External indicators of fisheries interactions in known bycaught dolphins from bather protection nets along the KwaZulu-Natal coastline, South Africa

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ABSTRACT

Detailed examinations of dolphins incidentally caught in bather protection nets along the KwaZulu-Natal coastline, South Africa, over the past 10 years have yielded a dataset that can assist in the examination of external signs of bycatch. Investigating these external signs of fisheries interactions could aid in determining whether they could be used as unequivocal indicators of entanglement in stranded dolphins for which cause of death is unknown. The aim of this study was to investigate the occurrence of netmarks and other external injuries on individuals of two dolphin species (*Tursiops aduncus* and *Sousa plumbea*), both bycaught and stranded, along the south-east coast of South Africa. Necropsy reports and photographs of 107 bycaught and 15 stranded dolphins between 2010 and 2017 were investigated to determine prevalence of netmarks and other external injuries in relation to species, sex, age class, and water temperature. Our results indicated that 36% of the bycaught dolphins and 13% of stranded dolphins showed netmarks on the skin. In bycaught animals, females were more likely to show netmarks (58%) and the majority of dolphins with netmarks were immatures (66%; immatures included calves, neonates and subadults). There was little evidence for water temperature affecting the appearance of netmarks. Furthermore, species, sex or age class did not play a significant role in the probability of netmark occurrence. Other external injuries were also observed in the bycaught (3–50%) and stranded animals (7–100%), with subcutaneous bruising being the most prominent sign in bycaught animals. Our study showed that only a small percentage of known bycaught animals actually present external signs of entanglement. Thus, additional evidence, such as histopathological examinations, is required to reliably identify entanglement cases in stranded animals.

KEYWORDS: FISHERIES, GILLNETS, INCIDENTAL CATCHES, INDIAN OCEAN

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INTRODUCTION

Bycatch of marine mammals is a major issue of global concern, and particularly so in the Indian Ocean, where bycatch monitoring is limited and relatively lax (Ardill *et al.*, 2013; Anderson *et al.*, 2020). Bycatch refers to the unintentional capture of non-target species, such as cetaceans, in fishing nets (IWC, 2011). It has become a considerable conservation issue as indicated by Read *et al.* (2006), who calculated the annual global bycatch of marine mammals at 300,000 animals and summarised that this number is almost certainly increasing each year due to advances in modern fishing technology. A considerable amount of literature focuses on bycatch of cetaceans in different types of fisheries globally (Northridge, 1984; Hofman, 1990; Read *et al.*, 2006; Reeves *et al.*, 2013).

Off the South African coastline, several, considerably different types of commercial fisheries are in operation. While fisheries along the coast of KwaZulu-Natal (KZN), South Africa, comprise of oyster gathering, estuarine bait collecting, beach seine-netting, line-fishing, industrial trawling and pelagic long-lining, none of these activities are very extensive in scale (Fennessy *et al.*, 2014). Although there has been an increase in bycatch awareness of turtles, seabirds and sharks in South Africa, particularly with the hake trawl and long-line fisheries (Walmsley *et al.*, 2007; Petersen, 2008; Attwood *et al.*, 2011), marine mammal bycatch is still not considered to be a major issue. In contrast, bycatch of marine mammals in the bather protection nets (BPN) along the KZN coast has been documented extensively (Atkins *et al.*, 2013; Erbe *et al.*, 2016; Plön *et al.*, 2020). These gillnets are set to catch sharks to reduce their abundance, thereby reducing the likelihood of shark interactions with humans (Dudley, 1997). BPN are therefore considered to be a type of shark fishery. However, in addition to the target species (i.e., the large sharks that could threaten the safety of bathers), a range of other non-target marine vertebrates, such as birds, turtles, non-target elasmobranchs, teleost fishes and several marine mammal species, are caught (Dudley and Cliff, 1993). BPN have been used off the coastline of KZN since 1952 as a result of a series of fatal shark attacks in the 1950s and 1960s (Cliff *et al.*, 1996). These gillnets are made of black multifilament polyethylene braid weaved to a stretched mesh size of 51cm. Most nets are 213.5m long by 6.3m deep and are permanently anchored parallel to the coast beyond the surf, 300-500m offshore, in 10–14m of water (Cliff and Dudley, 1992). Previous attempts have been made to mitigate bycatch in the BPN (Peddemors *et al.*, 1990; Cliff and Dudley, 2011), including the use of pingers (Erbe *et al.*, 2016), but none have been successful.

Common signs of bycatch include linear indentations (i.e., netmarks), subcutaneous bruising, cuts, and abrasions on the skin, but also muscular tearing, fractured beaks, bleeding in various organs and muscle tissue, pulmonary edema and congestion, as well as torn and severed fins and flukes (Kuiken *et al.*, 1994; Siebert *et al.*, 2001; 2006; 2020; Bernaldo de Quirós *et al.*, 2018; Dolman and Brakes, 2018). Netmarks and other external injuries as indicators of entanglement vary among species and net types and few studies examine these in stranded cetaceans (Kemper *et al.*, 2005; Secchi, 2007; Stockin *et al.*, 2009; Bernaldo de Quirós *et al.*, 2018; Siebert *et al.*, 2020). Trying to identify bycatch as the cause of death of stranded animals can be problematic due to a combination of factors, some of which include the disappearance of netmarks due to post-mortem changes and autolysis (Bernaldo de Quirós *et al.*, 2018; IJsseldijk *et al.*, 2020). A study comparing known fisheries bycaught animals with stranded cetaceans and pinnipeds from Massachusetts, USA, makes no mention of netmarks on the stranded animals, while 75% of the bycaught animals showed signs of entanglement in the form of netmarks (Bernaldo de Quirós *et al.*, 2018). Another study, which focused solely on strandings of *Tursiops truncatus* (Secchi, 2007), showed that 50% of the 14 animals examined exhibited signs of interactions with fisheries. From those animals whose sex could be determined, four were male and one was female, while the majority were immature animals. A seasonal trend of higher bycatch coincided with the peak operating season of the coastal artisanal gillnet fishery (Secchi, 2007). These types of studies suggest that netmarks are an important indicator to identify bycaught animals among strandings.

