Response of Bull Sharks (*Carcharhinus leucas*) to Sharkbanz Deterrents
June 25, 2018

Introduction

On the dates of November 15-17, 2017, The Sharkbanz Team, in association with Discovery Canada and Sharkdefense Technologies, LLC., conducted a comparative study with Sharkbanz products on wild bull sharks in Bimini, Bahamas. The bull shark is responsible for a substantial number of attacks in the USA and globally. The team's goal was to test the hypothesis that Sharkbanz technology creates an effective barrier and deterrent, thus reducing bull shark attacks even under the most extreme test scenarios.

Methods

Between 5 and 15 bull sharks (*Carcharhinus leucas*) were present during the experimental trials. The study consisted of trials that simulated a worst case scenario. Each trial was conducted with the experimental treatment (i.e. Sharkbanz or Sharkleash), and then replicated exactly with the control (i.e. no Sharkbanz). Bait chunks (Bonita, *Sarda sarda*) were intermittently distributed around the human model (i.e. Bernie) to continuously stimulate and attract the sharks to interact with the treatment and control. During all trials bait chunks (approximately 300 g) were placed into the human model at the foot (i.e. inside the sock) to attract the sharks to bite. Various treatments were tested including control (i.e. no Sharkbanz or Sharkleash), Sharkbanz, or Sharkleash.

Trials were filmed with up to 4 cameras each. The interactions were categorized as follows (Figure 1 and Figure 2):

1. Attack bites – shark violently attacks the bait model (Figure 2. G-I).
2. Test bite – shark begins to open the mouth but does not engage, then turns away.
3. Bumps – shark bumps the human model.
4. Pass through – shark swims past human model through the boundary without changing direction.
5. 45° turn – shark makes a 45° turn when inside the boundary.
6. 90° turn – shark makes a 90° turn when inside the boundary (Figure 2. D-F).
7. >90° turn – shark makes a >90° turn when inside the boundary.

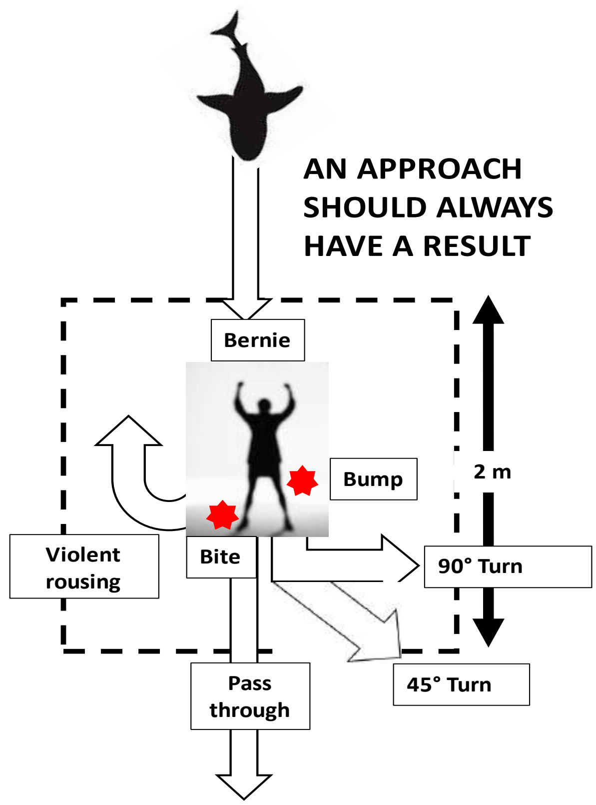

Figure 1. Schematic illustration of the experimental design showing the various shark behaviors once an approach to the experimental apparatus occurred.

