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Behavioral responses to fishing line entanglement of a juvenile bottlenose dolphin in Shark Bay, Australia

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Abstract

Entanglement in marine debris has become a serious matter for marine fauna, yet most data come from deceased animals. Here we studied a non-lethal entanglement event involving a female juvenile bottlenose dolphin (*Tursiops aduncus*), known as EDE, in Shark Bay, Western Australia who has been monitored and observed since birth as part of a long-term study. We compared her behavior before, during, and after entanglement. During entanglement, EDE markedly decreased time spent foraging, and increased time spent traveling. In contrast to before and after entanglement, EDE was mostly alone during entanglement, which may compound the negative impacts in a social species. During entanglement, erratic behaviors including leaps and fast swims were frequent. After entanglement, her activity budget and associations were similar to the period before entanglement. This study marks a rare opportunity to systematically examine the effects of entanglement on dolphin behavior and has implications for other highly social marine species.

Introduction

Marine pollution and debris have become an issue of epic proportions. Plastic makes up the majority of marine litter with over 250,000 tons floating in the sea [1] [2]. In 2010 alone it has been estimated that 4–12 million metric tons of plastic entered the ocean [3]. The impacts of debris, such as ingestion, entanglement, and habitat degradation are occurring in every ocean worldwide. Entanglement in marine debris is a major problem for marine fauna, including marine mammals, sea turtles, sea birds, fish, sharks, and crustaceans [4] [5] [6]. Marine debris, such as fishing gear, is particularly problematic for marine animals that breathe air, travel large distances and dive for food. Synthetic fishing gear, which does not breakdown naturally, remain in the oceans for decades and entangle large numbers of cetaceans, pinnipeds, and sea turtles well after active use [7]. The International Whaling Commission estimates that 308,000 whales and dolphins die each year due to entanglement in fishing gear [8]. The impacts of entanglement may be short-term and non-lethal, or prolonged and result in death from infection, loss of appendages or drowning due to constricted body parts. Other possible outcomes are starvation due to impaired foraging ability, and exhaustion due to hydrodynamic drag. Gear from commercial fisheries is responsible for the majority of serious entanglements recorded. Drift nets are estimated to kill thousands of dolphins (*Delphinus delphis, Stenella coeruleoalba)* in the Mediterranean each year [9]. The majority of humpback whales (*Megaptera novaeangliae*) in near-shore waters of northern Southeast Alaska bear scars of non-lethal entanglement [10]. Fishing gear entanglement is the leading cause of death for large whales in the Northwest Atlantic [11], and is one of the greatest threats to the critically endangered Mediterranean monk seal [12]. While bycatch has caused the vaquita population to diminish to 30 individuals, making it the most endangered cetacean in the world [13] [14].

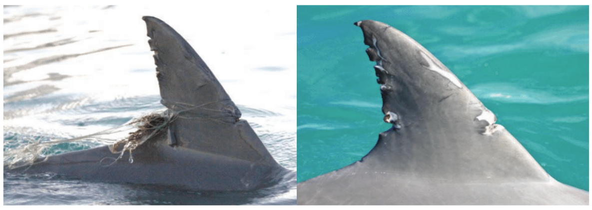
Coastal cetaceans are also affected by recreational fishing practices. For example, in Sarasota Bay, Florida, veterinary records from 1988–2006 show over 600 deceased bottlenose dolphins (*Tursiops truncatus*) have ingested fishing gear [15]. In addition to ingestion, entanglement in fishing gear can also result in death [16]. Studies of entanglement are usually based on necropsies or scarring [10] [16], but there are a few that have examined the impact of entanglement on cetacean behavior [17] [15] [18]. Virtually no studies have detailed behavioral changes based on observations of individuals before, during, and after entanglement. Here, we describe observations of a female bottlenose dolphin (*Tursiops aduncus*), EDE, before, during and after entanglement in a fishing line.

The entanglement was non-lethal and it took EDE one week to free herself from the line.

