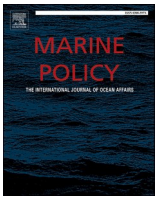
Marine Policy 132 (2021) 104633

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol



Recreationist perceptions of lethal and non-lethal management of sharks in two of South Africa's marine areas

Kate Sheridan [a], M. Justin O'Riain [a], Mark D. Needham [b,*]

[a] Institute for Communities and Wildlife in Africa, University of Cape Town, Cape Town, South Africa
[b] Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR, USA

ARTICLE INFO

Keywords:
Recreation
Wildlife management
Shark safety
Shark nets

ABSTRACT

Despite growing public pressure to use non-lethal strategies for managing predators (e.g., sharks) in marine ecosystems, the response of many governments remains largely lethal. This article examined recreationist support and understanding of approaches for managing sharks in two of South Africa's marine areas. Questionnaires completed by 575 ocean recreationists at beaches near Cape Town and Durban showed they strongly disagreed with lethal management of sharks. The non-lethal Shark Spotters program was the most strongly supported strategy, followed by heat sensor cameras to detect sharks. Other non-lethal strategies (exclusion nets, personal repellent devices, deterrent cables, camouflage wetsuits) were supported by fewer than 50% of respondents, but were still more strongly supported than specific lethal strategies (shark hunts, drumlines, shark nets). Shark Spotters was more strongly supported near Cape Town, whereas the lethal strategies and a few of the other non-lethal approaches (personal electric repellent devices, electric deterrent cables, exclusion nets) were more strongly supported near Durban. Few respondents understood that shark nets and drumlines are designed to catch and kill large sharks. Understanding the function of shark nets correlated negatively with support for their use and positively with support for temporary exclusion nets. Implications of these results were discussed within the framework of a global transition from lethal to non-lethal management.

1. Introduction

The lethal management of predators (e.g., lions, sharks) that pose a risk of injury or death to people represents a major threat to the survival of predators both on land [48] and in the ocean [7]. Many of these predators play important regulatory roles in trophic networks and their removal may have severe and unpredictable cascading effects in the ecosystems they inhabit [39,47,6]. Despite the threat of lethal management on predator populations and growing public pressure for non-lethal alternatives [12,35,41,43,49], the response of many governments to predators (e.g., sharks) that occasionally kill or injure people has remained largely lethal [15,23,29].

Since the 1930s, many governments have believed that sharks must be killed to reduce the threat they may pose to the public [29]. Consequently, governments have heavily invested in 'catch-and-kill' programs to mitigate risks from sharks by depleting local shark populations, minimizing the spatial overlap between people and sharks, and reducing the likelihood of negative interactions [28]. Three examples of lethal measures are shark nets (also known as gill nets), drumlines, and shark hunts. First, shark nets are designed to catch and kill large sharks, but many other marine species are also caught and killed in these nets as bycatch, including rays, cetaceans, and non-target shark species [25,4,45]. Shark nets were introduced to many coastlines and beaches popular for recreation activities, including in South Africa's KwaZulu-Natal (KZN) province and beaches near the city of Durban. The first introductions of shark nets in this area followed a spate of shark bites in the 1950s and 1960s [5]. Second, drumlines were introduced to this area more recently and are large baited hooks suspended from an anchored surface float [45], designed to attract sharks actively feeding. Drumlines were introduced to KZN (in the 1990s) and other parts of the world (in the 1960s) with the intention of reducing non-target bycatch. The KZN Sharks Board (KZNSB) claimed that the capture of non-target species has declined almost 48% following the installation of drumlines [20]. Third, a shark hunt is a targeted mission with the purpose of killing either the individual shark responsible for a bite or any sharks in the area, and these hunts often arise as a response to a shark bite incident. Given the slim likelihood of conclusively proving which individual shark was responsible for a bite, shark hunts are probably best understood as a

* Corresponding author.
E-mail address: mark.needham@oregonstate.edu (M.D. Needham).

https://doi.org/10.1016/j.marpol.2021.104633
Received 4 September 2020; Received in revised form 19 May 2021; Accepted 4 June 2021
Available online 23 June 2021

form of theater aimed to control fear and give the public a sense that action has been taken following an emotional response to a shark bite [35].

An improved understanding of sharks, including their behavior, ecological importance, and economic value associated with recreation and tourism, has led some wildlife managers to seek non-lethal strategies [28]. One of the most systematic and sustained non-lethal shark programs is Shark Spotters in the Cape Town, South Africa area. Spotters are trained to detect sharks from a vantage point and provide first response assistance to any shark bite victims [19]. Colored flags are displayed at beaches where Shark Spotters are operating, with these flags denoting the levels of risk and spotting conditions. A siren is also used when a shark is spotted in the vicinity of people in the water, posing a potential threat.

Other non-lethal methods include those seeking to deter sharks from approaching people in the water through understanding sensory cues that sharks use for catching prey and interacting with their environment [18]. Electric repellent devices, for example, have been developed to be aversive to sharks with these devices being at the individual (e.g., hand-held) or landscape levels (e.g., extending across coastlines; [18]). Another non-lethal method involves exclusion nets that function as a barrier to sharks. These nets have been installed at locations such as Fish Hoek beach in South Africa. The design of the net minimizes entanglement and extends throughout the entire water column, creating a barrier to sharks. Other non-lethal advances include: (a) wetsuit colors and patterns that reduce the wearer's visibility to sharks, which have poor color vision [18]; (b) monochrome wetsuits; and (c) surfboard stickers mimicking dangerous marine organisms such as orcas or sea snakes.

A primary argument in support for using lethal methods instead of non-lethal approaches to control sharks is that the outdoor recreation and tourism industries would suffer if people do not feel safe in the water [34], and lethal control of sharks is necessary for people to feel safe. In recent years, however, lethal methods of shark control have been heavily criticized [15]. Surveys conducted before and after shark bites have concluded that shark bite incidents do not always negatively influence public perceptions of sharks. For example, levels of "pride" in the resident white shark population near Cape Town, South Africa and confidence in local beach safety management remained similar before and after a bite occurred [30]. This largely undocumented insight suggested that shark bite incidents alone do not always result in overwhelmingly negative public reactions toward sharks.