8. Violent rousing – shark displays a noticeable repellent reaction (i.e. as if exposed to an electric shock).

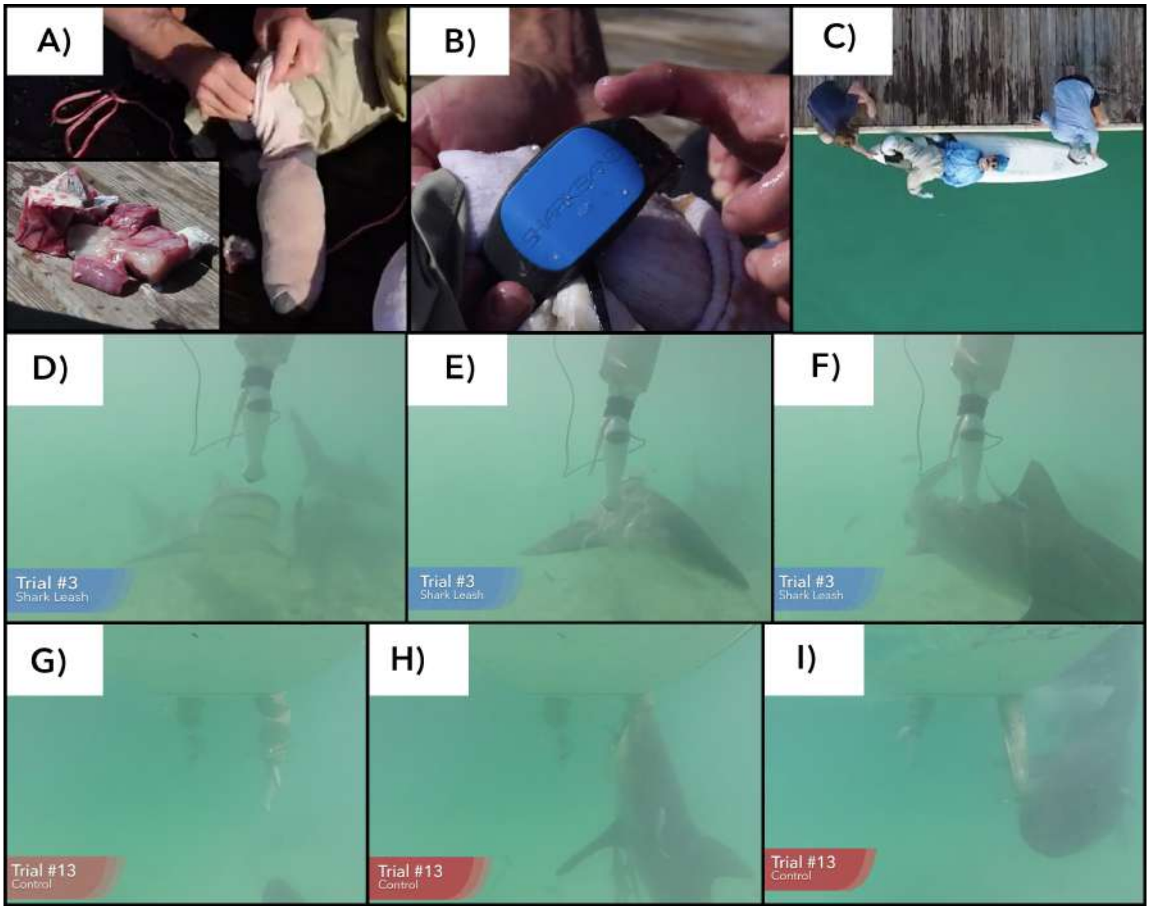

Figure 2. A) – C) Photographic documentation of the experimental setup, D) – F) bull shark behavior in the presence of a Sharkbanz, and G) – I) bull shark behavior without a Sharkbanz present.

Each experimental trial concluded when a shark attacked the baited foot, or 15 minute (whichever came first).

Statistical Methods

As the sharks approached the experimental apparatus (control or treatment), the number of specific shark behaviors per minute of exposure was determined as a rate (behaviors/min). Behaviors were categorized as: (1) attack or bite, (2) no reaction (i.e. approach and swimming past), (3) aggressive reaction (i.e. bump or test bite), and (4) repellent behavior (i.e. avoidance). An equal probability model was used to develop the null hypothesis,

H_0: $E_1 = E_i$

where E_1 = the expected value (i.e. the average rate of all control treatments) and E_i is the observed value (i.e. the observed rate of i^{th} trial run during experimental treatments). The null hypothesis suggests behaviors would be equal regardless of the treatment type. A Chi-square analysis with $\alpha = 0.01$ (i.e. the probability, p, of significantly different results set at $p \leq 0.01$) and used to generate a Chi-square statistic to test the null hypothesis.

