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OBSERVATIONS OF AN APPROACH BEHAVIOUR TO A POSSIBLE PREY
PERFORMED BY SOME GREAT WHITE SHARKS, *CARCHARODON CARCHARIAS*
(LINNAEUS, 1758), AT THE NEPTUNE ISLANDS, SOUTH AUSTRALIA

Summary. We describe an approach behaviour performed by great white sharks, *Carcharodon carcharias*. The behaviour was observed during February 2000, at the Neptune Islands, South Australia. Underwater observations were made from cages, under baited conditions. Tuna oil, blood and macerated fish were used to attract the sharks to the vessel and also attracted schools of jack mackerels, *Trachurus declivis*. Some great white sharks, estimated total lengths of 350-400-cm, performed the following tactic when approaching the observer: when the shark made the first pass towards the cage, the predator arrived from the side of the cage that was covered by numerous jack mackerels, then the shark observed the possible prey remaining at the visibility limit behind the school of jack mackerels. This behaviour was observed on 4-5 occasions, on different days. Larger individuals, exceeding 350-400 cm total length, were never observed performing this tactic. We have named this behaviour "hidden approach" and we suggest that some white sharks may use this tactic to increase the element of surprise when attacking prey and to estimate the size of the prey, and its strength, before executing an attack.

Key words: great white shark, *Carcharodon carcharias*, behaviour, predatory tactic

Riassunto. Osservazioni su una tattica di avvicinamento ad una possibile preda messa in atto da alcuni squali bianchi, *Carcharodon carcharias* (Linnaeus, 1758), alle Isole Neptune, Australia del Sud.

Viene descritta una tattica di avvicinamento dello squalo bianco, *Carcharodon carcharias*. Il comportamento è stato osservato nel Febbraio 2000, alle Isole Neptune, Australia del Sud. Le osservazioni subacquee sono state fatte da gabbie, su animali attratti tramite esche. Olio di tonno, sangue e pesce macerato sono stati usati per attrarre gli squali presso l'imbarcazione, e hanno attirato anche esemplari di *Trachurus declivis*. Alcuni squali bianchi, di lunghezza stimata tra 350 e 400 cm, hanno messo in atto la seguente tattica nell'avvicinare l'osservatore: quando lo squalo effettuava il primo passaggio verso la gabbia, arrivava dal lato della gabbia che era coperto da numerosi *Trachurus declivis*, quindi osservava la possibile preda mantenendosi ai limiti della visibilità dietro al banco di pesci. Questo comportamento è stato osservato in 4-5 occasioni, in giorni diversi. Gli individui di maggiori dimensioni, sopra 350-400 cm di lunghezza totale, non sono mai stati visti usare tale tattica. Questo comportamento viene definito "avvicinamento nascosto", e si suggerisce che alcuni squali bianchi possano farne uso sia per accrescere l'elemento sorpresa durante l'attacco ad una preda, sia per stimare le dimensioni e la forza della preda prima di eseguire l'attacco.

Parole chiave: squalo bianco, *Carcharodon carcharias*, comportamento, tattica predatoria

INTRODUCTION

The great white shark, *Carcharodon carcharias* (Linnaeus, 1758) often suddenly attacks the fast-swimming animals on which it feeds. The success of this predatory strategy depends on the element of surprise (Strong, 1996). The victim typically never sees the shark until it is too late and is overwhelmed by the unexpected assault and the violent force with which it is executed. These sharks have been reported to attack seals, sea lions, sea otters, dolphin, tuna, and human beings using this method (MILLER & COLLIER, 1980; TRICAS & McCOSKER, 1984, LONG & JONES, 1996; LONG et al., 1996; AMES et al., 1996; BURGESS & CALLAHAN, 1996; LEVINE, 1996; WEST, 1996). It is thought that the great white shark would have difficulty

capturing a healthy, fast-swimming prey item if the animal were aware of the predator's presence.