Recent research into public perceptions of sharks has suggested that the traditional negative view of sharks as 'threatening human-eaters' is shifting [21,35,36]. Studies in Australia, for example, found that public opinion appears to be changing from one in which management should protect people from sharks, to one where sharks need protection from people [43,52]. In addition, recent studies in Australia and South Africa found limited support for lethal control of sharks [21,35], signaling a shift in perceptions that may alter the future landscape of shark management. Other recent studies have examined public perceptions of non-lethal strategies for managing sharks and found the majority of respondents were significantly more supportive of these strategies than lethal actions [14,17,23,34]. Possible explanations for these changes in perceptions include increasing public recognition of the: (a) environmental roles of sharks and their importance in marine ecosystems; (b) small likelihood of unprovoked shark bites, especially those leading to human fatalities; (c) advances in beach patrols and emergency medical responses; and (d) aesthetic, educational, and economic values of sharks, especially from recreation and tourism activities [1,15,2,25,3,8].

Despite examining different strategies for managing sharks, a recent study in South Africa found no significant differences among five beaches in respondent knowledge, attitudes, and behavior toward sharks, and general approaches for mitigating hazards from sharks (e.g., government responsibility for preventing human interactions with sharks, responsibility of people in the water; [21]). However, the study did not assess responses toward various specific lethal and non-lethal strategies for mitigating these hazards, whether respondents understood how these interventions work, and if these responses differed by location. For example, if people initially think that shark nets are a non-lethal barrier, but then realize they kill sharks and other species, these people may alter their perceptions and support for current management. In addition, some strategies may be more or less acceptable in places where they are used (e.g., shark nets and drumlines in the KZN / Durban area, spotting programs in the Cape Town area) compared to where they are not used.

Using surveys of ocean recreationists in South Africa, this article explored four applied research questions. First, do these ocean recreationists agree or disagree with lethal management of sharks in general and specific lethal approaches in particular (e.g., drumlines, shark nets, shark hunts)? Second, do these ocean recreationists understand the function of some of these lethal approaches, and is this understanding related to their support or opposition? Third, do these ocean recreationists support or oppose various non-lethal approaches being used for managing sharks (e.g., spotter programs, repellent devices, exclusion nets)? Fourth, to what extent do these responses differ between geographic locations (Cape Town and Durban areas in South Africa)?

2. Methods

2.1. Study sites

Recreationists (e.g., surfers, swimmers) were surveyed at three beaches near two of South Africa's major coastal cities: (a) Muizenberg beach (34.1087° S, 18.4702° E) near the city of Cape Town, and (b) North beach and Bay of Plenty beach (29.8476° S, 31.0349° E) near the city of Durban (Fig. 1). These beaches were selected because they are popular with recreationists of all abilities, have a history of shark bite incidents, and have active management to reduce human interactions with sharks. For example, Muizenberg beach has Shark Spotters operating daily from sunrise to sunset, and the Durban beaches have a combination of shark nets and drumlines.

Muizenberg beach is situated in the north-western portion of False Bay approximately 14 km (9 mi) from Seal Island, a known white shark aggregation site during the winter (June to August). Sea temperatures range from 14° to 21°C (57–70°F), peaking in January and at their lowest in July. Muizenberg is an exposed beach with prevailing north-westerly winds in the winter and south-easterly winds in the summer (December to March). The beach is microtidal and characterized by a Mediterranean climate [22].

North beach and Bay of Plenty beach are adjacent to each other and form part of Durban's Golden Mile. These beaches are exposed to the dominant southerly swell and have a much steeper incline from the high-water mark to where the waves break compared to Muizenberg. An artificially created offshore mound refracts wave fronts to enhance wave formations suitable for surfing, and the wooden piers create rip currents that surfers use to more easily access the backline of the waves [37]. Sea temperatures range from 20 °C (68°F) in early August to 27 °C (81°F) in early February.

Based on a dataset compiled by the Shark Research Institute, there have been five shark bite incidents at Muizenberg beach since 1960 (in 1964, 1983, 1984, 2004, and 2014). All victims were surfers and none of the incidents were fatal. Between 1940 and 1990, there were eight shark bite incidents at North beach: one in 1943 (fatal), three in 1944 (all fatal), one in 1947 (non-fatal), one in 1950 (fatal), one in 1971 (non-fatal), and one in 1986 (non-fatal).

2.2. Data collection

Questionnaires were administered on-site (i.e., face-to-face) between 07:30 and 17:00 over consecutive days at both the Cape Town (October 3–10, 2019) and Durban (October 22–30, 2019) beaches (see the supplemental files for the questionnaires used in this study). Every adult recreationist coming out of the water on these days during these hours