Results

A total of 25 trials were conducted with the treatments (i.e. Sharkbanz and Sharkleash) and control resulting in 2 hr 38 min of soak time exposed to the bull sharks with a total of 1235 approaches and observed behaviors. During the 2 hr 19 min with the treatment, there were zero attacks on the human model. Trials with the control were stopped once the human model was attacked. During the 18 minutes of trials with the control, the human model was attacked approximately every 46 seconds.

Sharkbanz Experiment

There were no attack bites on the treatment (Sharkbanz) after 53:31 minutes of experimental treatment. Meanwhile, on the experimental control (No Sharkbanz), attack bites occurred repetitively at a rate of 0.7 bites per minute for the duration of the experimental control treatment (18:48 minutes) (Figure 3).

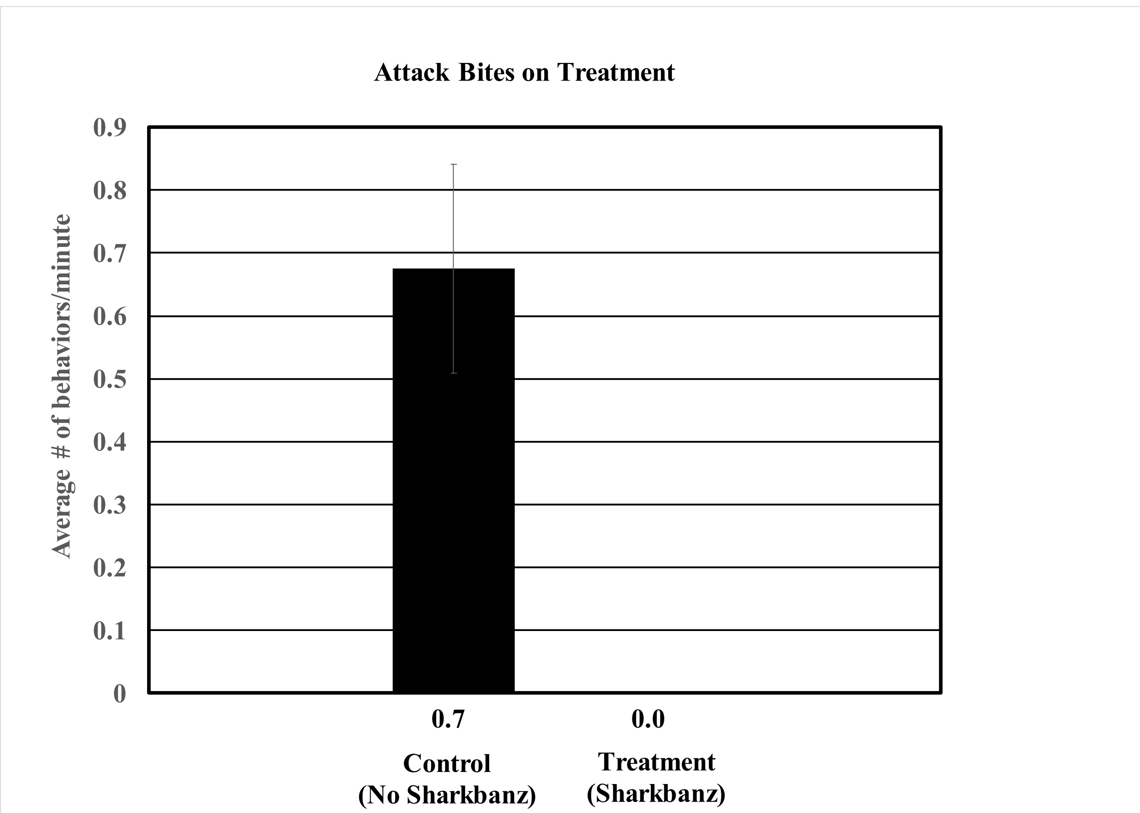

Figure 3. Comparison between control (No Sharkbanz) and treatment (Sharkbanz) for shark attack bite behavior.

There was a significant difference ($p \leq 0.01$) in shark avoidance behavior between control (i.e. no Sharkbanz) and treatment (Sharkbanz). Sharks were 85% more likely (i.e. percent change) to avoid the baited human model leg with a Sharkbanz present than without (Figure 4).

