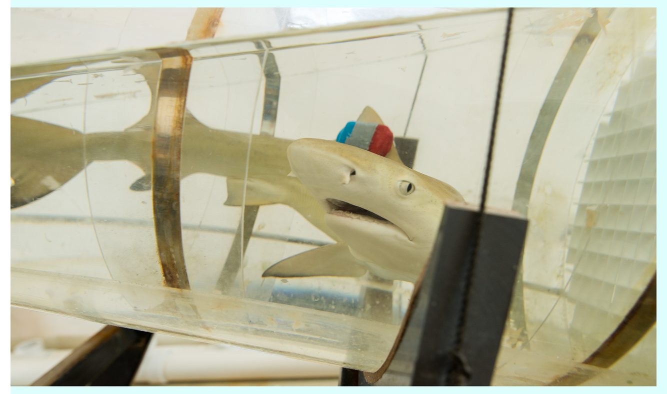

Figure 2b: A juvenile lemon shark with the applied treatment of wearing an accelerometer

Figure 2c: The simulated mangrove habitat where sharks were recorded and data was taken as they swam over the grid

This mangrove habitat models the natural habitat of juvenile lemon sharks. A GoPro™ (Hero 3 Silver, Woodman Labs Inc., Half Moon Bay, CA, USA) hanging on this structure recorded footage of sharks with and without accelerometers. Data was logged on tail beat cycles (a full cycle of the sharks tail back and forth) and swimming speed (measured in body lengths per second) of these sharks. With these data two kinds of statistical tests were conducted: t-tests and linear regression tests. T-tests were conducted on the difference between tail beat frequency (TBF) with and without accelerometers as well as swimming speed with and without accelerometers. Linear regression tests were conducted on the relationship between overall dynamic body acceleration and swimming speed with accelerometers, as well as between overall dynamic body acceleration and tail beat frequency with accelerometers.

RESULTS

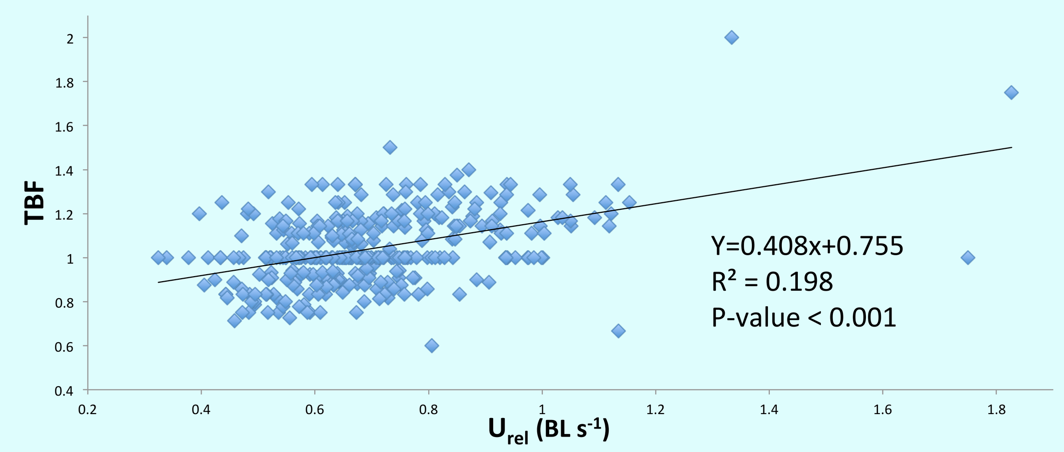

Figure 3a: This graph displays the relationship between tail beat frequency (TBF) and swimming speed relative to body length (U_{rel}) without an accelerometer attached. The relationship was found to be significant, meaning that as tail beat frequency increases, so does swimming speed.