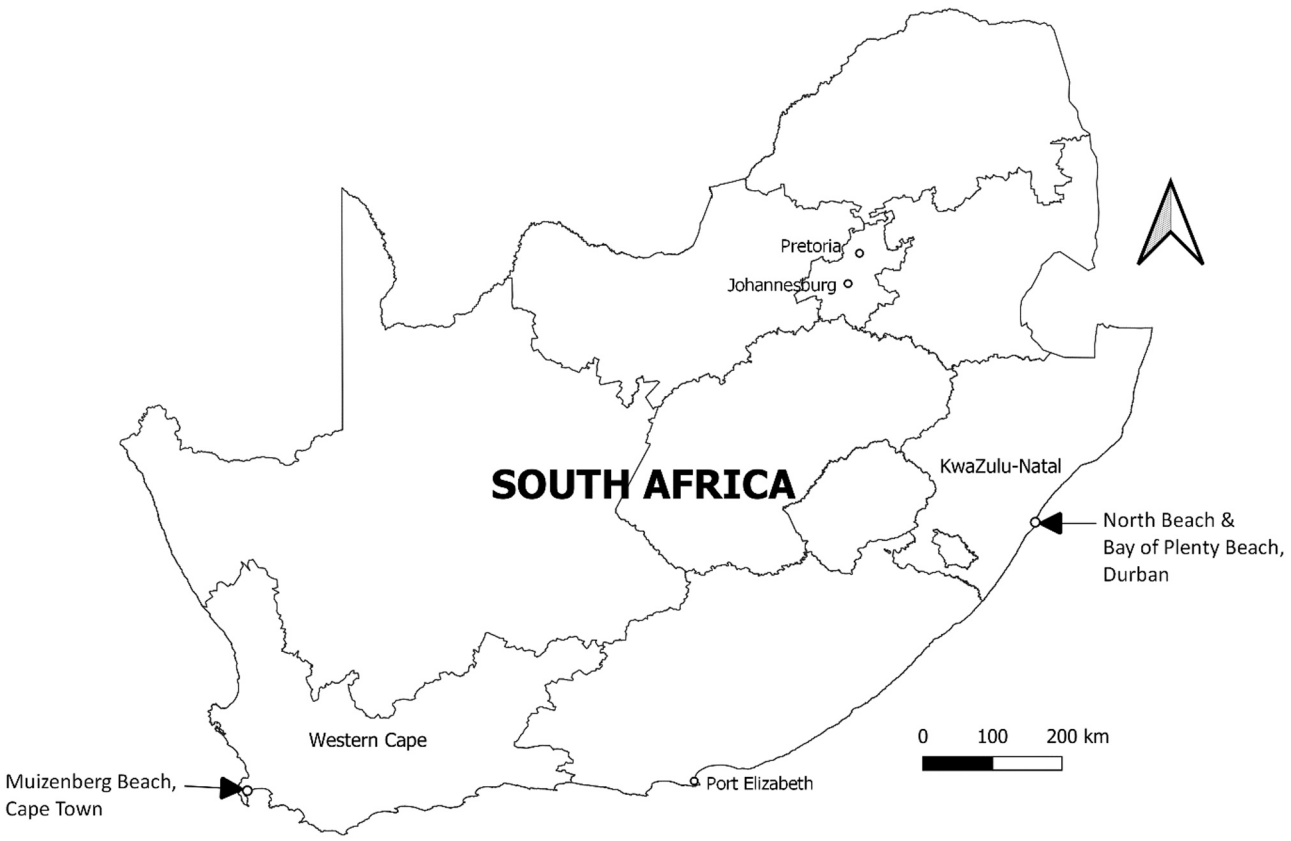


Fig. 1. Map of study site locations near Cape Town and Durban in South Africa.

was approached and invited to participate. Although targeting these recreationists does not ensure a representative sample of the entire population at each beach, people who recreate in the water in areas affected by shark bite incidents have been targeted by studies on perceptions about sharks and shark management, as this segment of the population is most likely to be directly affected [14,17,21,34,42]. This study design did not involve sampling people who had come to the beach but opted not to enter the water, or people who had opted not to come to the beach at all. Respondents were left to complete the questionnaire on their own and asked to return it immediately on completion; the field researcher did not suggest possible answers. Each questionnaire took between five and 15 min to complete. A total of 434 people were approached at the Cape Town beach (Muizenberg) and 370 completed a questionnaire, resulting in an 85% response rate (±5.1% margin of error at the 95% confidence level; [51]). At the Durban beaches (North beach and Bay of Plenty beach), 235 people were approached and 205 completed a questionnaire, yielding an 87% response rate (±6.8% margin of error at the 95% confidence level; [51]). The total sample size across both sites combined was 575 respondents (86% response rate; ±4.1% margin of error at the 95% confidence level; [51]). These high response rates (85–87%) are consistent with other recreation and tourism research of this type involving on-site face-to--face data collection [51].

2.3. Analysis variables

The questionnaire measured a few demographic and activity characteristics of respondents (Table 1). To measure level of agreement with

Table 1
Demographic characteristics of respondents.

		All (n = 575)	Cape Town (n = 370)	Durban (n = 205)	t or χ^2 value	p value	Effect size (r_{pb} or V)[a]
Age (years)					3.80	<0.001	0.16
	Mean	35.67	34.03	38.72			
	Standard dev.	13.61	13.10	14.06			
	Range	18 – 80	18 – 80	18 – 76			
Sex (%)					20.59	<0.001	0.19
	Male	65	59	76			
	Female	35	41	23			
	Non-binary	<1	0	1			
Main activity (%)					8.51	0.074	0.12
	Surfing	71	75	65			
	Swimming	24	20	30			
	Paddle boarding	5	5	4			
	Kayaking	1	<1	1			
	Scuba diving	<1	<1	1			

[a] Effect size for age measured using r_{pb} where .10 is "small" or "minimal" .24 is "medium" or "typical," and .37 is "large" or "substantial." Effect size for sex and main activity measured using Cramer's V where .10 is "small" or "minimal," .30 is "medium" or "typical," and .50 is "large" or "substantial" [10,51].

the lethal management of sharks in general, the questionnaire contained seven statements with responses on a 5-point scale from 1 "strongly disagree" to 5 "strongly agree." These statements are listed in Table 2. The questionnaire also measured level of support toward 10 specific lethal and non-lethal approaches for managing sharks (e.g., drumlines, shark nets, exclusion nets, spotter programs) with responses on a 5-point scale from 1 "strongly oppose" to 5 "strongly support." These items are listed in Table 3. An open-ended question was used for measuring respondent understanding of the purpose of the shark nets used in KZN (i.e., Durban area). Despite shark nets not being used in the Cape Town area, a goal was to determine whether the lethal action of using these nets was better understood where they are used (i.e., Durban area) compared to Cape Town where only non-lethal methods are used. In the questionnaire administered in the Durban area, respondents were also asked about the function of drumlines (drumlines are not used near Cape Town). To avoid potential order effects, these open-ended questions occurred earlier in the questionnaire. Responses to these two open-ended questions about shark nets and drumlines were recoded into dichotomous variables (0 = incorrect, 1 = correct) using content analysis. Correct understanding of shark nets meant that respondents had identified that these nets are designed specifically to catch or kill large sharks. Correct understanding of drumlines meant that respondents knew they are baited hooks designed to attract and kill large sharks. The methods used in this study were approved by the University of Cape Town Faculty of Science Research Ethics Committee.

3. Results

3.1. Respondent profile

The majority of respondents were 35 years old or younger (58%, mean [*M*] = 35.67, standard deviation [*SD*] = 13.61), male (65%), and participating in surfing as their main activity on the day they completed the questionnaire (71%; Table 1). Compared to those at the Cape Town beach, those at the Durban beaches were slightly older and more likely to be male. These differences between locations were statistically significant ($p < 0.001$), but using guidelines from Cohen [10] and Vaske [51] for interpreting effect sizes, the effect sizes were relatively "small" or "minimal," respectively (age: point-biserial correlation [r_{pb}] = 0.16; sex: Cramer's $V = 0.19$).