Off KZN, the most commonly caught dolphin species in the BPN are the Indo-Pacific bottlenose dolphin (*T. aduncus*), followed by the Indian Ocean humpback dolphin (*Sousa plumbea*). The Indo-Pacific bottlenose dolphin (*T. aduncus*) has a wide geographical distribution throughout the Indian Ocean from South Africa to India, the coast of Australia and surrounding waters into the Pacific Ocean, preferring inshore habitats where the water is less than 50m deep (John and Yang, 2009; Plön *et al.*, 2012). The Indo-Pacific humpback dolphin (*S. plumbea*) ranges from False Bay in South Africa to the Bay of Bengal in India (Parra and Ross, 2009). *S. plumbea* are usually found in shallow coastal waters less than 25m deep and are found mostly in the surf zone, which is less than 15m deep (Plön *et al.*, 2012). The continued bycatch of these dolphins has provided an opportunity to investigate whether common external lesions and injuries in animals that are known to have been bycaught in the BPN, like netmarks, can be used exclusively to verify fisheries interactions in stranded animals where cause of death is unclear. Thus, the aim of our study is two-fold. Firstly, to investigate the occurrence and prevalence of netmarks and other external injuries, such as subcutaneous bruising, lacerations (cuts/grazes), and fractured teeth/rostra, on bycaught dolphins in the BPN to determine whether these are reliable indicators of entanglement, which could then be applied to stranded dolphins for which cause of death is unclear. Secondly, to investigate the prevalence of netmark occurrence and other external injuries on stranded animals of the same species along the south-east coast of South Africa for comparative purposes.

MATERIALS AND METHODS

The BPN are set along the most popular KZN bathing beaches (Fig. 1). These nets are maintained and managed by the KwaZulu-Natal Sharks Board (KZNSB) and are checked every morning during weekdays (weather permitting). All bycaught animals (including sharks, turtles, and cetaceans) found alive are released, while carcasses are removed and taken back to the laboratory at the KZNSB headquarters for research purposes. Detailed information about the nets, the shark control programme and historical fishing effort are provided by Dudley (1997) and Cliff and Dudley (2011). Under a long-standing agreement, detailed measurements and samples are taken from the carcasses and accessioned to the Port Elizabeth Museum (PEM; Cockcroft, 1990; Plön *et al.*, 2012). Since 2009, detailed sampling and investigations into the health status of the carcasses from both the BPN and strandings alike has been conducted and routine pathological investigations have been carried out (Lane *et al.*, 2014; Plön *et al.*, 2015a).

We retrospectively assessed necropsy and histopathology reports, together with photographs of 107 animals caught between 2010 and 2017 to identify the presence of netmarks on animals known to have been incidentally caught in the BPN (Fig. 1 and 2). All investigated bycaught individuals showed common signs of asphyxiation, such as pulmonary edema, emphysema and haemorrhaging as well as froth/foam in the trachea or lungs (Siebert *et al.*, 2001). Netmarks were identified as parallel linear indentations or lacerations visible on the skin which extended around the entire body or parts the body (Fig. 2). As this was a retrospective study, we were unable to identify these netmarks through histological analyses as being acute. However, given the inshore habitat of these two dolphin species and the scarcity of prevailing fishery activities along the KZN coast, it is highly unlikely that these cetaceans would have acquired these netmarks from another fishery. In addition, the Agulhas current, which flows southwards along the southeast of South Africa, is one of the fastest-flowing currents in any ocean, reaching an estimated top speed of 9.3km per hour (Lutjeharms, 2006). This fast-flowing current makes it highly unlikely that previously bycaught carcasses would end up caught in the BPN post-mortem as these carcasses would be carried southwards down the coast. We therefore conducted the study under the assumption that all netmarks were caused by the BPN at the time of death. Bycaught animals displaying netmarks were sub-divided by species, sex and age class to identify any patterns in netmark occurrence (Table 1). Individuals were classified as immatures (including calves, neonates and subadults) or adults following Cockcroft and Ross (1990) and Plön *et al.* (2015b). We performed the same examinations of netmarks and external injuries on 15 animals stranded along the Eastern Cape (EC) and KZN coastlines (Fig. 1, Table 1) as a control group. Because KZN is considered to have a sub-tropical climate, seasons are not very pronounced and thus the investigation of seasonal differences was not a viable option for this study. However, temperature has been shown to affect the decay of carcasses over a period of time (Forbes *et al.*, 2014; Brooks, 2016), which should affect the appearance of netmarks (i.e. higher temperatures can cause quicker carcass decay and lead to more prominent netmark indentations). To investigate these effects of water temperature (°C) on the appearance of netmarks, data were obtained from the KZNSB, where available, for all bycaught animals (*n* = 102). However, due to the nature of the KZNSB operations, temperature measurements are taken at the time of the animal discovery and not at the time of death as the latter is unknown. For that reason, 2°C water temperature intervals were selected as these provided for a representative number of animals per temperature bin, i.e., ensured that animals were evenly distributed across temperature bins. Thus, water temperature was grouped into five bins, ranging from 18°C to 27°C, and the percentage (%) of netmarked versus non-netmarked animals were analysed. In order to investigate the probability of animals displaying netmarks as a function of sex, age class, and water temperature, a chi-squared test of goodness-of-fit was performed for the bycaught animals; unfortunately, sample sizes for stranded animals were too small to conduct any statistical analyses.