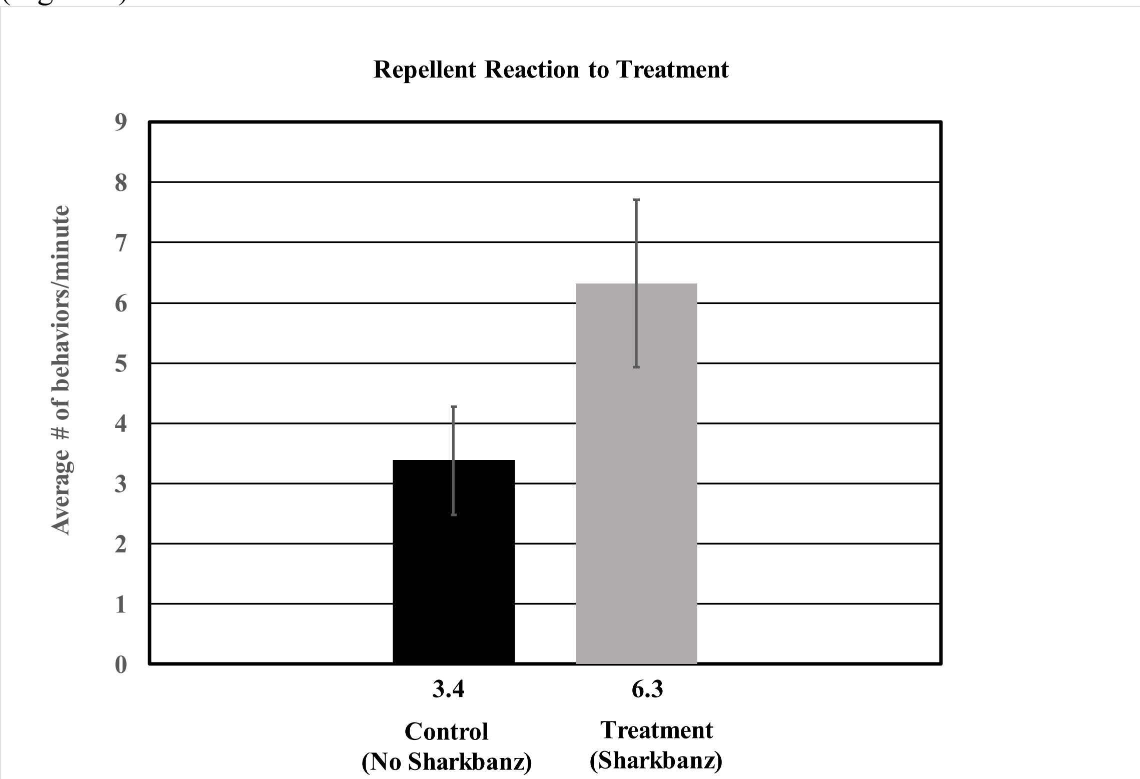

Figure 4. Comparison between control (No Sharkbanz) and treatment (Sharkbanz) for shark repellent behavior (e.g. avoidance).

There was also a significant difference ($p \leq 0.01$) in shark non-avoidance behavior (i.e. no reaction) between control (i.e. no Sharkbanz) and treatment (Sharkbanz). Sharks were 67% (i.e. percent change) more likely to swim past the control (i.e. No Sharkbanz) showing no reaction than the baited leg with a Sharkbanz present (Figure 5).