3.2. Agreement and disagreement with lethal management in general

Respondents were more likely to agree with the two statements against lethal management of sharks ("I do not support the killing of sharks as a safety measure," "I do not support the killing of sharks under any circumstances") compared to the other five statements that were all in favor of lethal management (e.g., "I support the killing of sharks at any time [not just after a bite incident]," Table 2). In total, 87% of respondents agreed with the two statements against lethal management and these had the highest mean agreement ($M = 4.45$–4.48, $SD = 1.22$–1.26). There were, however, statistically significant differences ($p \leq 0.009$) in the levels of agreement with these two statements between respondents at the Cape Town and Durban beaches, with those at the Cape Town site having stronger agreement ($M = 4.56$–4.59, $SD = 1.10$–1.13) than those at the Durban beaches ($M = 4.24$–4.26, $SD = 1.40$–1.46). Regardless, mean agreement was high at ≥ 4.24 across both statements and sites, and the effect sizes ($r_{pb} \leq 0.13$) were "small" [10] or "minimal" [51], suggesting that the strength of these differences was not substantial.

Most (80–91%) respondents strongly disagreed with the five statements in favor of lethal management. The statement receiving the most agreement for lethal management was "killing sharks makes it safer for water users," but only 8% of respondents agreed ($M = 1.44$, $SD = 1.01$). The statement receiving the least agreement was "I support the killing of sharks at any time (not just after a bite incident)" with only 2% agreeing

Table 2
Responses to lethal shark management in general.

Questionnaire statements	% on scale (all; $n = 575$)[a]					Mean (Standard dev.) on scale			*t* value	*p* value	r_{pb}[b]
	SD (1)	D (2)	N (3)	A (4)	SA (5)	All ($n = 575$)	Cape Town ($n = 370$)	Durban ($n = 205$)			
Against lethal management											
I do ***not*** support the killing of sharks as a safety measure	10	2	1	4	83	4.48 (1.26)	4.59 (1.13)	4.26 (1.46)	2.64	0.009	0.12
I do ***not*** support the killing of sharks under any circumstances	9	2	2	9	78	4.45 (1.22)	4.56 (1.10)	4.24 (1.40)	2.70	0.007	0.13
In favor of lethal management											
Killing sharks makes it safer for water users	80	8	4	4	4	1.44 (1.01)	1.34 (0.90)	1.62 (1.19)	2.75	0.006	0.13
Lethal shark policies (killing sharks) keep water users safer than non-lethal policies (e.g., exclusion nets, inform users, repellent devices)	81	7	7	2	3	1.38 (0.91)	1.33 (0.89)	1.47 (0.95)	1.54	0.124	0.07
I support the killing of sharks only after a shark bite incident	87	7	3	2	2	1.26 (0.77)	1.20 (0.70)	1.35 (0.89)	1.95	0.052	0.09
Killing sharks is justified to lower the probability of a shark bite	87	6	3	1	2	1.25 (0.75)	1.18 (0.65)	1.36 (0.90)	2.40	0.017	0.12
I support the killing of sharks at any time (not just after a bite incident)	91	4	3	1	1	1.17 (0.64)	1.13 (0.59)	1.25 (0.71)	1.89	0.060	0.09

[a] Responses on a scale: 1 "strongly disagree" (SD), 2 "disagree" (D), 3 "neither" (N), 4 "agree" (A), 5 "strongly agree" (SA).
[b] Effect size measured using r_{pb} where .10 is "small" or "minimal," .24 is "medium" or "typical," and .37 is "large" or "substantial" [10,51].

($M = 1.17$, $SD = 0.64$). Two of these five statements about lethal management were statistically different between locations, with those in the Durban area more likely to agree that "killing sharks makes it safer for water users" and "killing sharks is justified to lower the probability of a shark bite." The effect sizes ($r_{pb} \leq 0.13$), however, were "small" [10] or "minimal" [51].

Reponses to the two statements against lethal management were reverse coded and then, after testing for measurement reliability using Cronbach's alpha, were combined with the five other statements into a single mean index measuring responses to lethal management in general. An alpha coefficient that is approximately ≥0.65 indicates that variables are measuring the same concept and justifies combining them in further analyses [11,31]. The alpha was 0.77 and reliability would not be improved by deleting any of the seven statements (alphas if items deleted = 0.72–0.75). The mean of this index was 1.38 (i.e., strongly disagree with lethal management; $SD = 0.67$). There was a statistically significant difference between locations with those at the Cape Town beach disagreeing slightly more with lethal management of sharks ($M = 1.30$, $SD = 0.61$) compared to those at the Durban beaches ($M = 1.53$, $SD = 0.76$), $t = 3.46$, $p = 0.001$. The effect size ($r_{pb} = 0.16$), however, was relatively "small" [10] or "minimal" [51].

3.3. Understanding about lethal management strategies

In total, only 48 respondents (8%) correctly understood that shark nets reduce risks to humans by catching or killing sharks (28 [8%] from the Cape Town beach, 20 [10%] from the Durban beaches). There was no significant difference between locations, $\chi^2 = 0.40$, $p = 0.525$. However, a significantly greater proportion of respondents from the Cape Town site (101 [27%]) thought that shark nets function by forming a physical barrier to sharks (Durban site = 28 [14%], $\chi^2 = 19.55$, $p < 0.001$), although the phi ($\phi = 0.19$) effect size was relatively "small" [10] or "minimal" [51]. Only 48 (23%) of Durban respondents understood that the function of drumlines is to attract, catch, and kill large sharks. There was no significant difference in the proportions of Durban respondents who understood the functions of both drumlines and shark nets, $\chi^2 = 0.18$, $p = 0.673$.