Using netmarks as an indicator of bycatch, we then investigated which additional signs of fisheries interactions were seen in all bycaught and stranded animals investigated and compared this with the netmarked animals to determine whether there was a higher occurrence of these additional signs in netmarked animals. These signs were classified into three categories: i) subcutaneous bruising (hereafter referred to as 'bruising'), ii) lacerations (cuts/grazes), and iii) broken teeth/rostra (Fig. 5). The locations of these signs on the carcasses were also recorded. These external injuries have been used in previous studies investigating fisheries interactions (Kuiken *et al.*, 1994; Bernaldo de Quirós *et al.*, 2018; Dolman and Brakes, 2018). However, as indicated in previous studies, it should be noted that these external lesions and injuries are not specific to bycatch and these signs could have other origins; for example, bruising may have been caused by previous trauma, such as predation and/or vessel collision (Kuiken *et al.*, 1994). Further signs of possible fisheries interactions, such as gun-shot wounds and clean-cut mutilations, were also noted.

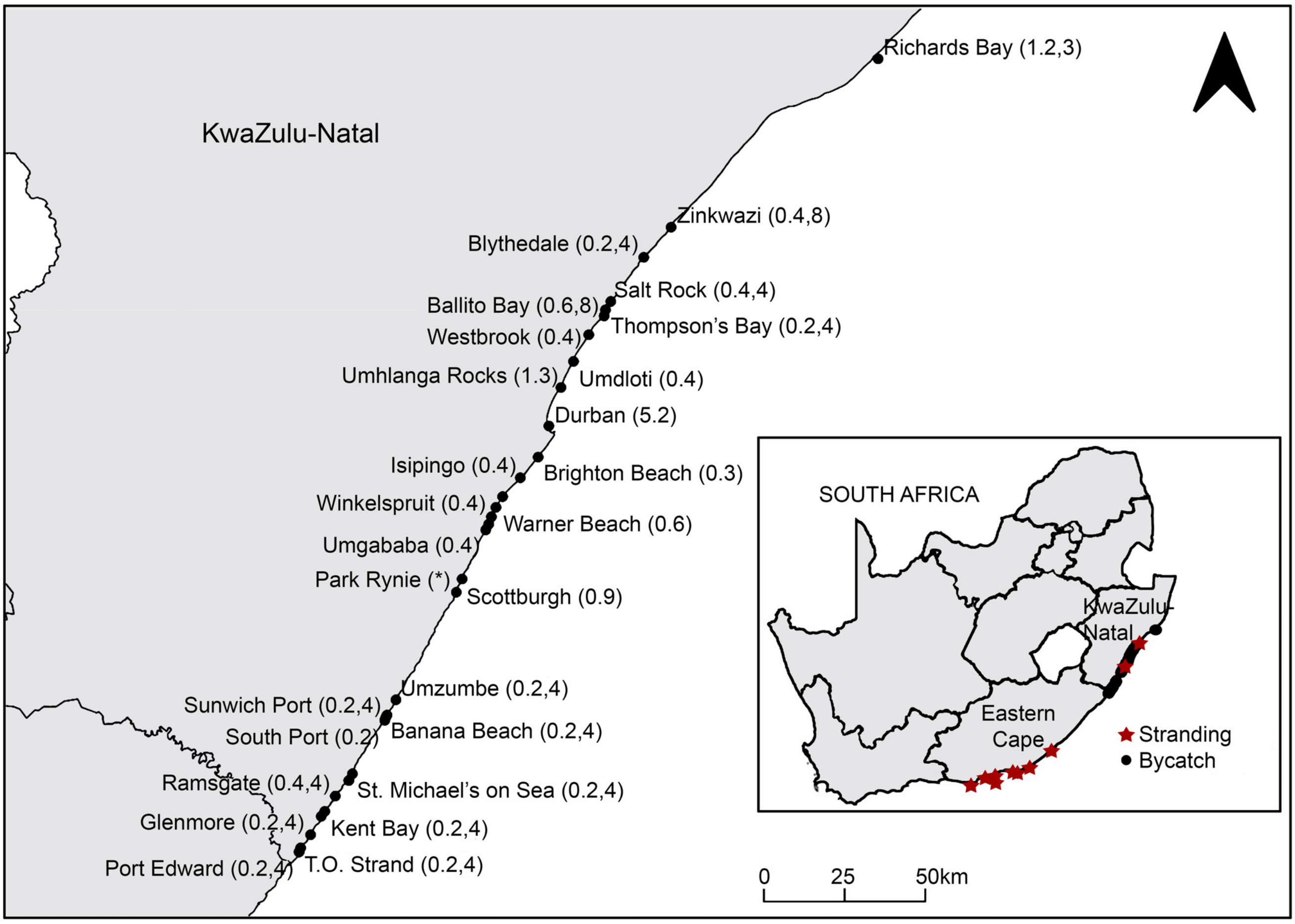

Fig. 1: Location for individual bather protection nets (BPN) along the KwaZulu-Natal coastline (numbers in parentheses indicate length of nets in km at respective beaches and the number of drumlines in December 2009). Insert: Map of South Africa indicating location of bycaught and stranded animals along the KwaZulu-Natal and Eastern Cape coastlines.