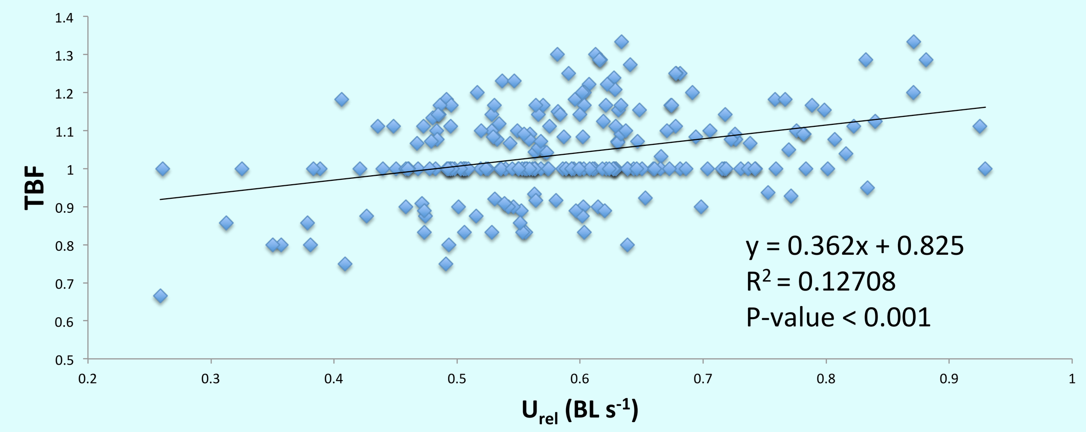

Figure 3b: This graph displays the relationship between tail beat frequency (TBF) and swimming speed (U_{rel}), with an accelerometer. The P value was found to be <.001, meaning the relationship was significant.

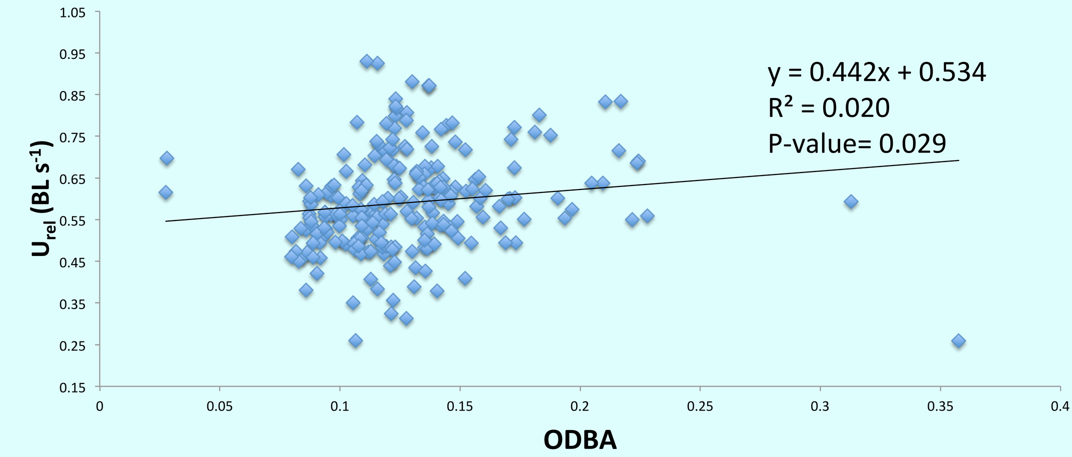

Figure 3c: This graph displays the relationship between overall dynamic body acceleration (ODBA) and swimming speed with an accelerometer (U_{rel}). This was found to be a significant relationship, having a P-Value of 0.029

