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When Competition Breaks the Rules: Feeding Frenzy as a Trigger for Unexpected Fatal Shark Predation Bites on a Human Sea-User by Non Traumatogenic Carcharinids in the Oriental Mediterranean

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ABSTRACT

The fatal shark attack on a male tourist in Hadera (Oriental Mediterranean coast) in 2025 involved several Dusky sharks (*Carcharhinus obscurus*), a species not considered to be traumatogenic to humans. Artificial provisioning in the area has resulted in habituation with behaviors including begging, potentially resulting in a bold shark displaying a first reflex/clumsiness bite targeting the camera held by the snorkeler, unintentionally wounding him. The sound and olfactory stimuli have likely triggered a feeding frenzy leading to multiple sharks engaging in predation bites. In this case study, extreme competition between individuals has probably overridden the non-instinctive prey nature of the human victim.

Within eco-tourism, shark-watching or swimming with sharks is economically important to several countries and is increasing globally (Séguigne et al. 2023). Consequently, this recurrent contact between humans and sharks will globally increase the likelihood of bites (Ferretti et al. 2015), which receive negative reception from members of the public, potentially to the detriment of these blue economies (Brena et al. 2015). Understanding the real risk from sharks is a major challenge in regard to improving seaside safety standards and requires meticulous analysis of the conditions for each incident before effective management measures can be established.

Shark 'attacks' (we prefer the term 'bite' as suggested by Neff and Hueter 2013) on humans are diverse and varied in nature, depending on the species of shark involved and the human activity that may have contributed to the bite. For the purpose of

this study, it is important to differentiate between a predatory bite: a shark seeking to actively feed on a human, and all the other possible motivations, including: territoriality/dominance, competition/resource access, self-defence/retaliation, or reflex/clumsiness, all of which can lead a shark to bite a human without actively seeking to feed on that human (Klimley et al. 2023, see details in table 1 in Clua et al. 2024). Identifying a predatory bite is materialized by large tissue loss in the case of predation, often leading to the death of the victim, compared with all the other motivations, where wounds generally remain superficial and rarely result in a fatality (Clua et al. 2023). The exploratory motivation to test a potential new prey item (Clua and Meyer 2023) has the particularity of being generally superficial (the animal merely assesses the taste, palatability and dangerousness of the unknown prey), although it can foreshadow predation and, as such, lies at the link between the two kinds

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of major motivations described above. Very few shark species consider humans as potential prey; those that occasionally do include Lamnid sharks, such as the white shark (*Carcharodon carcharias*) or the mako (*Isurus* spp.) and a Galeoceridae, the tiger shark (*Galeocerdo cuvier*). Within the Carcharhinidae family, only the bull shark (*Carcharhinus leucas*) and the Oceanic whitetip shark (*C. longimanus*) pose a true risk of predatory bites (GSAF 2025). The majority of the remaining extant shark species do represent a *potential* danger to humans, but not in terms of predation. By way of example, despite their imposing size (which can occasionally exceed 3.5 m in total length), the sandbar shark (*C. plumbeus*) and the dusky shark (*C. obscurus*) have not been identified in any cases of human fatalities around the world between the 19th century and 2024 (GSAF 2025).

The concept of 'feeding frenzy' is common in the animal kingdom and, in the case of carnivorous sharks, was described in the context of a tiger shark aggregation around a whale carcass in New Caledonia as a 'Mono or multi-specific aggregation of aquatic predators, esp. sharks, which get excited by a feeding stimulus, leading to frenetic and agonistic behaviours to access the food, with a decreased level of vigilance, biting within biting range, including other animals or inert materials' (Clua et al. 2013). While this definition emphasises the notion of competition at work in this phenomenon, it omits a major element in the context of a frenzy, namely the 'trigger' factor. This factor can lead animals to behave aggressively among themselves and alongside potential external factors, can significantly modify their natural behaviour. In terms of 'trigger', and in the context of the above mentioned aggregation (lasting several days), the numerous frenzies lasted a few minutes and were systematically re-launched, after a few minutes or sometimes several hours, when a new tiger shark (absent from the previous frenzy and potentially hungry) appeared in the area to pounce avidly on the carcass, resulting in aggressive rushes from its conspecifics and a new episode of frenzied feeding. This 'frenzy trigger' concept is also confirmed by Gilbert (1977), who mentions that 'Even with (strong) attractants, it is often difficult to get captive sharks to begin feeding. Once one shark in a group has rushed at a bait, however, other members of the group quickly follow, and a 'feeding frenzy' often develops' (p. 671). We also experienced this process in 2003 in New Caledonia, where, in the context of acquiring underwater video images, we presented a dead deer carcass underwater to a group of bull sharks, which refused to touch it while roaming nearby. Assuming that this food was not necessarily part of the animals' usual feeding repertoire, we inserted a dead fish into the deer's mouth. Instantly, the first shark approached to bite the fish, triggering a feeding frenzy involving several bull sharks that finished off the carcass in just a few minutes (EC, Unpubl. Data).