3.4. Support and opposition regarding specific lethal and non-lethal management strategies

The non-lethal Shark Spotters program was the most strongly supported strategy among respondents, with 89% supporting (56% strongly) and the highest mean response among all strategies overall ($M = 4.40$, $SD = 0.81$) and for each site (Table 3). The only other strategy that was supported by the majority of respondents was using heat sensor cameras to detect sharks moving close to people (62%, $M = 3.67$, $SD = 1.16$). The other non-lethal strategies were supported by fewer than 50% of respondents (camouflage wetsuits: 49%, $M = 3.36$, $SD = 1.23$; temporary exclusion nets: 46%, $M = 3.08$, $SD = 1.40$; personal electric repellent devices: 41%, $M = 2.97$, $SD = 1.37$; electric deterrent cables: 42%, $M = 2.92$, $SD = 1.43$; permanent exclusion nets: 26%, $M = 2.46$, $SD = 1.32$), with respondents most divided on temporary exclusion nets, personal electric repellent devices, and electric deterrent cables. Shark Spotters was significantly ($p = 0.004$) more strongly supported among those at the Cape Town beach ($M = 4.48$, $SD = 0.77$) than the Durban beaches ($M = 4.27$, $SD = 0.85$), but the effect size ($r_{pb} = 0.12$) was "small" [10] or "minimal" [51]. Conversely, all of the other non-lethal strategies were more strongly supported by those at the Durban beaches ($M = 2.79$–3.77, $SD = 1.15$–1.38) than the Cape Town beach ($M = 2.28$–3.61, $SD = 1.16$–1.41), with three of these (personal electric repellent devices, electric deterrent cables, permanent exclusion nets) being statistically significant ($p < 0.001$) with relatively "medium" [10] or "typical" [51] effect sizes ($r_{pb} = 0.18$–0.32).

All three of the lethal strategies (shark hunts, drumlines, shark nets)

Table 3
Responses to specific lethal and non-lethal shark management strategies.

Questionnaire items	% on scale (all; $n = 575$)[a]					Mean (Standard dev.) on scale			t value	p value	r_{pb}[b]
	SO (1)	O (2)	N (3)	S (4)	SS (5)	All ($n = 575$)	Cape Town ($n = 370$)	Durban ($n = 205$)			
Non-lethal											
A shark spotter program with flags indicating spotting conditions and level of shark risk	1	2	8	33	56	4.40 (0.81)	4.48 (0.77)	4.27 (0.85)	2.90	0.004	0.12
Heat sensor cameras to detect sharks moving close to water users	7	7	24	35	27	3.67 (1.16)	3.61 (1.16)	3.77 (1.15)	1.54	0.124	0.07
Cryptic wetsuits that camouflage the wearer with the background colors in the water based on a shark's visual system	11	12	28	29	20	3.36 (1.23)	3.29 (1.25)	3.48 (1.18)	1.73	0.085	0.07
Shark exclusion nets that are removed each night to prevent other species being caught	18	20	15	27	19	3.08 (1.40)	3.04 (1.41)	3.17 (1.38)	1.09	0.275	0.05
Personal electric shark repellent devices for water users	20	19	20	25	16	2.97 (1.37)	2.74 (1.33)	3.38 (1.35)	5.37	<0.001	0.22
Electric shark deterrent cables that do not kill sharks placed along stretches of coastline	24	17	17	25	17	2.92 (1.43)	2.59 (1.35)	3.54 (1.37)	7.82	<0.001	0.32
Shark exclusion nets that remain in place permanently	31	26	17	17	9	2.46(1.32)	2.28 (1.30)	2.79 (1.31)	4.36	<0.001	0.18
Lethal											
Shark hunts following a shark bite incident	77	11	6	3	3	1.45 (0.96)	1.39 (0.91)	1.56 (1.03)	1.88	0.061	0.08
Drumlines (baited buoys to catch and kill sharks)	80	7	6	4	3	1.43 (0.98)	1.26 (0.80)	1.74 (1.20)	4.95	<0.001	0.23
Gill nets set across beaches to catch and kill sharks	83	7	5	3	3	1.35 (0.90)	1.25 (0.80)	1.54 (1.03)	3.47	0.001	0.16

[a] Responses on a scale: 1 "strongly oppose" (SO), 2 "oppose" (O), 3 "neither" (N), 4 "support" (S), 5 "strongly support" (SS).
[b] Effect size measured using r_{pb} where .10 is "small" or "minimal," .24 is "medium" or "typical," and .37 is "large" or "substantial" [10,51].

were opposed by almost all respondents (87–90%) and had much lower means ($M = 1.35$–1.45, $SD = 0.90$–0.98) compared to the non-lethal strategies ($M = 2.46$–4.40, $SD = 0.81$–1.43). Setting shark nets across beaches to catch and kill sharks was the strategy that received the most opposition (90% oppose [83% strongly], $M = 1.35$, $SD = 0.90$). Although these lethal strategies were strongly opposed, on average, among respondents at both sites, there was less opposition (i.e., more support) among those at the Durban beaches ($M = 1.54$–1.74, $SD = 1.03$–1.20) than the Cape Town beach ($M = 1.25$–1.39, $SD = 0.80$–0.91), and these differences were significant ($p \leq 0.001$) with "small" to "medium" [10] or "minimal" to "typical" [51] effect sizes for both drumlines and shark nets (r_{pb} =0.16–0.23).

The two main strategies used for managing sharks in South Africa are the Shark Spotters program and shark nets. For all respondents taken together and at each site individually, Shark Spotters (non-lethal) was much more strongly supported (89% support overall, $M = 4.40$, $SD = 0.81$; Table 3) than shark nets (lethal; 6% support, $M = 1.35$, $SD = 0.90$). A paired sample *t*-test showed that this difference between the two strategies for all respondents taken together was significant with a "large" [10] or "substantial" [51] Cohen's *d* effect size, paired $t = 56.70$, $p < 0.001$, $d = 3.68$. There was also significantly more support for the Shark Spotters program among respondents at the Cape Town beach and significantly more support for shark nets among those at the Durban beaches (Cape Town: Shark Spotters $M = 4.48$, $SD = 0.77$, shark nets $M = 1.25$, $SD = 0.80$; Durban: Shark Spotters $M = 4.27$, $SD = 0.85$, shark nets $M = 1.54$, $SD = 1.03$), paired $t = 28.37$–51.25, $p < 0.001$, $d = 2.89$–4.11.