White shark approaches on a prey item can be oriented horizontally or vertically. The predator uses its heavy mass and speed to violently ram, disorient, and stun the prey. During vertical approaches, the white shark attacks its prey from below, swimming from depths as deep as 17 metres and moving on a line that is at an angle of 45-90° from the prey. The shark swims with such extreme velocity, that prey have been observed being propelled out of the water by the force of the shark's impact. The majority of approaches observed during a study of white sharks in Spencer Gulf, Australia, were horizontal, but a smaller number of vertical approaches were also observed (STRONG, 1996). It is believed that the predator is less visible when coming directly from below and has a better view of the prey. In comparison, white shark attacks on humans can be oriented horizontally or vertically. In these instances, the shark usually approaches from below, from the side, or behind its victim. As is the case with other prey items, frontal attacks on humans are relatively rare (MILLER & COLLIER, 1980; BURGESS & CALLAHAN, 1996; LEVINE, 1996).

Seals are a favourite white shark prey item and tend to be consumed more than sea lions. This apparent preference may reflect the observation that sea lions, with their speed and maneuverability, may be more difficult to catch. Like other pinnipeds, white shark attacks on elephant seals follow a general pattern (LONG et al., 1996). The shark executes an initial attack on the near-surface pinniped from below or behind, usually inflicting a deep bite on the rear portion of the body. The initial attack is often followed by a waiting period in which the elephant seal does not usually attempt to flee. Reasons for the lack of evasion include the disabling nature of the initial wound, and the onset of shock due to extreme blood loss. The elephant seal expires, due to the loss of blood, and the white shark returns within 1 to 5 minutes to begin to consume the dead animal. This behaviour has been termed "bite-and-spit" (TRICAS & MCCOSKER, 1984). White sharks appear to prefer young elephant seals, in the range of 1-2 years of age. These young seals may be the targets of attacks more frequently because they are less vigilant and have less experience with sharks than the adult seals (MICHAEL, 1993). In comparison, WEST (1996) found that a high percentage of white shark attacks on humans do not conform to this behaviour. Consequently, "bite-and-spit" is not the rule for all white shark attacks.

All of these behaviours enable the white shark to obtain food with minimal risk of injury and minimal energy expenditure. In this paper, we comment on an additional predatory tactic that would increase the element of surprise, possibly enabling the shark to capture its prey with greater ease. The observations within this paper describe a particular approach tactic employed by some white sharks, off Southern Australia.

MATERIALS AND METHODS

The expedition was conducted over a 10-day period, from 6 to 16 February 2000, in the waters of Southern Australia, Eastern Indian Ocean. The study area was located in the mouth of Spencer Gulf, around the waters of the Neptune Islands (North Neptune Island: Latitude 35° 14' south, Longitude 136° 03' east; South Neptune Island: Latitude 35° 16' south, Longitude

136° 05' east; Southern Ocean 135 miles WSW from Adelaide). In this area, several recorded observations indicate a high abundance of great white sharks. The operations were conducted aboard the vessel "Falie", a 45-m ketch.

White sharks were attracted to the vessel using large quantities of tuna oil, blood and macerated southern bluefin tuna, *Thunnus maccoyii* (Castelnaud, 1872). Whole southern bluefin tuna were also suspended from bait lines with a simple toy ballon tied near the end of each line to buoy the tuna at the surface. The baiting process was continuous, with watches maintained around the clock.

Safety measures were taken when humans entered the water with white sharks observed in the vicinity. A steel shark cage allowed one of the authors (V.G.) to observe sharks feeding on bait below the surface of the water. Sharks were photographed for subsequent attentive analyses, using a Nikon 801 with a 20 mm wide-angle lens, encompassing a total of about 1300 pictures. The size of each shark was estimated as total length with the caudal fin in its natural position (TLn).

Weather conditions were favourable for the duration of the expedition. Skies were quiet, with variable cloud formations. Seas exhibited a constant current, without extreme or strong variations in intensity. Waves were minimal in size, allowing the cage to remain on the surface. Water temperature, at the surface, was consistently measured at around 19°C. Average depth was about 30 m. However, the sea bottom was not always visible because of mild turbidity and also because it was covered by dark algae. All sharks (n=10) were observed while the vessel lay anchored approximately 100 metres off North Neptune Island. No sharks were encountered off South Neptune Island.

The blood and macerated fish consistently attracted several schools of jack mackerels, *Trachurus declivis* (Jenyns, 1841), ranging from 20 to 30 cm total length. The presence of these tightly packed schools further reduced visibility around the shark cage.

