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Does the Type of Dive Mask Matter to a Shark?

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Abstract

Eye contact with a shark is a crucial element during an interaction with a diver. Different mask frames change the size of a diver's available field of vision, and so make a person's eyes unequally visible from different angles, particularly when comparing mirrored to regular glass. This study examined whether it matters to a shark if it can see a diver's eyes when getting closer. The test-subjects changed masks in a random, timed routine, while the relative distance, the absolute distance between a shark and diver expressed in a fraction of the shark's body length, between approaching shark and human was tallied. Sharks came significantly closer ($p = 0.0139$) when a diver's eyes could not be detected, showing that they orient themselves and approach based on the human's eyes. Given that human comprehension of sharks is rudimentary, every possible benefit, even a minimal one like choosing the most optimal mask, is recommended whenever approaching sharks are likely to be encountered.

Keywords

Approach, Eye Contact, Interruption, Mask, Shark

1. Introduction

Human encounters with sharks draw more attention than with any other marine creature [1] [2] [3]. This publicity refers to a time when sharks seemed to be little more than ferocious beasts that made getting away unharmed rather unlikely [4]. However, their true nature could not be further from their mainly infamous popularity driven by the media, which still fuels every thinkable broadcast outlet [5] [6] [7]. This media presentation stands in stark contrast to their bite statistics, which confirms that sharks are the least involved predators within the context of animal-human conflict [8] [9]. Any shark encounter, especially with larger specimens, seems dire, though the total annual number of incidents barely reaches one hundred cases [10].

This discrepancy raises the question: Where does this fear of sharks originate? Sharks unify more concerns than any other animal [11], and the thought of being eaten or at least bitten tends to be the most prominent worry. Additionally, a shark's stare often causes the most unsettling feeling during an encounter. Unsurprisingly, people label their eyes frequently as "cold" or even "dead" [12] [13]. Yet, a shark's eyes are as vivid as any of the ones of any other top predator in the marine realm.

A scientific approach to evaluating interactions between two such different creatures posed the only rational choice as otherwise, we only have the subjective narration of people [14]. Sharks do not rush in whenever they detect a person but follow patterns [15] [16] [17]. They notice a person's body position [17], and orientation [16] when in close contact. They thus can estimate a human's field of vision. It may sound trite that a shark can detect a field of vision, and by extension, the person's eye positions, but humans and sharks did not co-evolve, hence expressions like "… a shark came from behind…" imply this dynamic without verification [18] [19] [20].

Given a choice, sharks prefer to approach humans from outside their field of vision [15] [16]. But not just eye contact or the lack of it influences the progress or outcome of an encounter, the same is true, should eye contact be interrupted during an ongoing interaction [21]. Even if a shark reaches the threshold where it commonly turns away from an observer, eye contact interruption at that distance often encourages the animal to get even closer.

Evidence suggests that a shark feels unobserved when drawing nearer from behind [16] or when eye contact is interrupted [21]; still, it abides unclear what a shark determines from afar when deciding to approach from the front or the back of a person [15] [16]. Is a shark rather close, it appears that it looks into a person's eyes, and also seems to be able to do so when the person is wearing a diver's mask. However, different mask frames and glass types may make a person's eyes unequally visible from different angles, which is especially true for mirrored glass.

We explored the potential influence of masks on shark interactions. Test-subjects wore different mask types, with regular, mirrored, or fully blacked-out glass. A distance-related effect between the shark and the diver depending on the mask type was likely, giving credence to prior work on the detection of human vision by sharks [15] [16].

2. Materials and Methods

The tests took place between August 10 and August 19, 2018. We used a sandy bottom open reef area, off of Walker's Cay in the Northern Abaco Islands, The Bahamas. Due to the open area, sharks could freely access the site. The depth varied between 11 m and 12 m, depending on tides. We used the Caribbean reef shark, *Carcharhinus perezi*, the most common species in the Northern Bahamas for these tests. For consistency, all tests took place between 10 am and 12 pm.

Preparation and data collection

Each of the six SCUBA divers who participated in the tests was thoroughly instructed on how to respond if a shark displayed discomfort and to follow strict safety precautions in the water. Part of the trials used blacked-out masks (see below); for this part, the responsibility to act should a shark get irritated, shifted to the documenting videographer.

For each test, a pair of randomly chosen divers from the pool knelt on the ocean floor in a back-to-back position to ensure that any approaching shark was in the field of vision (FOV) of one of the two divers (**Figure 1(a)**).

The videographer was placed above the two divers and right below the surface, thus avoiding interfering with the interacting sharks, as far away as possible.

Except for the masks, each diver wore black diving gear (dive suit, BCD, hoses) to avoid diver outfit variables.