Table 1

Total number of bycaught and stranded dolphins investigated for each category.

Categories		Number of dolphins			
		Bycatch (n = 107)		Stranding (n = 15)	
		T. aduncus (n = 89)	*S. plumbea* (n = 18)	*T. aduncus* (n = 14)	*S. plumbea* (n = 1)
Sex	Male	42	9	5	1
	Female	47	9	9	0
Age class	Adult	31	10	8	1
	Immature	58	8	6	0

RESULTS

Our investigations showed that out of the 107 bycaught individuals examined, 38 individuals (36%) showed netmarks (Fig. 2 and 3). In contrast, two individuals (13%) of the 15 stranded animals examined presented netmarks (Fig. 3). There was a difference between species (Table 2), with the majority of bycaught *T. aduncus* having netmarks (89%), but only four bycaught *S. plumbea* (11%) displaying netmarks. Among the bycaught animals, the proportion of females showing netmarks was higher (22 individuals; 58%) compared to males (16 individuals; 42%). Similarly, a higher number of immature animals had netmarks (25 individuals; 66%) than adults (13 individuals; 34%). Two of 15 stranded individuals had netmarks, and both were *T. aduncus* and females, but one was an adult, while the other was an immature animal.

A chi-squared test of goodness-of-fit was only performed for bycaught animals due to the larger sample size. The observed versus the expected number of animals with netmarks were very similar for sex, age class, and water temperature bins (Table 2). Results of the chi-squared test indicated that species, sex, age class and water temperature were not significant ($p > 0.05$; Table 2) and therefore, it is unlikely that these variables play a role in the probability of netmark occurrence.

Netmarked (range: 22-42%) and non-netmarked (range: 58-78%) animals showed similar percentages across water temperature bins (Fig. 4). The percentage of netmarked animals increases slightly from the 18–19°C (33%) to the 20–21°C (42%) temperature bin, with the latter having the highest percentage of netmarked animals across all temperature bins (Fig. 4). The percentage of netmarked animals then decreased across two bins, with the

Table 2

Probability of bycaught animals to display netmarks according to species, sex, age class and temperature bins.

Categories	*T. aduncus*	*S. plumbea*	Total	Chi² statistic
Species				
Total bycatch	89	18	107	χ^2 (1) = 1.08 p = 0.30
Observed with netmarks	34	4	38	
Expected with netmarks	32	6	38	

Categories	Male	Female	Total	Chi² statistic
Sex				
Total bycatch	51	56	107	χ^2 (1) = 0.47 p = 0.49
Observed with netmarks	16	22	38	
Expected with netmarks	18	20	38	

Categories	Adult	Immature	Total	Chi² statistic
Age class				
Total bycatch	41	66	107	χ^2 (1) = 0.27 p = 0.60
Observed with netmarks	13	25	38	
Expected with netmarks	15	23	38	

Categories	18–19	20–21	22–23	24–25	26–27	Total	Chi² statistic
Water temperature bins (°C)							
Total bycatch	3	26	47	18	8	102	χ^2 (4) = 1.36 p = 0.85
Observed with netmarks	1	11	15	4	3	34	
Expected with netmarks	1	9	15	6	3	34	

Fig. 2: Signs of netmarks (indicated by arrows) on incidentally bycaught dolphins: (a–d) *Tursiops aduncus* (Indo-Pacific bottlenose dolphin) showing prominent netmarks on the (a) ventral region; (b) around the body lateral to the dorsal fin; (c) around the body at the flippers; (d) tail region and (e–f) *Sousa plumbea* (Indian Ocean humpback dolphin) showing netmarks around the body at the level of the pectoral fins. Note: The rope around the tailstock of dolphin pictured in (d) was added post-mortem to identify the animal.

24–25°C temperature bin having the lowest percentage of netmarked animals (22%), before increasing again to 38% in the 26–27°C bin. The non-netmarked animals show the opposite trend, with the highest percentage recorded in the 24–25°C temperature bin (78%) and the lowest in the 20–21°C bin (58%; Fig. 4). However, the differences noted were not significant ($p > 0.05$).

The number of other signs of possible fisheries interactions (Fig. 5) for bycaught and stranded animals in both the total and the netmarked sample are shown in Table 3. Bruising was highest in the bycaught animals, both in the total sample (35 individuals; 33%) and the netmarked sample (19 individuals; 50%), with bruising location ranging from the head to abdomen (Table 3). For bycaught animals, cuts/grazes were the second most observed sign in the total sample (19 individuals; 18%) and the netmarked sample (10 individuals; 26%). Broken teeth/rostra