Objective

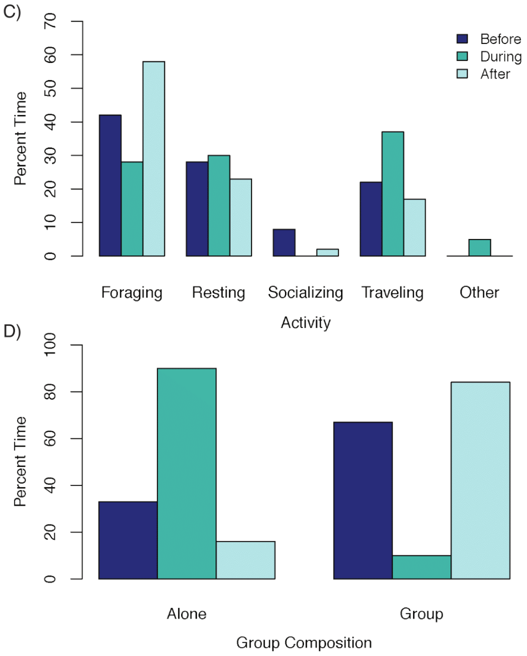
We aim to understand the behavioral impacts of fishing line entanglement on a female bottlenose dolphin (*Tursiops aduncus*), by examining her behavior before, during and after entanglement.

A)



B)

Behavioral event	Description
Fast swim	When a dolphin rapidly accelerates at or near the surface of the water
Rapid surface	When a dolphin quickly surfaces but maintains a horizontal position and the ventral side does not clear the surface of the water
Leap	When a dolphin surfaces rapidly in the horizontal position and the entire body clears the surface of the water
Synch	When two (or more) dolphins breathe in close proximity at exactly the same time, generally <5 m apart
With fish	When a dolphin is observed with a fish in its mouth, but the actual catch was not observed
Fish catch	When a dolphin is observed catching a fish with its mouth



a

Figure Legend

Figure 1. EDE entanglement.

(A) EDE's dorsal fin during (June 15, 2015) and after entanglement (July 1, 2015).
(B) Ethogram for a subset of common behavioral events.
(C) Activity budget for EDE before, during, and after entanglement.
(D) Group composition for EDE before, during, and after entanglement.

Results & Discussion

Activity Budget

Figure 1C shows EDE's behavior before, during and after entanglement. Notable changes in response to entanglement were no socializing, little foraging, in which we did not observe any successful foraging events such as fish catches or 'with fish', and an increase in traveling, particularly traveling more at faster speeds (5–6 kph) (5% before, 30% during, 3% after) and less at slower speeds (2–3 kph) (63% before, 20% during, 54% after). She also engaged in other behaviors, such as leaps, fast accelerations (fast swims), and rapid surfacings. Fast swims occurred at a rate of 5.68/hour compared to 1.62/hour before and 0.71/hour after entanglement. Her rapid surfacing rate increased to 3.79/hour, compared to 0.60/hour before and 0.32/hour after entanglement.

Group Composition

Prior to entanglement, EDE was in a group 89% of the time (61% of that with at least one maternal kin); however, during her entanglement, she was with others only 10% of the time (22% of that time with at least one maternal kin) (Fig. 1D). After she freed herself

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from entanglement, she spent 98% of her time in groups (71% of that time with at least one of her maternal kin) (Fig. 1D).

Entanglement in fishing gear is a major threat to nearly all marine mammals. Detailed observations of individuals throughout an entanglement event are rare but provide important insight into behavioral impacts of such events. Our longitudinal dataset on EDE enabled us to compare her behavior and social interactions before, during, and after entanglement. Several marked changes stand out. First, she spent 30–50% less time foraging and 45–60% more time traveling during entanglement than before or after. In addition to traveling more, she increased her travel speed and engaged in other fast and erratic behaviors such as fast swims, rapid surfacings and leaps. She did not socialize at all when entangled. Post-entanglement, her activity budget was similar to pre-entanglement.