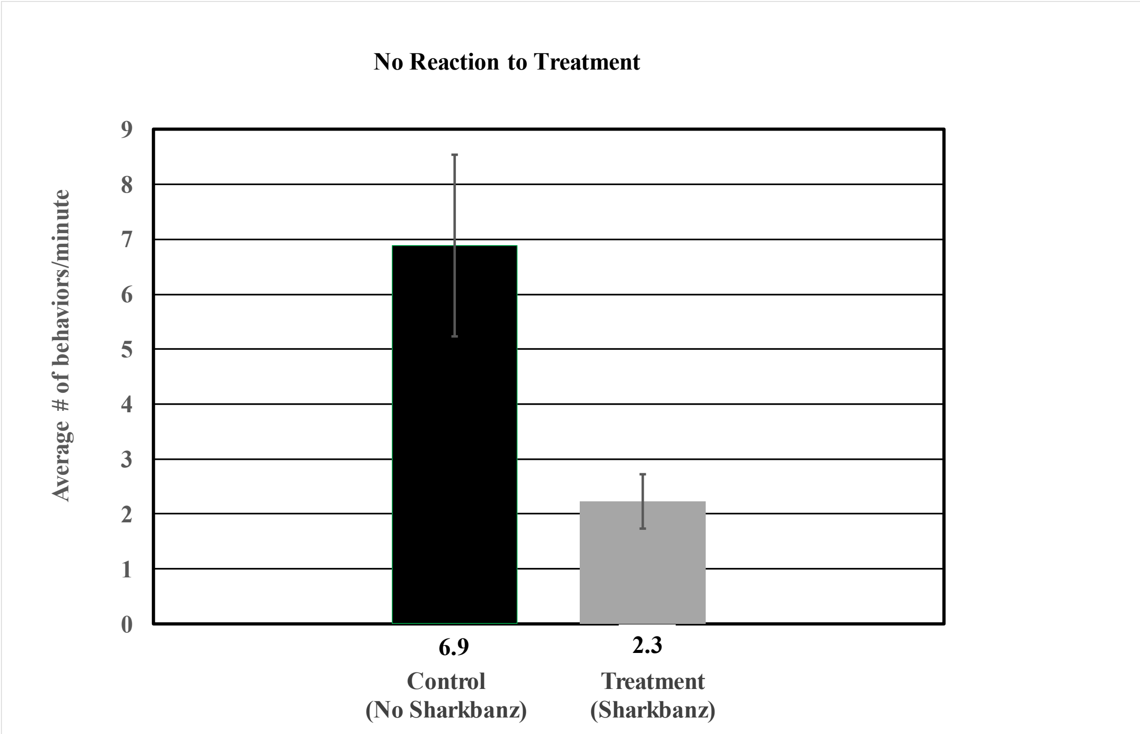

Figure 6. Comparison between control (No Sharkbanz) and treatment (Sharkbanz) for shark behavior showing aggressive behavior (e.g. bites and bumps).

Leash Experiment

There were no attack bites on the treatment (Leash) after 26:02 minutes of experimental treatment. Meanwhile, on the experimental control (No Leash), attack bites occurred repetitively at a rate of 0.7 bites per minute for the duration of the experimental control treatment (18:48 minutes) (Figure 7).