Understanding of the function of shark nets correlated negatively with support for their use, with support declining by a factor of 0.30 for respondents who correctly identified their lethal purpose, $F = 4.41$, $p = 0.036$. Understanding about these nets was also a significant predictor of support for temporary exclusion nets, with support increasing by 0.54 for those who understood how shark nets function, $F = 6.39$, $p = 0.012$. Understanding about shark nets, however, was not a significant predictor of support for permanent exclusion nets, $F = 0.69$, $p = 0.405$. Understanding about what drumlines are was not a significant predictor of support for them, $F = 0.60$, $p = 0.441$.

4. Discussion

One major finding of this study is that there was minimal support for lethal management of sharks according to the recreationists sampled at the sites. Respondents largely agreed with the statements related to non-lethal strategies, more strongly supported the non-lethal strategies (e.g., Shark Spotters, heat sensor cameras), strongly disagreed with the pro-lethal statements, and strongly opposed all three methods of lethal shark control (shark nets, drumlines, shark hunts). Shark nets were most strongly opposed (83% strongly opposed) and Shark Spotters was most strongly supported (89% supported), showing that the two main methods of shark management at the study sites were at the opposite ends of the spectrum in terms of respondent support. Similar results were found in Australia where non-lethal approaches were preferred over lethal approaches by 78–85% of respondents [34]. Together, these and other recent studies in locations such as Australia, South Africa, and the United States (e.g., Florida, Hawaii) suggest a global trend of reduced ocean recreationist support for lethal shark policies and increasing concern among these recreationists for conserving and protecting sharks irrespective of whether or not they bite humans [14,17,2,23,3,34,40,43,46].

Of great concern is the finding that only 8% of respondents (10% at the Durban beaches) were aware that the nets used in parts of South Africa (e.g., Durban) are lethal shark nets, and only 23% of respondents from the Durban beaches knew that drumlines are designed to catch and kill large sharks. Instead, most respondents believed that the shark nets form a physical barrier to prevent sharks from accessing the surf zone where most recreation activities take place (these are exclusion nets, not shark nets). Respondents who knew that shark nets are actually lethal nets were less likely to support this method. A study in Australia showed that support for shark nets may be due to their promotion as a passive and non-lethal form of management [17]. The same study found that respondents supported the shark nets at their local beaches, but were overwhelmingly against the general culling of sharks. Results presented here also showed that respondents were opposed to culling in general and specific forms of lethal management in particular, and thus were opposed to the use of shark nets and drumlines when eventually told in the questionnaire what their purpose was (e.g., "drumlines [baited buoys to catch and kill sharks]," "gill nets set across beaches to catch and kill sharks").

The higher proportion of respondents from the Durban beaches who correctly identified the role of drumlines (23%) compared to shark nets (10%) is possibly explained by the recent media attention surrounding the installation of drumlines (e.g., [53,16]). Both traditional media (e.g., television, newspaper) and more recently social media can have a marked influence on understanding and acceptance of wildlife management and policy [38]. In the 1970s, for example, public pressure and adverse media coverage led to the banning of using poisons for managing wildlife in South Africa [50]. More recently, the documentary titled Blackfish exposed the captive cetacean industry and public pressure led to laws being introduced to phase out captive orca exhibits [32]. Education through documentaries and media campaigns can change perceptions of some members of the public, ultimately leading to changes in environmental legislation and policies [13,24]. The low levels of understanding regarding the actual function of shark nets in Durban and other parts of the world need to be addressed as a matter of urgency if public pressure is going to ensure that local and national governments seek alternative methods to the ongoing culling of sharks and other marine organisms.

Although respondents voiced strong opposition to lethal management of sharks in both Durban and Cape Town, more than 90% were unaware that shark nets are a lethal intervention. There was slightly greater opposition to lethal management among Cape Town respondents and this might be a consequence of Cape Town's complete reliance on non-lethal management (e.g., Shark Spotters). Knowing that the probability of an incident with sharks is low at beaches with non-lethal management could be helping to foster a belief that lethal management techniques are unnecessary and, given their negative ecological impacts, worth opposing. Nevertheless, the differences between Cape Town and Durban respondents in their opposition to lethal shark control was small, and the most notable outcome of these findings is that few respondents supported lethal management of sharks despite it being the mainstay of current government management efforts in KZN (e.g., Durban area). A similar schism between the public and government has been documented in Australia [17], and suggests that wider consultation with stakeholders and efforts to inform about the impacts of management are imperative to drive change. In addition, results of studies such as these need to be provided to governments to show that some of their current management efforts are not within public tolerance limits.

Respondents who understood the purpose of shark nets were less likely to support their use and more likely to support temporary exclusion nets that are removed each night to prevent bycatch. Lethal shark control programs have been heavily criticized in the past due to their lack of selectivity and management authorities have thus been

encouraged to devise methods to reduce bycatch [33,44,9]. Drumlines were designed specifically to reduce the impacts on non-target species while still removing large sharks. However, opposition to drumlines has been clearly documented both here and in past studies [23,26,27,53], and this opposition primarily centers around killing sharks.

5. Conclusions

This study showed that recreationists at beaches near Cape Town and Durban strongly disagreed with lethal management, although those near Durban were slightly more likely to agree with this form of management. The Shark Spotters program was most strongly supported, followed by heat sensor cameras to detect sharks. All other non-lethal strategies (exclusion nets, personal repellent devices, deterrent cables, camouflage wetsuits) were supported by fewer than 50% of respondents, but were still more strongly supported than any lethal strategy (drumlines, shark nets, hunts). Shark Spotters was more strongly supported near Cape Town where this program operates, whereas several other strategies were more strongly supported near Durban.

One of the most alarming results was that 92% of all respondents and 90% of those specifically surveyed at the Durban beaches were unaware that shark nets are a lethal intervention for managing sharks even though this is the common approach used in the Durban area. It is not clear whether this is the result of a deliberate communication strategy on behalf of relevant authorities and Sharks Boards or simply an absence of effective communication between the public and managers. However, there is an urgent need for people to be informed about the true intentions and ecological costs of these nets. Given that this study provides evidence that ocean recreationists surveyed at popular beaches near Cape Town and Durban strongly oppose lethal management of sharks in general and shark nets in particular, it is likely that exposing the lethal approaches currently used by authorities will result in them facing serious backlash from some members of the public.