Some of our observations are similar to those observed in Mann *et al.* (1995), where costly behaviors such as fast travel and leaping increased during entanglement [17]. Further, the additional drag from trailing fishing gear can exacerbate energy expenditure and prevent efficient foraging. Van der Hoop *et al.* (2013) placed a Dtag on an entangled Northern right whale and found slower diving ascents and descents, as well as shallower dives during entanglement than for whales that were not entangled [18]. Modeling the drag force of gear attached to the entangled right whale also showed that whales entangled in fishing gear experience a greater energetic demand [18]. Further, there appears to be a critical duration period in which the duration of additional drag due to entanglement can be a predictor of survival [19]. Thus, the combination of increased energetic behaviors and drag due to a fishing line may further decrease the chances of survival, especially with long durations of entanglement [20].

In addition to physical and behavioral impacts, there was a drastic decrease in EDE's social interactions. She was alone during the vast majority of the entanglement period, the inverse of time in groups before and after, respectively. Similarly, Wells *et al.* (1998) observed an entangled female dolphin in Sarasota Florida who was alone during each sighting of her entanglement, in comparison to only 24% of sightings alone when not entangled [15]. Weinrich (1996) observed 30-40 Atlantic white-sided dolphins (*Lagenorhynchus acutus*) abandon a conspecific immediately after the individual became entangled in a gillnet [21]. They noted that not a single conspecific remained or returned to investigate or assist the entangled individual. While this observation isn't surprising, one might expect that close kin may remain with a distressed mother, calf, or sibling. When a young calf was entangled in Shark Bay, the mother remained nearby and others joined briefly, but none were close to the calf except the mother [17].

There are multiple examples of dolphins pushing a dead conspecific at the surface, in what appears to be an attempt to assist the deceased [22] [23] [24]. Mann and Barnett (1999) observed dolphins attempting to intervene and defend a calf from a tiger shark attack [24]. Gibson (2006) observed a non-lethal shark attack on a calf in which there was very little response to the presence of several small to medium-sized sharks or the attack from the calf, mother or group members [25]. Therefore, dolphins do not always flee or abandon an individual in a potentially dangerous situation, particularly when it is between a mother and calf.

This begs the question then, why have we observed a pattern of seemingly social avoidance by conspecifics following entanglement? One hypothesis is that social avoidance is a strategy to avoid danger or an unfamiliar object. Furthermore, avoidance of diseased conspecifics has been observed in social lobsters [26]. Even EDE's brief encounters with others were simply in passing.

Previous studies of entanglement focused on large whale species, such as right and humpback whales, which are classified as solitary [27]. Here, we use longitudinal data to quantify the impact of entanglement in a highly social species. In addition to marked behavioral changes, we identified an additional stressor, isolation, which has received little attention with respect to entanglement. As such, the costs of entanglement (e.g., infection, injury, energetic costs, inability to forage), are likely exacerbated by social isolation. Bottlenose dolphins have highly differentiated social relationships that last for years [28]. Thus, the effect of even short-term isolation could be substantial.

These observations highlight the need for regulating the disposal of fishing gear and decreasing pollution in marine habitats. Marine debris is an increasing global threat that impacts a wide array of species. The number of individuals entangled in marine debris is three times higher than that of the 1990s [29] and nearly 50% more species have been reported in marine debris encounters since 1997 [30]. Shark Bay is a relatively pristine habitat, listed as a UNESCO World Heritage Site in 1991, which experiences very low anthropogenic pressures. Despite that, in addition to EDE, at least five provisioned dolphins and their calves have been entangled in fishing gear at Monkey Mia [17] (unpublished records). Many other sites around the world experience much greater fishing pressure (both recreational and commercial) and human impacts, thus even stricter regulations should exist in these regions. While such detailed observations of entanglement are rare, they offer a glimpse into the costs of entanglement for dolphins and whales.

Limitations

This study is comprised of one individual, so we cannot draw population or species level conclusions. Because these data were collected opportunistically and the entanglement period was brief, we have a limited amount of data during entanglement. Although entanglement of marine animals is not a rare event, systematic data of this nature for an entangled individual are quite rare.

Additional Information

Methods and Supplementary Material

Please see https://sciencematters.io/articles/201711000011.

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Ethics Statement

This work was approved by the Georgetown University Animal Care and Use Committee (permits 07-041, 10-023, 13-069), DPaW (permits SF009311, SF008076, SF009876) and The University of Western Australia (animal ethics permit 600-37).

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