The tested dive masks had the same frame but featured a

1) clear, non-colored glass, called regular;

2) reflective glass, with the diver's eyes only visible from the immediate front and center, called mirrored; or

3) blacked-out glass without the ability to see a diver's eyes, called blacked-out.

We only conducted one 60-minute test daily to keep any conditioning of the sharks to a minimum. Likewise, the test site and position of the diver pair were changed within the general site daily. The divers alternated masks every 10 minutes to eliminate a shark's choice whom to approach or avoid based on a previous encounter. Even if a returning shark remembered its previous actions, it would have to decide again to get closer or stay farther away during the new

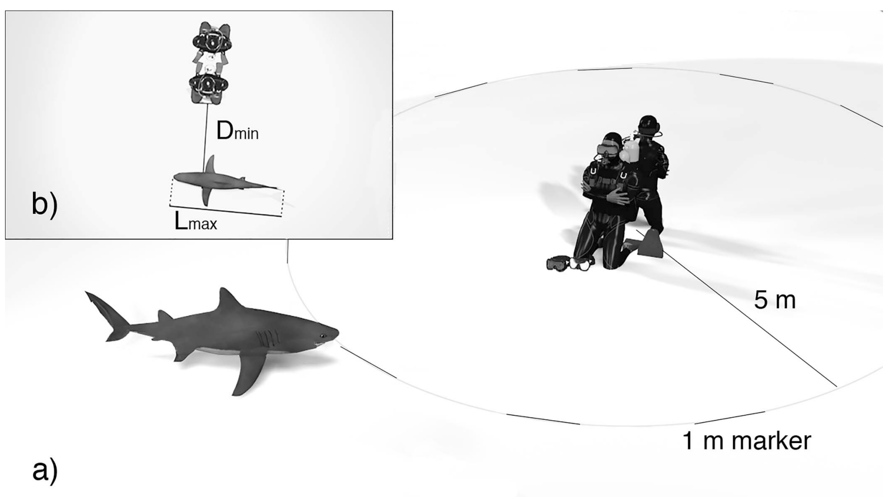

Figure 1. Experimental underwater setup. (a) the circle was created by 1 m markers (the circle shown is for presentation purposes only); (b) measurements taken once the shark reached the closest distance to the diver, Dmin = minimal distance, Lmax = total length of shark (=tip of the snout to end of tail).

encounter. Overall, each diver wore each mask type for 20 minutes during the one-hour test.

The water was chummed with a specified amount of fish to attract sharks to the testing site. After chumming, we waited for 30 minutes and then started the tests, independent of shark presence. Due to the wait in between, it could be assured that present sharks would not associate the offered food with the test-objects.

Measurements

Length markers (1 m) were distributed around the divers (**Figure 1(a)**). The total length of a shark (tip of snout to the tip of the tail, Lmax) and the minimal distance between a shark and a test-subject were measured (**Figure 1(b)**). The minimal distance was expressed as a fraction of the shark's body length (BL), called relative distance (Drel). We only included those sharks in the evaluation that approached the divers directly over the bottom; this is the preferred approach behavior for sharks in close(r) vicinity to humans [15]. We measured only if a shark reached at least its approximate inner circle threshold or idiosphere [15] [17] [22]. This distance represents the minimum space a shark requires to maneuver freely close to an object. The radius of this circle commonly reflects about 2 BL of a shark [15] [16]. We expected Caribbean reef sharks of up to 2.5 m lengths; thus, a circle with a radius of 5 m was outlined around the divers with 1 m length markers (**Figure 1(a)**). This distance of 2 BL is also the maximum distance of near-field water pressure detection for teleosts [23] [24] [25]. A shark's lateral line system appears to detect water pressure from the same distance, pending experimental verification [26].

We used Pixelstick 2.3 (Plum Amazing Software) to measure distances, combined with the video software QuickTime 6.0 by Apple®. We took the average of the two nearest markers when a shark did not immediately pass close to one marker.

We previously rejected tagging sharks to distinguish individuals [15] [16]. Tagging likely affects a shark's behavior in the short run and may even alter the behavior long-term. Any form of tagging requires catching a shark by net or hook to apply the tag or shooting a tag into the animal with a spear gun or harpoon. Any of those procedures creates distress in the animal [27] [28] [29], and some tagged sharks would have likely avoided the testing site after the procedure.

Statistical approach

We used a non-parametric, one-factor analysis of variance, the Kruskal-Wallis test, for relative distance, as well as shark length, with a significance level of 0.05. The two null hypotheses were that the three distributions of each mask (regular, mirrored, blacked-out) for relative distance, and shark length, would be identical versus the alternative hypothesis that both parameters would be different.