Ocean recreationists are an important stakeholder in shark management, so understanding their perspectives is critical. The results presented here may influence the management of sharks in South Africa by demonstrating that this important interest group strongly favors non-lethal approaches over lethal alternatives. Reduced reliance on lethal methods to control sharks would have positive impacts on the overall conservation of shark species, bycatch species, and the greater marine ecosystems in which sharks play a critical role. These findings, however, may not generalize to other ocean users and non-users, and other coastal and marine environments. This study was based on samples of ocean recreationists at select beaches near Cape Town and Durban during one month of one year. Although every adult recreationist coming out of the water was targeted for sampling during this time period, those who had not entered the water and those who had opted not to come to the beach at all were not sampled. The results presented here, therefore, may not be representative of all beach users and non-users at the study locations or other areas where sharks are found. The applicability of these results to other ocean recreationists, stakeholders, and geographical areas remains a topic for future empirical investigation.

CRediT authorship contribution statement

Kate Sheridan: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Project administration. **M. Justin O'Riain**: Conceptualization, Methodology, Investigation, Resources, Writing - original draft, Supervision, Project administration. **Mark Needham**: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Supervision, Project administration.

Funding

Funding for this project was from the University of Cape Town's strategic funds to the Institute for Communities and Wildlife in Africa (iCWild).

Declaration of Competing Ineterest

None.

Acknowledgements

The authors thank the study participants for completing questionnaires. Nicoli Nattrass, Tammy Engelbrecht, and Sarah Waries are thanked for their input and guidance. Two anonymous reviewers, the Associate Editor, and the Editor-In-Chief are thanked for their comments on earlier versions of this article.

Appendix A. Supporting information

Supplementary information (questionnaires) associated with this article can be found in the online version at doi:10.1016/j.marpol.2021.104633.

References

[1] D. Acuña-Marrero, R. de la Cruz-Modino, A. Smith, P. Salinas-de-Léon, M. Pawley, M. Anderson, Understanding human attitudes towards sharks to promote sustainable coexistence, Mar. Policy 91 (2018) 122–128.
[2] K. Apps, K. Dimmock, D. Lloyd, C. Huveneers, Is there a place for education and interpretation in shark-based tourism? Tourism Recreation, Research 20 (2017) 24–45.
[3] K. Apps, K. Dimmock, C. Huveneers, Turning wildlife experiences into conservation action: can white shark cage-dive tourism influence conservation behaviour? Mar. Policy 88 (2018) 108–115.
[4] S. Atkins, M. Cantor, N. Pillay, G. Cliff, M. Keith, G.J. Parra, Net loss of endangered humpback dolphins: Integrating residency, site fidelity, and bycatch in shark nets, Mar. Ecol. Prog. Ser. 555 (2016) 249–260.
[5] S. Atkins, G. Cliff, N. Pillay, Humpback dolphin bycatch in the shark nets in KwaZulu-Natal, South Africa, Biol. Conserv. 159 (2013) 442–449.
[6] R.L. Beschta, W.J. Ripple, Large predators and trophic cascades in terrestrial ecosystems of the western United States, Biol. Conserv. 142 (2009) 2401–2414.
[7] H. Bornatowski, R.R. Braga, J.R.S. Vitule, Threats to sharks in a developing country: The need for effective and simple conservation measures, Braz. J. Nat. Conserv. 12 (2014) 11–18.
[8] A. Cisneros-Montemayor, M. Barnes-Mauthe, D. Al-Abdulrazzak, E. Navarro-Holm, U. Sumaila, Global economic value of shark ecotourism: Implications for conservation, Oryx 47 (2013) 381–388.
[9] G. Cliff, S.F.J. Dudley, Reducing the environmental impact of shark-control programs: a case study from KwaZulu-Natal, South Africa, Mar. Freshw. Res. 62 (2011) 700–709.
[10] J. Cohen, Statistical Power Analysis for the Behavioral Sciences, Erlbaum, Hillsdale, NJ, 1988.
[11] J.M. Cortina, What is coefficient alpha? An examination of theory and applications, J. Appl. Psychol. 78 (1993) 98–104.
[12] T. Engelbrecht, A. Kock, S. Waries, M.J. O'Riain, Shark Spotters: Successfully reducing spatial overlap between white sharks (Carcharodon carcharias) and recreational water users in False Bay, South Africa, PLoS One 12 (2017) 1–15.
[13] L.A. Friedrich, R. Jefferson, G. Glegg, Public perceptions of sharks: gathering support for shark conservation, Mar. Policy 47 (2014) 1–7.
[14] L. Gibbs, A. Warren, Transforming shark hazard policy: learning from ocean-users and shark encounter in Western Australia, Mar. Policy 58 (2015) 116–124.
[15] L. Gibbs, L. Fetterplane, M. Rees, Q. Hanich, Effects and effectiveness of lethal shark hazard management: the Shark Meshing (Bather Protection) Program, NSW, Australia, People Nat. 2 (2020) 189–203.
[16] S. Govender, February 21. Drumlines to replace shark nets at some KZN beaches. Times Live, 2019. Available from ⟨https://www.timeslive.co.za/news/south-africa/2019–02-21-drumlines-to-replace-shark-nets-at-some-kzn-beaches/⟩.
[17] G.M.E. Gray, C.A. Gray, Beach-user attitudes to shark bite mitigation strategies on coastal beaches; Sydney, Aust. Hum. Dimens. Wildl. 22 (2017) 282–290.
[18] N.S. Hart, S.P. Collin, Sharks senses and shark repellents, Integr. Zool. 10 (2015) 38–64.
[19] A. Kock, S. Titley, W. Peterson, M. Sikweyiya, S. Tsotsobe, D. Colenbrander, H. Gold, G. Oelofse, A pioneering shark safety program in Cape Town, South