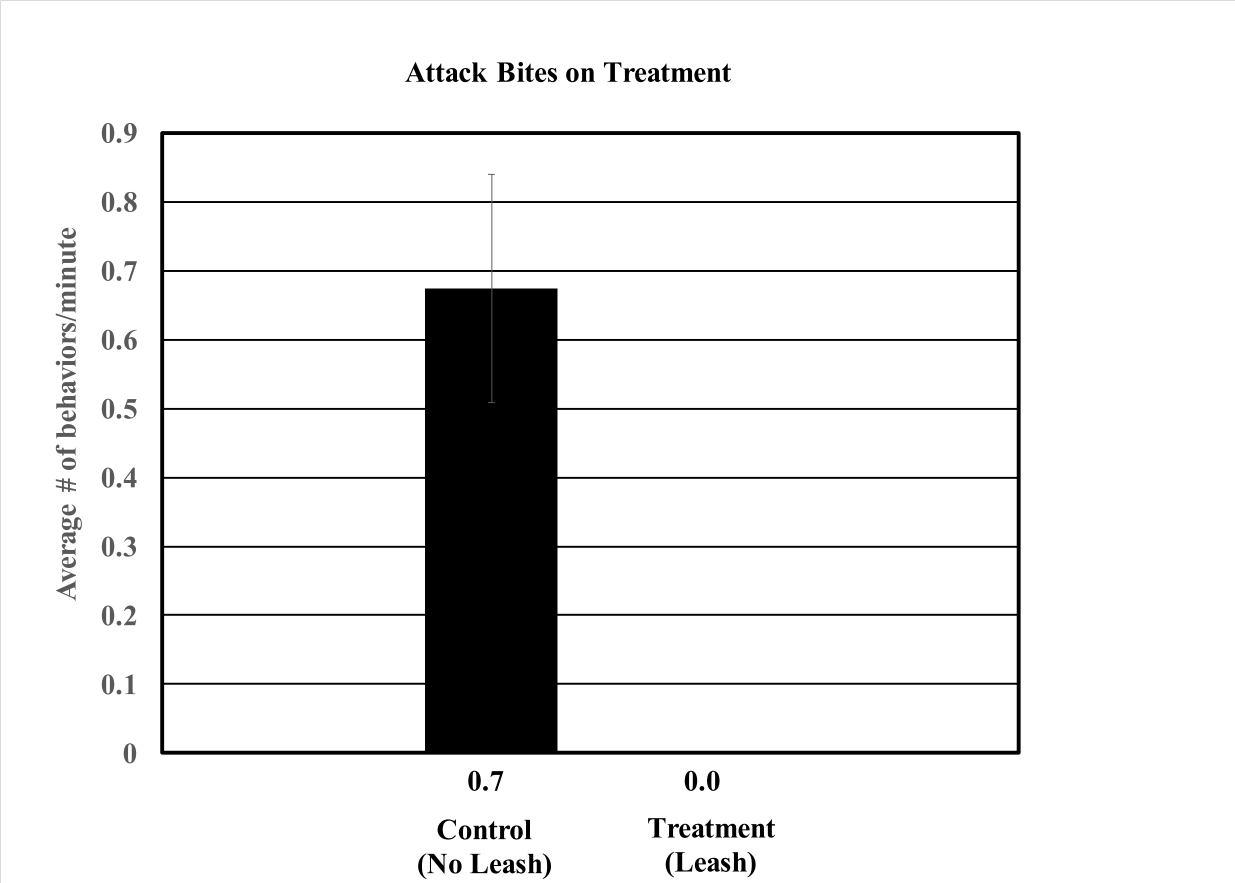

Figure 7. Comparison between control (No Leash) and treatment (Leash) for shark attack bite behavior.

There was a significant difference ($p \leq 0.01$) in shark avoidance behavior between control (i.e. no Leash) and treatment (Leash). Sharks were 26% more likely (i.e. percent change) to avoid the baited human model with a Leash present than without (Figure 8).