3. Results

Overall, 362 approaches were tallied. Between five and seven sharks joined at the site each day, with an average length of 2.3 m (N = 362, SD = 0.316). Sharks drew nearest to divers wearing the regular dive masks (N = 135). Mirrored, and blacked-out masks were approached 110 and 117 times, respectively. The average relative distance between a shark and the three types of divers were 1.59 BL (SD = 0.491) for regular masks, 1.46 BL (SD = 0.449) for mirrored, and 1.48 BL (SD = 0.491) for blacked-out masks, respectively (Table 1), which was significant (p = 0.0453) with a chi-square value (from the Kruskal-Wallis test) of 6.1901 (Table 2).

The average shark length ranged from 2.28 m (SD = 0.326) for regular masks to 2.26 m (SD = 0.324) for mirrored ones and 2.38 m (SD = 0.292) for blacked-out masks (Table 1), and did not indicate a significant difference between the three mask types (p = 0.3137) (Table 2). The distribution for the average shark lengths could be assumed identical.

4. Discussion

Eye contact between humans and animals can trigger emotions and reactions on both sides [30] [31] [32]. Direct eye contact causes behavioral reactions in animals, and so does gazing or avoiding eye contact by humans [33]. Regardless of the impact of direct eye contact, avoidance, or gaze direction creates on the animal, eyes are a focal point during any interaction [34] [35] [36].

Eye contact plays a crucial role during interactions with sharks, though this has been barely examined, except in a few studies [15] [16] [21]. Sharks prefer to approach outside a person's FOV and, in the process, draw closer should the person remain unaware of their presence. Sharks also move nearer, should eye contact be interrupted during an approach [21].

Table 1. Relative distance (Drel) and shark length (Lmax) for the three different mask types (regular, mirrored, blacked-out). N = number of sharks, Ø = average in BL or m; SD = standard deviation; min = minimal relative distance or length; max = maximal relative distance or length.

Factor	Mask type	N	Ø	SD	min	max
Drel	regular	135	1.59	0.491	0.60	3.30
	mirrored	110	1.46	0.449	0.60	3.00
	blacked-out	117	1.48	0.491	0.40	2.90
Lmax	regular	135	2.28	0.326	1.50	3.00
	mirrored	110	2.26	0.324	1.25	3.00
	blacked-out	117	2.38	0.292	1.50	3.00

Table 2. Statistical values of Kruskal-Wallis for significance of relative distance (Drel) and shark length (Lmax). DF = degrees of freedom; p = p-value.

	Kruskal-Wallis	DF	p	
Drel	6.1901	2	0.0453	significant
Lmax	2.3188	2	0.3137	non-significant

We expected that sharks in the current tests got closest to those divers who wore blacked-out masks, which was confirmed. The sharks that could not detect a diver's FOV drew significantly closer than when the diver wore a regular mask with clear glass.

Sharks approached significantly closer when a diver wore a mirrored mask instead of a regular one. The main difference between these two types of masks lies in the fact that with mirrored glasses, a person's eyes are not detectable once the shark is off-center of the person's FOV. Since eyes were not detectable with a blacked-out mask at all, we expected that the sharks would also come closer than while wearing regular masks, based on our previous results [15] [16] [21] where sharks either got closer when staying in the blind region of a diver or once a diver interrupted eye-to-eye contact.

A shark follows a decision-making process during a potential encounter. The animal first identifies a diver's FOV. It remains unknown how the shark determines it, especially from afar since the diver's eyes cannot be seen from a certain distance on, even in excellent visibility. It then either remains outside of the diver's FOV while closing in or approaches within it until the shark can detect the person's eyes, remains eye contact and adapts its swim pattern accordingly. It is thus advisable to maintain eye contact with the shark until the encounter is over.

The understanding of an interaction between a shark and a human is in its infancy despite the vast number of divers who encounter sharks daily [37] [38] [39]. The reason for this discrepancy is that it is chiefly logistical with the primary task creating tests that allow statistically supported conclusions. Considering that many shark species are quite elusive or challenging to meet, many encounters will never go beyond an unanticipated but welcome event. General tendencies of how these encountered shark species see humans and try to gather further information will likely occur similarly or even the same. Thus, even as seemingly minor as direct eye contact with a particular type of dive mask might be, it is a step toward better understanding should a diver meet a shark.

5. Conclusion

Our preliminary suggestion for people who may come across sharks during diving is to wear regular masks with plain glass for establishing the best eye-to-eye contact between the diver and shark. Since the range of the relative distance between sharks and divers in this study was relatively small, albeit statistically significant, it is prudent to conduct more tests with a broader size range, and use different species to verify this preliminary result. Even so, the initial effect of wearing a particular mask, as indicated in this study, supports other results related to approach patterns of sharks in the vicinity of humans.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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