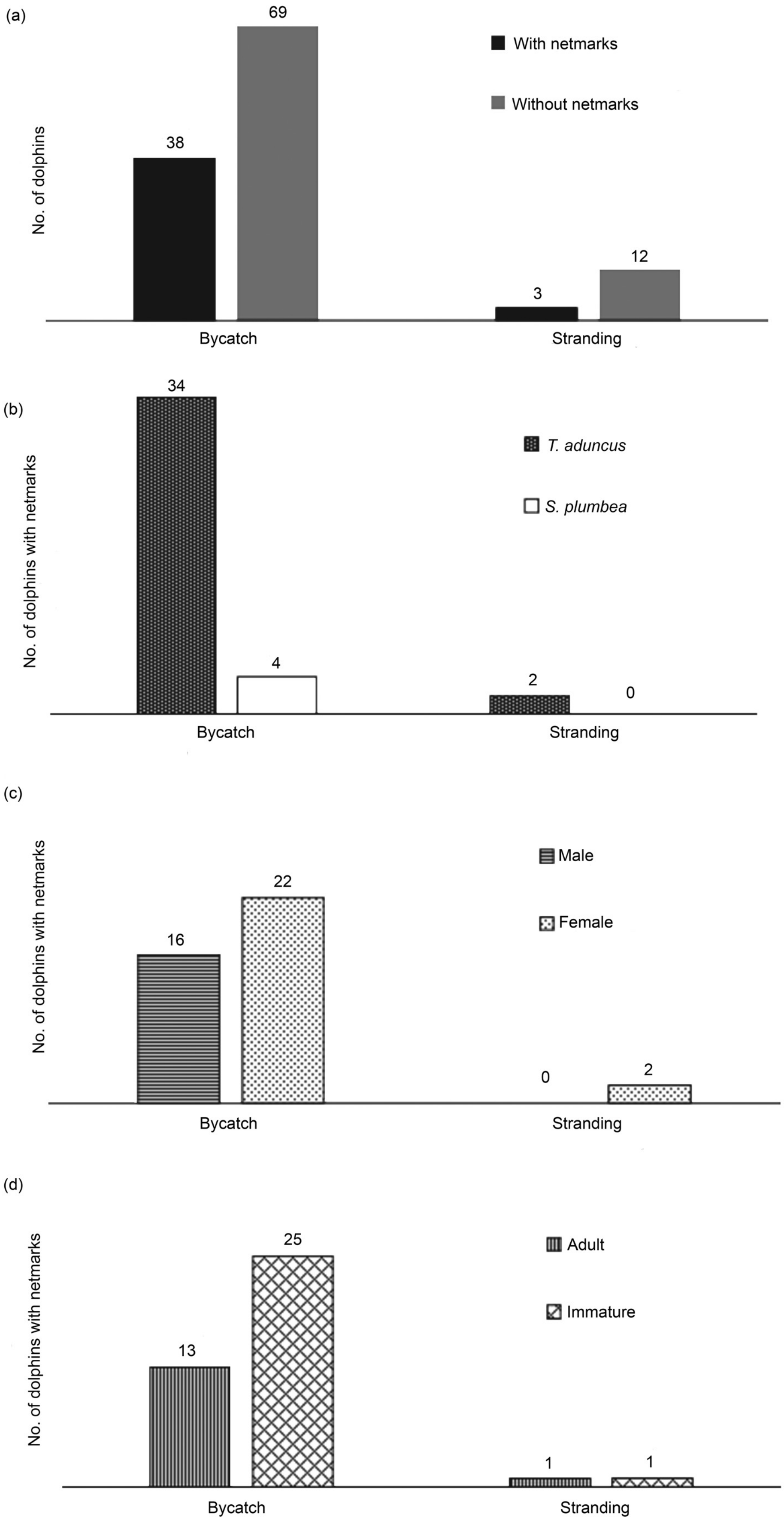

Fig. 3: Number of bycaught and stranded dolphins (a) displaying netmarks. Dolphins displaying netmarks were further sub-divided according to (b) species, (c) sex, and (d) age class.

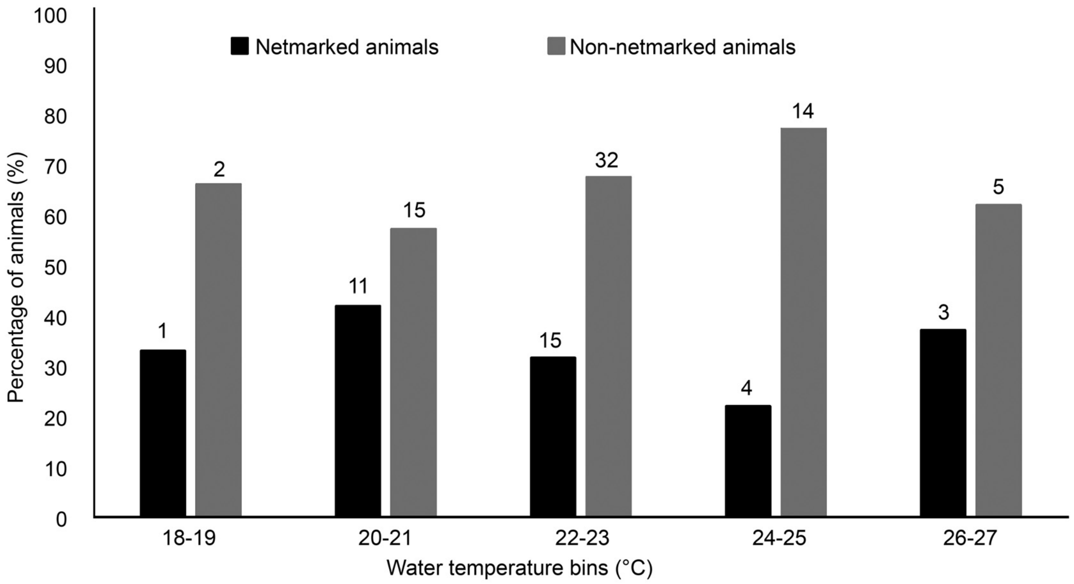

Fig. 4: Percentage (%) of netmarked versus non-netmarked animals across various water temperature bins. Numbers on top of bars represent the number of individual animals per category.