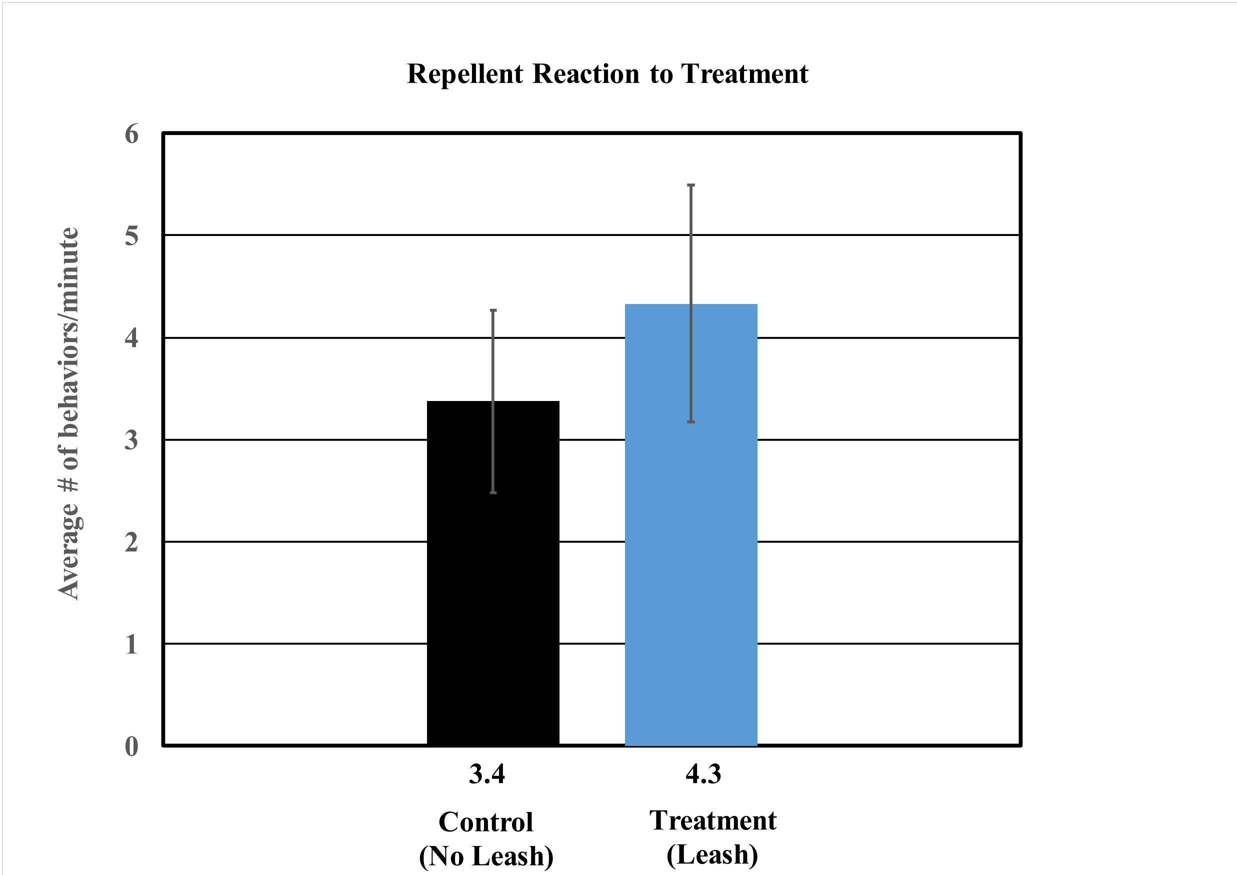

Figure 8. Comparison between control (No Leash) and treatment (Leash) for shark repellent behavior (e.g. avoidance).

There was also a significant difference ($p \leq 0.01$) in shark non-avoidance behavior (i.e. no reaction) between control (i.e. no Leash) and treatment (Leash). Sharks were 86% (i.e. percent change) more likely to swim past the control (i.e. No Leash) showing no reaction than the baited leg with a Leash present (Figure 9).