By the end of the 20th century, the coast of the oriental Mediterranean sea hosted several power plants that use sea water for cooling. Hadera and Ashkelon are the biggest stations, generating more electricity and discharging the larger volumes of warm water back into the sea. The Hadera station (50 km north to Tel Aviv—Israel) is being used by nearby desalination plants as dump sites for desalination brines consisting of organic and inorganic particles (Barash et al. 2018). Although the exact mechanism has not been described, the modified local environment in this area have contributed to the

seasonal aggregation (approx. 60–80) of (mainly female) dusky and (mainly male) sandbar adult sharks, with a peak presence during the cold season. This aggregation has contributed to the development of an un-regulated observation tourism unprecedented in the Mediterranean, both in terms of its nature and its strong economic impact (Shamir, Shamir, et al. 2019; Shamir, Zemah Shamir, et al. 2019). Several studies have emphasised the need for management adapted to the conflicting challenges of economic development, shark conservation and the risk of agonistic interactions between animals and humans (Barash et al. 2018; Shamir, Shamir, et al. 2019; Shamir, Zemah Shamir, et al. 2019; Bigal et al. 2024). In the absence of said management, numerous testimonies point to the uncontrolled artificial feeding of sharks, which has led to a phenomenon of habituation (*sensu* Bejder et al. 2009) reducing their caution towards humans and allowing very close observations for sea-users (Barash et al. 2018). As spearfishing is well developed in this part of the world (Frid et al. 2023), we also expect interactions with spearfishermen in the area (DM 2025), resulting in competition between sharks and humans for the access to wounded fish (Clua et al. 2024). Despite this, until recently, no significant agonistic human-wildlife interaction had been observed on the Hadera site, until the incident of April 21, 2025, which led to the fatal shark attack of a 40-year-old male tourist, in the presence of several witnesses who filmed the incident. The day after, searches at sea recovered human remains (in very small quantities) that allowed the forensic confirmation of the victim identity, but also led to the conclusion that he had been devoured by 'several' sharks during this incident (DR 2025; TOI 2025a, 2025b, 2025c).

Considering all these points, and in particular the non-traumatogenic nature of the shark species potentially involved in this fatal predation, we propose here the most likely hypothesis to explain this exceptional incident; before arguing it and suggesting shark-risk management strategies to prevent such an incident from happening again. The aim is to make shark-watching activities in this part of the world more sustainable and secure. From a conservation perspective, the aim is also to prevent radical measures of indiscriminate shark culling being implemented, as is the case in other areas of the world facing shark bite clusters.

In order to develop this hypothesis, we analysed the multiple interviews (accessible via the Internet) provided by witnesses to the incident and those close to the victim, as well as the numerous videos that were posted, combining both images and witness statements. This material is available online using the following key-words: 'Hadera+shark+attack'. The aim of this analysis was to answer two central questions related to: (1) the species and number of sharks potentially involved in the incident and (2) the behaviour of both the shark(s) and the human prior to the first and subsequent bites.

Interviews agree that the 40-year-old was snorkelling at a distance >100 m from Hadera beach to observe the sharks, equipped with a GoPro camera. Witnesses heard him shouting: 'Help...they're biting me' before he disappeared from sight as the water turned red and some dorsal and caudal fins appeared on the surface (FOEJ 2025). Regarding the first question about the species involved, careful analysis of the images revealed that the sharks showing at the surface are likely dusky sharks; based on

the size and shape of their dorsal fin, which is comparatively smaller than it is in the sandbar shark, for individuals of comparative size (Compagno 1984). Regarding the number of sharks involved, besides the exclamation provided by the victim who evokes several individuals in his shouting as well as several witnesses (TOI 2025b), a thorough analysis of photos extirped from a video allows clear identification of at least two individuals, probably of the same species *C. obscurus* (Figure 1).