Table 3

Number of total and netmarked animals bycaught and stranded showing other signs of possible fisheries interactions and their location on the animals' body.

Sign	No. of total sample (*n* = 107)	No. of netmarked sample (*n* = 38)	Regions on body
Bycatch			
Bruising	35 (33%)	19 (50%)	Head; neck; abdomen (around flippers to genital slit)
Cuts/grazes	19 (18%)	10 (26%)	Head; neck; peduncle; tail; abdomen (mostly around flippers)
Broken teeth/rostrum	3 (3%)	1 (3%)	Head
Sign	No. of total sample (*n* = 15)	No. of netmarked sample (*n* = 2)	Regions on body
Strandings			
Bruising	5 (33%)	1 (50%)	Head; neck; tail
Cuts/grazes	5 (33%)	2 (100%)	Across entire surface
Broken teeth/rostrum	1 (7%)	0	Head
Possible gunshots	2 (13%)	0	Head

were the least observed sign in both the total and the netmarked sample (both at 3%). In contrast, bruising and cuts/grazes were observed in equal numbers of stranded individuals (5 individuals; 33%), while only one individual had a broken rostrum (Table 3). Two stranded individuals also had possible gunshot wounds. In the stranded animals with netmarks, bruising was observed on one individual, while cuts/grazes were observed on both animals, with no other visible signs of fisheries interactions (Table 3).

With the exception of broken rostra/teeth, the occurrence of signs of possible fisheries interactions was higher in the netmarked sample than in bycaught animals.

DISCUSSION

This study used a dataset collected over several years (2010–2017) of bycaught and stranded *T. aduncus* and *S. plumbea* to examine the occurrence of netmarks from BPN. Of the 107 bycaught animals investigated, only 36% showed netmarks. The majority of bycaught animals with netmarks were immature females, while no trend could be detected amongst the stranded animals as only two *T. aduncus* out of 15 individuals examined had netmarks. When examining the effects of water temperature on netmark appearance, the percentage of netmarked (range: 22-42%) and non-netmarked (range: 58-78%) animals were similar across the five water temperature bins. No significant differences were found for species, sex, age class or water temperature