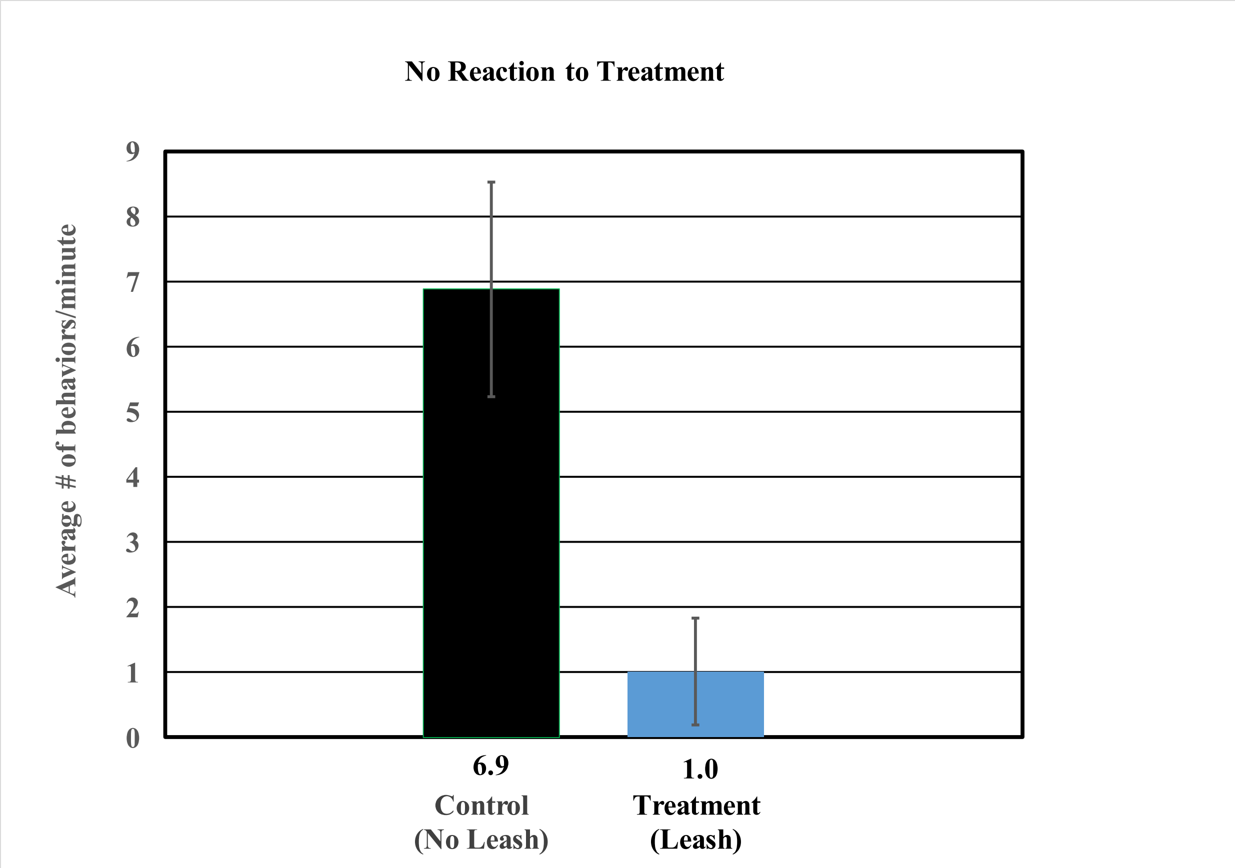

Figure 10. Comparison between control (No Leash) and treatment (Leash) for shark behavior showing aggressive behavior (e.g. bites and bumps).

Discussion

Bull sharks were obviously attracted to the experimental apparatus during all trials and showed continuous feeding behavior. The most striking observation was that there were no attacks observed on the treatments (either Sharkbanz or Sharkleash) during the entire duration of the trials. Sharks demonstrated repeated approaches but never attacked or bit the human model (Figure 3 and Figure 7). Conversely, when the treatments were removed, the sharks attacked and bit the human model repeatedly. Based on these results, if sharks are approaching the experimental apparatus but not attacking or biting the human model, then one would expect to see more repellent reactions during treatment trials than control trials. This is in fact what was observed (Figures 4 and Figure 8). Moreover, if there was no effect of the treatments (i.e. Sharkbanz or Sharkleash), then one would expect to observe an equal distribution of behavior showing "no reaction" between control and treatment experiments. However, there was a significant difference between shark behavior showing "no reaction" with significantly more sharks passing through the 2 m experimental boundary during control trials than treatment trials (Figure 5 and 9). Therefore, based on the on the results of these preliminary experiments, the data suggests that bull sharks are more likely to avoid the human model when Sharkbanz products (i.e. Sharkbanz and Sharkleash) were present and significantly less likely to attack it, even when baited.

Conclusion

The current preliminary study is the first conclusive comparative study demonstrating the effectiveness of Sharkbanz products against bull sharks. The results suggest that wearing a Sharkbanz or using a Sharkleash significantly reduces the probability of bull shark interactions (i.e. attack or bite as defined in the experiment) in a similar situation where a human leg is suspended in the water column from a floating object (like a surf board). Although the current study does not meet all of the demands of a rigorous scientific study, and contains temporal variation between control and treatment trials, and not all trials were identical, the data clearly demonstrated overwhelming evidence that the magnetic technology applied in the Sharkbanz products created an effective deterrent to bull sharks even when enticed to feed. In fact, variation in the experimental trials were intended to explore the limits of the effectiveness and as such only resulted in more compelling evidence of the Sharkbanz effectiveness. Future rigorous studies are planned for 2018 that meet the demands of a rigorous scientific study and will be submitted for peer review. The data from this study is currently being reviewed by an independent researcher and conforms with results from other peer reviewed scientific publications on the effects of very strong permanent magnets on shark behavior, (O'Connell et al., 2010; 2011a; 2011b), and more recently relative to bull sharks (O'Connell et al., 2014).

Literature Cited:

O'Connell, Craig P., Abel, Daniel C., Rice, Patrick H., Stroud, Eric M. and Simuro, Nicole C. (2010). 'Responses of the southern stingray (Dasyatis americana) and the nurse shark (Ginglymostoma cirratum) to permanent magnets', *Marine and Freshwater Behaviour and Physiology*. 43(1):63-73.

[a]O'Connell, C.P., Abel, D.C., Gruber, S.H., Stroud, E.M. and Rice, P.H. (2011). Response of juvenile lemon sharks, *Negaprion brevirostris*, to a magnetic barrier simulating a beach net. *Ocean & Coastal Management*, 54(3):225-230.

[b]O'Connell, C.P., Abel, D.C., Stroud, E.M. and Rice, P.H. (2011). Analysis of permanent magnets as elasmobranch bycatch reduction devices in hook-and-line and longline trials. *Fishery Bulletin*, 109:394-401.

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