RESULTS

During underwater diving, one of the authors (V.G.) observed several great white sharks performing a particular approach tactic with respect to the cage. When the shark made its first pass towards the cage, the predator approached from the side of the cage that was obscured by numerous jack mackerels (fig. 1). The diver did not observe the shark until it was very close, due to the presence of the school of fish between the shark and the cage. This natural screen enabled the predator to approach the possible prey item undetected, until it was within a few metres. The shark continued to assess the possible prey item, remaining at the visibility limit behind the school of jack mackerels (fig. 2). The white shark's coloration, with a dark dorsal surface, lighter flanks, and a white ventral surface, resembled the color pattern exhibited by the schooling fishes. This apparent camouflage may have helped to render the large predator almost invisible to the observer at a greater distance. After multiple passes using this tactic, the shark retreated beyond visibility limits and was not observed in the area for upwards of 30 minutes. Some of the animals returned after variable absences, and did not continue to exhibit the above-described behaviour. The change in behaviour may be due to the predator

evaluating the situation and deciding that the diver presented no threat or did not resemble a possible prey item.

This behaviour was clearly observed in 4-5 cases, and occurred on different days of the expedition. All white sharks that were observed performing this tactic ranged from 350 to 400 cm in total length (TLn). The larger individuals, exceeding 350-400 cm TLn, were never observed performing this approach tactic. They simply swam towards the cages without any apparent effort to remain hidden. The observations are further documented by the photographs published within this monograph.

DISCUSSION AND CONCLUSIONS

The lateral line system and the inner ear enable sharks to detect movement in the water. They are able to discern both the directionality and intensity of movement in the water from great distances. Therefore, they are able to detect both movement and position of small schooling fishes and of any possible prey item. Consequently, the white shark should be able to move towards a prey item using a tightly packed school of fish as camouflage to obscure

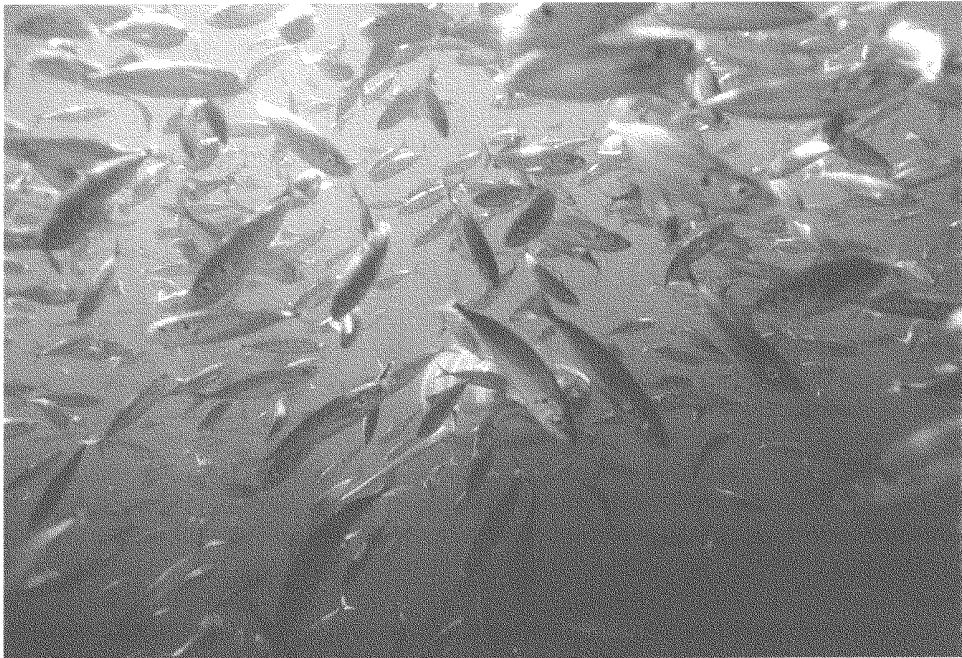


Fig. 1. An estimated 350-400-cm great white shark, *Carcharodon carcharias*, making its first pass towards the shark cage, arriving from the side where there is a large school of jack mackerels, *Trachurus declivis*. Using the school of fish as a shield enables the shark to approach the possible prey undetected. Photo by Vittorio Gabriotti.