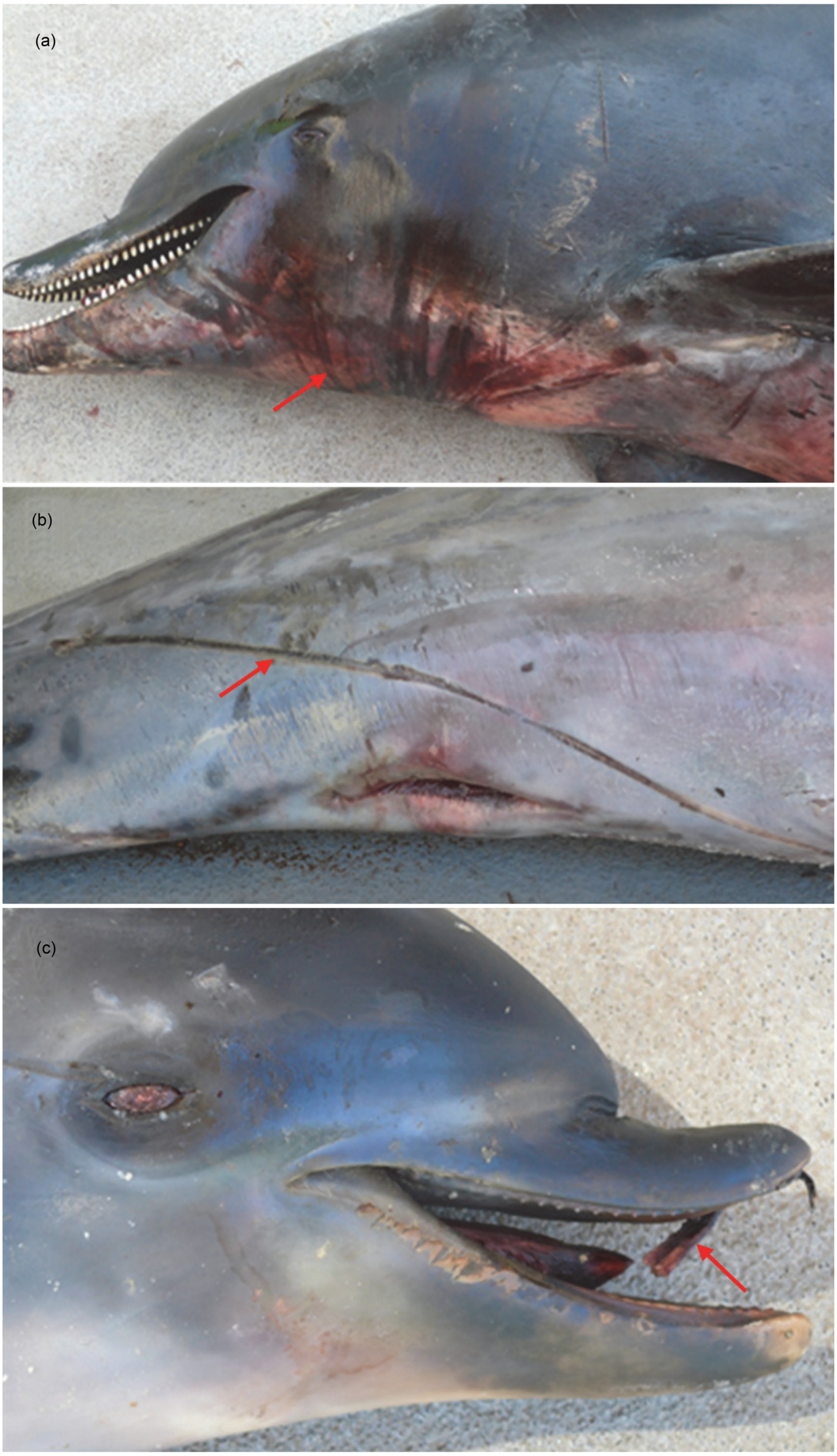

Fig. 5: *Tursiops aduncus* (Indo-Pacific bottlenose dolphin) showing indications of possible fisheries interactions, including (a) bruising; (b) lacerations (cuts/grazes); and (c) broken rostrum.

($p > 0.05$) and it is likely that these factors do not play a role in the probability of netmark occurrence. Other signs of possible fisheries interactions varied in magnitude and location on the body, with bruising most common in bycaught animals for both the total (33%) and netmarked (50%) sample. Additional signs in stranded animals were limited in number (< 33%) for both the total and netmarked sample as a result of the smaller sample size ($n = 15$).

Bycaught and stranded cetaceans and seals from Massachusetts (USA) were investigated using netmarks as the sole indicator of entanglement (Bernaldo de Quirós *et al.*, 2018). This study also found a higher proportion of bycaught animals with netmarks (15 out of 20 individuals) compared to stranded animals (0 out of 16 individuals). The authors stated that there is a need to better determine entanglement cases in stranded animals, but that this is complicated due to the carcass condition at the time of report (Bernaldo de Quirós *et al.*, 2018). Bycaught cetaceans regularly display netmarks as shown in many investigations (Kuiken *et al.*, 1994; Wünschmann *et al.*, 2001; Siebert *et al.*, 2001; 2006; 2020; IJsseldijk *et al.*, 2020). Stranded animals are often in an advanced state of decomposition, which hinders the determination of the presence of netmarks and other external injuries that could indicate fisheries interactions prior to stranding events. However, identifying suspected bycatches among stranded marine mammals is an important topic to recognise areas of conflicts with fisheries and collecting minimum bycatch numbers (ICES, 2019). In addition to external self-inflicted netmarks, other signs associated with forced underwater submersion by fisheries entanglement can also be used. These include post-mortem mutilations caused by removal of the animals from fishing gear, internal morphological findings suggestive of bycatch-associated asphyxia including pulmonary edema and congestion, and bleedings in different organs. These animals also often have a full stomach (Wünschmann *et al.*, 2001; Bernaldo de Quirós *et al.*, 2018; Siebert *et al.*, 2001; 2006; 2020; Epple *et al.*, 2020; IJsseldijk *et al.*, 2020).

Our study showed that, for the bycaught animals, netmarks were more prevalent on immature females (Fig. 3); however, this may also reflect the bycatch composition in the BPN (Table 1). This is in line with Plön *et al.* (2020) who investigated *T. aduncus* bycatch in the BPN and found a higher bycatch of immature females than males. As in other studies, Plön *et al.* (2020) attributed the higher catch of immatures to their more inquisitive nature, inexperience, or the still-developing biosonar-relevant structures, while the higher proportion of females could reflect the ‘skewed-sex’ ratio of the bycatch composition in the BPN (see Table 1). Interestingly, a previous study investigating bycatch of *S. plumbea* indicated a higher bycatch of immature male animals in the BPN (Atkins *et al.*, 2013). The authors proposed various explanations for this sex/age bias, which included that it reflected the demographic of the population, spatial distribution of the various age classes and varying tendencies for capture as a result of age/sex differences in behaviour or physiology of this species.

Contrary to our expectation of finding a higher appearance of netmarks at higher environmental temperatures due to quicker decay of the carcasses as shown in other studies (Forbes *et al.*, 2014; Brooks, 2016), our results showed that the probability of water temperature affecting netmark appearance was non-significant ($p = 0.85$; Table 2). This would imply that water temperature, either plays a less significant role in the appearance of netmarks than originally assumed, or that the range of environmental temperatures (18–27°C) is too narrow to assess this further. For example, Secchi (2007) investigated fishery-related mortality in stranded cetaceans using netmarks and mutilations in the warm temperate Patos Lagoon estuary (southern Brazil). These signs were more prevalent during late austral spring and summer (September-March) when temperatures ranged between 22–30°C and lower in austral winter and autumn (April–August) when temperatures were at their lowest and ranged from 10 to 15°C. This study showed a clear difference in netmark appearance during spring/summer and winter/autumn when water temperatures varied, but it also had a wider temperature range (approx. 20°C) compared to our study (approx. 10°C). Similarly, all other factors investigated showed no significant differences indicating that for species, sexes and age classes, the absence of netmarks does not indicate that the animal was not caught in the nets. This indicates that there is a risk of undercounting cetacean bycatch when only examining characteristic external injuries on animals, irrespective of species, age or sex category or the temperature environment. Similar conclusions were drawn by IJsseldijk *et al.* (2020) who examined bycaught harbour porpoises (*Phocoena phocoena*) from gillnets in the southern North Sea. Previous studies confirm that there is a risk of underestimating bycatch rates when assessing stranded animals (ICES, 2019).