Regarding the second question, it is appropriate to structure the hypothesis in two phases. Phase 1 is linked to the triggering of the first bite. A video camera, even when stationary, emits a slight electro-magnetic signal which leads certain sharks to identify the source of this signal as a potential prey item, such as a wounded fish in the hand of a spearfisherman (Clua et al. 2024). We can legitimately imagine that the sharks frequenting the Hadera area, in addition to the phenomenon of habituation linked to regular access to food provided by humans, have developed a 'begging' behaviour that drives them to approach (even to the point of contact for the boldest individuals) humans in order to obtain a food reward (Clua 2018). In the presence of these electrical signals, the shark can trigger a reflex/clumsiness bite (See Klimley et al. 2023, 68). While humans are not considered potential prey, this bite may impact a part of their body, usually the hands (Clua 2018). If the shark is highly motivated and given the speed of execution, it is often difficult for a human to anticipate and parry the bite. The sharp dentition of Carcharhinidae means that even the slightest bite can be devastating, leading to severe bleeding. In addition to the olfactory stimulus (linked to the blood), the sound of the bite (through the induced snapping of the jaw) may have rapidly mobilised other sharks in the area. Phase 2 is linked to the triggering of the frenzy: alerted by the stimuli of the first bite (not motivated by predation on humans) one or more sharks may have rapidly pounced on the victim displaying predation bites (with a feeding purpose). The competition (on which the feeding frenzy is based) for access to the food resource overrides the species' usual behaviour (Clua et al. 2013), including the intrinsic non-instinctive nature of the (human) prey. Schultz (1967) describes an account about people trapped in a boat sinking by writing 'Once fresh blood is mixed with the water, sharks have gone into a feeding frenzy resulting in nearly 100% fatality of the victims' (p. 60).

In this Hadera case study, the combination of information from this atypical incident and our knowledge of shark behaviour towards humans led to the hypothesis that the victim had been partially consumed by at least two individuals of a shark species not known to have the slightest appetite towards humans. The situation likely occurred via a process of juxtaposition bites, with two distinct motivations: the first, a (probably single) reflex/clumsiness bite driven by food begging, and the second, several predatory bites triggered by a feeding frenzy. The fact that only two individual dusky sharks were formally identified (through this study) does not call into question the possibility that several other individuals may have also taken part in this collective predation, potentially including one or more sandbar sharks. The similarity of behaviour between these two species (Compagno 1984) does not alter the mechanisms behind the proposed hypothesis. Although low in quantity and quality, the images make it indeed possible to eliminate another legitimate hypothesis that would be based on the involvement of other shark species known to be traumatogenic to humans, as well as being potentially present in the Mediterranean, such as the white shark, the mako shark or the tiger shark. Apart from their characteristic morphology (absent from any visual clue in the Hadera case study), the first two have predominately pelagic distribution, and their presence along such a beach is highly unlikely. As far as the tiger shark is concerned, the close proximity of Israel to the Suez Canal suggests a potential Lessepsian migration of this species (Spanier and Zviely 2022), it is indeed capable of biting people close to the shore, as is regularly the case in the Red Sea (Midway et al. 2019). However, no data support the presence of any tiger shark in this region and the hypothesis of its involvement in this human fatality. Regarding the likelihood of the first triggering reflex/instinctive bite and beside the described 'begging' behaviour that could have facilitated the process, the swimmer's (relatively) high distance from the beach may have been a facilitating factor for the shark's boldness in daring to bite the swimmer. Recent studies show the probable existence of personalities in Carcharhinidae, and has also been demonstrated within a population of bull sharks in Fiji (Vignaud et al. 2023). Within a given population of Carcharhinids, the existence/emergence of particularly bold and risk-taking individuals, to the point