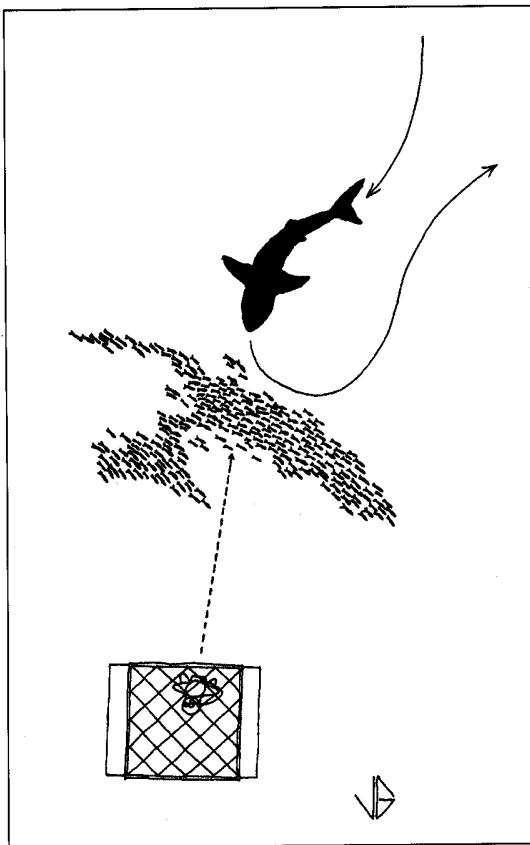


Fig. 2. An estimated 350-400-cm great white shark observes the possible prey remaining at the visibility limit behind the school of jack mackerels. Photo by Vittorio Gabriotti.

its approach. By applying this approach tactic, the smaller white sharks could be deciding whether to attack the cage immediately, or to further assess the viability of the possible prey item. The shark can continue to evaluate the parameters of the predatory event and remain, undetected, at the visibility limit behind the school of fish, swimming on an axis of shark / school of fish / prey. We have named this behaviour “hidden approach” (fig. 3).

White sharks typically attempt to acquire their prey with minimal risk of predator injury and minimal energy expenditure. Each predatory tactic that increases the element of surprise, enables the predator to obtain its food while minimizing risk and energy expenditure. When the prey is disoriented and disabled by a successful surprise attack, it is less capable of resistance to further attacks. The approach tactic that is described within this study, enhances our understanding of the general predatory behaviours of *C. carcharias*. This tactic also provides evidence for possible behavioural modifications as they relate to the size of white sharks. The observation that larger white sharks didn't show this kind of approach behaviour could be related to their greater size and strength. It could also be further indicative of a lack of necessity for such a cautious behaviour past a certain point in the growth and development of the shark. Estimating the size and behaviour of a possible prey item before executing the attack would appear to be an important tactic for smaller sharks to employ. This cautious behaviour would allow the smaller animals to obtain food with minimal risk and energy expenditure.

Fig. 3. Some great white sharks, estimated total lengths of 350-400-cm, performed the following tactic when approaching the observer: when the shark made the first pass towards the cage, the predator arrived from the side of the cage that was covered by numerous jack mackerels, then the shark observed the possible prey remaining at the visibility limit behind the school of jack mackerels. Drawing by Vittorio Gabriotti.



It has been documented that sharks learn from past experience and are able to refine their predatory tactics. They improve their hunting abilities and test them (MARTIN, 2003). It is possible that the behaviour described in this paper has been observed in this limited number of white sharks because only these individuals, in this particular environment, have developed and learned to use this technique. It is also important to consider that the white sharks inhabiting Spencer Gulf have been studied by multiple researchers, over an extended period of time. Therefore, the fact that the behaviour described in this monograph has never been reported before, may suggest that "hidden approach" is a relatively new tactic developed by South Australian great white sharks. However, Spencer Gulf white sharks may have become desensitized to the presence of humans and their associated research equipment. These sharks may have learned to associate certain olfactory and acoustic stimuli with the presence of humans. These parameters may have modified the white shark's normal behaviour, and these modifications may have resulted in some specimens developing alternative approach tactics. Conversely, the fact that "hidden approach" has never been described in other areas where white

sharks have been observed, may tentatively suggest that this behaviour is a new tactic developed by South Australian great white sharks.

The hypothesis presented requires confirmation through additional studies. Similar studies need to be conducted, both in the waters of the Neptune Islands, and in other areas frequented by great white sharks.

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