Our study focused on investigating external signs of animals bycaught in the BPN as an indicator of possible fisheries interactions. In contrast, previous studies have focused on stranded individuals (Kemper *et al.*, 2005; Secchi, 2007; Stockin *et al.*, 2009) and have used external signs, such as bruising, lacerations (cuts and grazes), and broken teeth or rostra, in addition to pathological findings, as evidence of entanglement (Moore and Barco, 2013; Dolman and Brakes, 2018). In this study, bruising was highest in bycaught animals (33–50%), and was concentrated around the head and neck region, but observed on the abdomen as well. Similarly, Kemper *et al.* (2019) investigated external injuries and pathological signs of entanglement in bycaught common dolphins of the South Australian sardine fisheries. They observed bruising in 100% of the bycaught dolphins which was concentrated around the head and neck region of the dolphins (Kemper *et al.*, 2019). Other signs, such as cuts/grazes, netmarks and broken/missing teeth were also much lower in our study (< 36%) when compared to Kemper *et al.* (2019) study (> 60%). One possible reason for these differences is the type of net used in the two fisheries (purse seine netting in Australia versus gillnets in South Africa). Purse seine nets are used in active fisheries where the nets encircle a shoal of fish near the sea surface, and the pursed net is pulled toward the boat (Breen *et al.*, 2012). In comparison, gillnets are a passive fishery where the nets are suspended in the water column by buoys with fish having to ‘catch themselves’ by swimming into the net (Brownell *et al.*, 2019). Thus, the degree of injury for any one animal caught in purse seine netting may be higher, because animals struggle against other animals caught in a moving net, whereas in gillnets, animals only struggle in a stationary net (Mood, 2010). It should be noted that there is a possibility that external injuries, apart from netmarks, could have also occurred pre-mortem (i.e., before the animal was caught in the net) and could be a result of conspecific or heterospecific interactions (Kiszka *et al.*, 2008).

The finding in this study indicate that netmarks or other external injuries in *T. aduncus* and *S. plumbea* are only present on a small proportion of bycaught animals. This should be taken into account when investigating stranded individuals where carcass condition often affects external signs of entanglement. In addition, as shown in this study, a higher occurrence of netmarks on some groups of animals may be a reflection of the demographics of the population rather than individuals from these groups being at higher risk of bycatch. There were no significant differences in the proportions of known bycaught animals showing netmarks of either *T. aduncus* and *S. plumbea* by species, sex, age class and water temperature, suggesting that these factors play a less significant role in netmark occurrence in the study area. This would suggest that the magnitude of external signs of entanglement may be primarily affected by the type of nets used in the fishery. In addition, while it is expected that carcass condition (i.e. state of decay) would influence the prevalence of netmarks, it was not possible to examine this, as the carcasses examined in this study were mostly of the same stage of decay, were generally treated in the same way and for the same time period after being caught. This would not be the case for stranded animals that had been killed or injured in nets.

The continued significant decrease in the population sizes of marine mammal species, caused by a number of factors including bycatch, could have significant effects on the structure and functioning of aquatic environments (Borrvall and Ebenman, 2006; Heithaus *et al.*, 2008). Marine mammals, as top predators, play a crucial role in regulating aquatic ecosystems and patterns of food consumption by marine mammals have strong effects on community structure (NRC, 1996). Furthermore, their high diversity, long life spans, high trophic level, and bioaccumulation of anthropogenic toxins make marine mammals’ good indicators of ecosystem change (Bossart, 2006; Moore, 2008). Many of these species, including *S. plumbea*, are listed as ‘endangered’, ‘threatened’ or ‘data deficient’ on the Red List of Threatened Species of the IUCN (International Union for Conservation of Nature; Vié *et al.*, 2008). Many groups and consortia, such as the SouSA Consortium in South Africa, have been created to manage and conserve these threatened marine mammal species; however, human-induced threats must be identified and addressed (Marsh *et al.*, 2002), including bycatch in fishery operations. For example, in South Africa, standardised documentation of external injuries is encouraged by using standard necropsy protocols (see Plön *et al.*, 2015a). This would enable future comparison based on a larger sample of stranded animals which could provide more information on potential fisheries interactions in stranded animals (see Puig-Lozano *et al.*, 2020). Due to the poor quality of data often received from stranded animals, stranding networks are encouraged and vital (Wilkinson and Worthy, 1999). They respond to reports of washed-up marine mammals to either assist in rescuing the animal or, in cases of dead or emaciated animals, collect valuable scientific data that could help to adequately determine cause of death (Plön *et al.*, 2015a). Our study highlights that purely investigating external injuries/netmarks on stranded animals may not a reliable indicator of fishery entanglement. This was a retrospective study and as such, the netmarks investigated could not be identified as being acute as has been shown in studies by Siebert *et al.* (2001; 2006; 2020). Thus, future studies should include a histological analysis of netmarks to differentiate between acute and older/chronic netmarks. Future studies on suspected fisheries interactions in stranded animals should also include other indicators, such as mutilations and pathological data as evidence of entanglement (Epple *et al.*, 2020; IJsseldijk *et al.*, 2020; Puig-Lozano *et al.*, 2020).

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