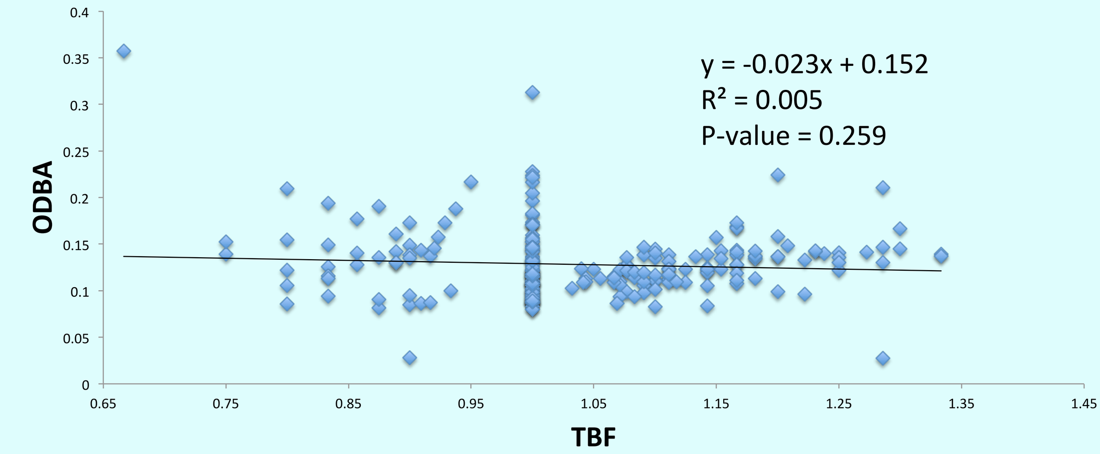

Figure 3d: This graph displays the relationship between overall dynamic body acceleration (ODBA) and tail beat frequency (TBF) with an accelerometer. A P- value of .25 was found, signifying a not statistically significant relationship.

Equations:
Overall Dynamic Body Acceleration= 0.022* Natural Tail Beat Frequency + 0.110
Overall Dynamic Body Acceleration= 0.045*Natural Swimming Speed+ 0.102

These equations were derived from data taken from the graphs and will allow overall dynamic body acceleration to be calculated without the need for accelerometers by using tail beat frequency and swimming speed. This is significant because the sharks' energetics can be found without using accelerometers that have effects on their swimming performance.

DISCUSSION

The results gathered show sharks with accelerometers had higher tail beat frequency (TBF) and lower swimming speed relative to body length (U_{rel}), meaning the sharks had to work harder to swim at slower speeds than sharks without accelerometers, suggesting that accelerometers do affect sharks swimming performance. This was an expected result due to a previous study that also showed external tags have effects on fish's swimming performance (Methling et al. 2011).

Future Research:

The next step to be taken in this research is to use a swimming respirometer, which measures oxygen consumption to calculate the activity levels of sharks with and without accelerometers so the effects of the accelerometer can be quantified and subtracted in future experiments. Along with this, a direct relationship can be found between overall dynamic body acceleration (ODBA) received from the accelerometer and activity levels received from the swimming respirometer. This relationship can then be used to calculate the activity levels from acceleration data received from a shark in its natural habitat with an accelerometer attached.

As the first of its kind, this study provides data on the sublethal effects of capture. Future studies can take this research to pelagic sharks directly affected by bycatch. This information can be used to show that capture has significant effects on the post-release survivorship of sharks. This information can be taken to fisheries management to place restrictions on commercial fisheries to limit mortality and reduce bycatch.

Figure 4: A juvenile lemon shark in a swimming respirometer. Oxygen levels are continuously measured to find activity levels of the shark

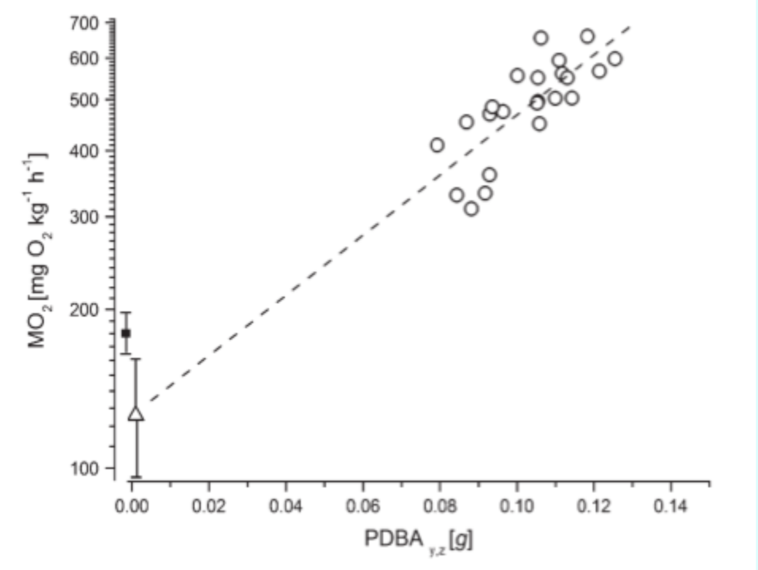

Figure 5: The linear relationship between acceleration and oxygen and oxygen consumption found in juvenile scalloped hammerheads (Gleiss *et al.* 2010). This relationship can be applied to other shark species to find energy expenditure without an accelerometer.

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