Africa. Global Perspectives on the Biology and Life History of the White Shark, CRC Press, 2012, pp. 447–466.
[20] KZNSB, Kwa-Zulu Natal Sharks Board, 2021. Available from: ⟨https://www.shark.co.za/Pages/ReducingCatches⟩.
[21] S. Lucrezi, S. Ellis, E. Gennari, A test of causative and moderator effects in human perceptions of sharks, their control and framing, Mar. Policy 109 (2019), 103687.
[22] S. Lucrezi, M.F. van der Walt, Beachgoers' perceptions of sandy beach conditions: demographic and attitudinal influences, and the implications for beach ecosystem management, J. Coast. Conserv. 20 (2016) 81–96.
[23] C. McCagh, J. Sneddon, D. Blache, Killing sharks: The media's role in public and political response to fatal human-shark interactions, Mar. Policy 62 (2015) 271–278.
[24] E. McKinley, S. Fletcher, Individual responsibility for the oceans? An evaluation of marine citizenship by UK marine practitioners, Ocean Coastal Manag. 53 (2010) 379–384.
[25] D. McPhee, Unprovoked shark bites: are they becoming more prevalent? Coast. Manag. 42 (2014) 478–492.
[26] J. Meeuwig, Has Queensland really saved lives by killing thousands of sharks? The Conversation, 2014. Available from ⟨https://theconversation.com/has-queensland-really-saved-lives-by-killing-thousands-of-sharks-23437⟩.
[27] J. Meeuwig, C. Bradshaw, Why we're opposing Western Australia's shark cull: Scientists. The Conversation, 2014. Available from ⟨https://theconversation.com/why-were-opposing-western-australias-shark-cull-scientists-28653⟩.
[28] J.J. Meeuwig, L.C. Ferreira, Moving beyond lethal programs for shark hazard mitigation, Anim. Conserv. 17 (2014) 297–298.
[29] C. Neff, The Jaws effect: how movie narratives are used to influence policy responses to shark bites in Western Australia, Aust. J. Political Sci. 50 (2015) 114–127.
[30] C.L. Neff, J.Y.H. Yang, Shark bites and public attitudes: policy implications from the first before and after shark bite survey, Mar. Policy 38 (2013) 545–547.
[31] J.C. Nunnally, I.H. Bernstein, Psychometric Theory, McGraw-Hill, New York, NY, 1994.
[32] E.C.M. Parsons, N.A. Rose, The Blackfish effect: corporate and policy change in the face of shifting public opinion on captive cetaceans, Tour. Mar. Environ. 13 (2018) 73–83.
[33] R.A. Paterson, Effects of long-term anti-shark measures on target and non-target species in Queensland, Australia, Biol. Conserv. 52 (1990) 147–159.
[34] C. Pepin-Neff, T. Wynter, Shark bites and shark conservation: An analysis of human attitudes following shark bite incidents in two locations in Australia, Conserv. Lett. 11 (2018) 1–8.
[35] C. Pepin-Neff, T. Wynter, Reducing fear to influence policy preferences: an experiment with sharks and beach safety policy options, Mar. Policy 88 (2018) 222–229.
[36] C. Pepin-Neff, T. Wynter, Save the sharks: reevaluating and (re)valuing feared predators, Hum. Dimens. Wildl. 24 (2019) 87–94.
[37] R. Preston-Whyte, Constructed leisure space: the seaside at Durban, Ann. Tour. Res. 28 (2001) 581–596.
[38] D. Reljic, The news media and the transformation of ethnopolitical conflicts, in: A. Austin (Ed.), Transforming Ethnopolitical Conflict: The Berghof Handbook, Springer, 2004, pp. 321–339.
[39] E.G. Ritchie, C.N. Johnson, Predator interactions, mesopredator release and biodiversity conservation, Ecol. Lett. 12 (2009) 982–998.
[40] D. Shiffman, C. Macdonald, H. Ganz, N. Hammerschlag, Fishing practices and representations of shark conservation issues among users of a land-based shark angling online forum, Fish. Res. 196 (2017) 13–26.
[41] J.A. Shivik, Non-lethal alternatives for predation management, Sheep Goat Res. J. 19 (2004) 64–71.
[42] P. Simmons, M.I. Mehmet, Shark management strategy policy considerations: community preferences, reasoning and speculations, Mar. Policy 96 (2018) 111–119.
[43] C.A. Simpfendorfer, M.R. Heupel, W.T. White, N.K. Dulvy, The importance of research and public opinion to conservation management of sharks and rays: a synthesis, Mar. Freshw. Res. 62 (2011) 518–527.
[44] W.D. Sumpton, B. Lane, A. Ham, Gear modifications and alternative baits that reduce bait scavenging and minimize by-catch on baited drum-lines used in the Queensland shark control program, Proc. R. Soc. Qld. 116 (2010) 23–34.
[45] W.D. Sumpton, S.M. Taylor, N.A. Gribble, G. McPherson, T. Ham, Gear selectivity of large-mesh nets and drumlines used to catch sharks in the Queensland Shark Control Program, Afr. J. Mar. Sci. 33 (2011) 37–43.
[46] S. Sutcliffe, M. Barnes, The role of shark ecotourism in conservation behaviour: evidence from Hawaii, Mar. Policy 97 (2018) 27–33.
[47] J. Terborgh, L. Lopez, P. Nuñez, M. Rao, G. Shahabuddin, G. Orihuela, M. Riveros, R. Ascanio, G.H. Adler, T.D. Lambert, L. Balbas, Ecological meltdown in predator-free forest fragments, Science 294 (2001) 1923–1926.
[48] S. Thirgood, R. Woodroffe, A. Rabinowitz, The impact of human-wildlife conflict on human lives and livelihoods. People and Wildlife, Conflict or Co-existence, Cambridge University Press, 2005, pp. 13–26.
[49] A. Treves, R.B. Wallace, L. Naughton-Treves, A. Morales, Co-managing human-wildlife conflicts: a review, Hum. Dimens. Wildl. 11 (2006) 383–396.
[50] L.M. van Eeden, C.R. Dickman, E.G. Ritchie, T.M. Newsome, Shifting public values and what they mean for increasing democracy in wildlife management decisions, Biodivers. Conserv. 26 (2017) 2759–2763.
[51] J. Vaske, Survey Research and Analysis, 2nd ed., Urbana, IL, Urbana, IL, 2019.
[52] S. Whatmough, I. Van Putten, A. Chin, From hunters to nature observers: a record of 53 years of diver attitudes towards sharks and rays and marine protected areas, Mar. Freshw. Res. 62 (2011) 755–763.
[53] ZigZag, Drumlines to replace shark nets in KZN. ZigZag, 2019. Available from ⟨https://www.zigzag.co.za/featured/drumlines-to-replace-shark-nets-in-kzn/⟩.