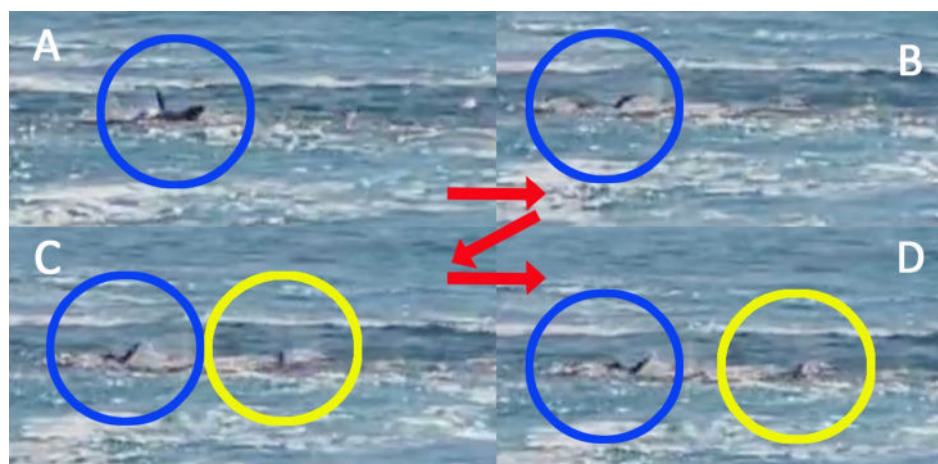


FIGURE 1 | Visual proof of involvement of several sharks in the predation. Photo-sequences (extirped from video) showing dorsal fin and tail revealing the involvement of a shark predating the victim (blue/dark circles in A and B) followed by the implication of a second one (yellow/clear circles in C and D) (from FOEJ 2025).

of biting a human, is probably applicable to the population of dusky sharks in Hadera. As much as this notion of personality may have played a role in the initial bite, it would perhaps remain secondary once the frenzy is underway, allowing shy/timid individuals to get involved.

As for the causes of the incident, several experts have cited environmental factors such as water turbidity or, more specifically, hypoxia in the waters of the river adjacent to the site of the incident, which may have caused the asphyxiation and death of bony fishes (potential shark prey), resulting in higher-than-normal aggregation and 'abnormally aggressive' shark behaviour (Abd Rabou et al. 2025; TOI 2025a, 2025c). While all these factors may indirectly result in a higher-than-average level of interaction with humans, made more complex by the lack of visibility, they certainly mathematically increase the probability of a potential accident, but do not directly explain the behavioural processes that may have led one (or indeed multiple) shark species that are not usually traumatogenic to humans, to ultimately partially consume a human. In addition, the involved shark species do not feed on large prey species, which makes the 'mistaken identity hypothesis' even more unlikely, were it to be legitimately raised as an explanation for this incident (Clua and Meyer 2023). In our view, the most plausible explanation lies not just in the characterisation of environmental factors, but in the detailed analysis of shark behaviour, the two of which in combination, can lead to incidents like these.

This very rare case of collective predation is vastly different from other cases of fatal bites on humans perpetrated by a traumatogenic species. Should the local authorities decide to maintain shark-watching tourism while making it safer, the solutions to be taken are simpler and more effective than in the case of a classic fatal shark bite. The central objective is to eliminate the begging behaviour in sharks, and this can only be achieved by establishing and enforcing a complete and total ban on all artificial feeding of sharks by the public, as well as spearfishing in the area, which can often fuel the impulse in sharks to obtain food from humans. Any other measure could be complementary, but undeniably less relevant than this approach. By the mere presence of warm waters, sharks would likely continue to frequent the area, but may remain more distant and inherently be less dangerous towards humans. The worst solution would be to unselectively eliminate all sharks present in this area in the form of a cull, since the responsibility for this specific incident lies essentially with humans.

Author Contributions

Eric E. G. Clua: conceptualization, investigation, funding acquisition, writing – original draft, methodology, validation, visualization, writing – review and editing, project administration, data curation, supervision, formal analysis. **Kristian. J. Parton:** validation, writing – review and editing, methodology, visualization.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The information used in this study is freely available on the Internet, with communications agencies renowned for their reliability. The victim's anonymity has been respected as far as possible. As far as it is relevant to this atypical video-based study, the STRANGE protocol was respected by authors.

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