Human Safety and Shark Conservation: An Analysis of Surfer Risk Perceptions and Attitudes towards Shark Management

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Abstract

South Africa has a history of human conflict with sharks and shark safety management. Management of this conflict differs throughout the country, with Cape Town opting for a non-lethal approach in the form of the Shark Spotters programme, and Kwa-Zulu Natal (KZN) opting for a lethal approach using shark nets and drumlines. Lethal management of sharks stems from a belief that without it, people would be too afraid to go in the water, leading to adverse effects on tourism and other associated industries. I assessed surfers' perceptions of risk from sharks, how they value sharks, their knowledge of sharks, and their attitudes towards shark management. I surveyed surfers at Muizenberg Beach in Cape Town, and North Beach and Bay of Plenty Beach in Durban by asking them to answer questions in a questionnaire. A conjoint analysis assessed how likely respondents were to go in the water under various scenarios using situational factor levels related to shark presence, surf/sea and spotting conditions, and whether other people were in the water. The questionnaire results showed no support for lethal shark control and only 8.3% of respondents were aware the nets used in KZN were a lethal form of shark control. Respondents had good knowledge of shark ecology and a positive perception of sharks, both of which have been shown to benefit shark conservation in previous studies. A multiple linear regression model showed a positive correlation between perception of shark risk and perception of other risks, such as car accidents and natural disasters, with respondents perceiving other risks as greater than shark risks. In the conjoint analysis, shark presence was the most influential factor for surfers deciding to go in the water, but respondents were more likely to go in under good surf conditions and spotting/sea conditions even if a shark had been seen recently. Overall, sharks do not deter people from going in the ocean. Implications of these results undermine the longstanding argument that lethal shark management is necessary to protect tourism. Furthermore, the lack of knowledge that lethal shark control is being practised in South Africa coupled with the opposition to lethal management found in this study highlights a clear disconnect between water users and shark managers in KZN.

1. Introduction

1.1 Human-Wildlife Conflict

Human-wildlife conflict occurs throughout the world, involving a variety of taxa. The only constant in all human-wildlife conflict situations is humans; and such humans define the course and resolution of the conflict (Manfredo & Dayer 2004). Therefore, to mitigate such conflicts, it is essential to understand the human component, including the actions, opinions, and perceptions of relevant stakeholders. The phrasing of 'human-wildlife conflict' automatically posits that wildlife is consciously antagonistic towards humans (Peterson et al. 2010). Acknowledging that wildlife are not deliberately antagonising humans, Redpath et al. (2013) pushed for the term 'conservation conflicts' and recommended partitioning conflicts into impacts dealing with direct interactions between humans and other species, and conflicts between people trying to conserve species and people with other goals. Likewise, others have suggested that the phrase human-wildlife conflict should be replaced with human conflict over wildlife because wildlife is usually taking its natural course in its behaviour (Fraser-Celin et al. 2018).

1.2 Risk perception

The concept of risk is central to human conflicts with wildlife. Perceived risk is the degree that people believe they are or may be exposed to a hazard or danger (Gore et al. 2007). Risk perceptions can influence behaviour and attitudes and are an important component of conservation conflicts. Risks associated with conservation conflicts include economic risks such as damage to property or livelihoods, environmental risks, and when it comes to predators, risks to people's safety. Understanding how people perceive risks can improve wildlife management through understanding the stakeholders involved and helping choose the best management strategy to mitigate that risk (Slovic 1987; Gore et al. 2009). However, it is possible some risk perceptions are not derived from specific concerns relating to that risk, but an inherent predisposition to rate all risks highly (Needham et al. 2017). This is known as risk sensitivity. Slovic's psychometric paradigm (1987) argued that people perceive risk based on the presence or absence of certain factors, including control over the risk, trust in risk managers, and catastrophic potential. This suggests wildlife management needs to ensure trust and give at least the impression of control to be effective in reducing conservation conflicts where such conflicts are based on perceptions of risk in excess of actual risk. Determining how people perceive wildlife management and how well they understand it is therefore an important component of assessing how they perceive the risk from that wildlife.

1.3 History of human-shark conflict

Despite reports of risks such as shark attacks on sailors overboard (Bendersky 2002; Rediker 2008), historically, scientists thought sharks were cowardly scavengers and would not attack a living, uninjured human swimming in the surf zone unless provoked (Baldridge 1988). This opinion changed after an unprovoked shark bite incident in 1931 in Florida, US that had multiple witnesses (Baldridge 1988). Today, tiger sharks (*Galeocerdo cuvier*), bull sharks (*Carcharhinus leucas*) and white sharks (*Carcharodon carcharias*) are all regarded as among the most common shark species that pose the occasional risk to humans (Chapman & McPhee 2016). All three species frequent South African waters and have at some stage been confirmed as having bitten individuals in South African waters.

The year with the most unprovoked shark bites worldwide was 2015 when of the 98 bites, only six were fatal (International Shark Attack File (ISAF) 2015; Shark Spotters 2019). This was based on data administered by the American Elasmobranch Society and the Florida Museum of Natural History, which records all known shark bite incidents and is considered the most complete and extensive epidemiological dataset on shark bites (Caldicott et al. 2001). ISAF distinguish between "provoked" and "unprovoked" attacks based on criteria developed by Schultz (1963), where "provoked" refers to where the shark has been antagonised somehow, such as by injuring, catching or annoying the shark, and "unprovoked" attacks mean there is an innocent human victim (Neff & Hueter 2013). This thesis used the same terminology. The KZN Sharks Board (KZNSB; 2019) stated that there are, on average, six shark bites per year in South Africa. The majority of these incidents are minor (Woolgar et al. 2001) and only a small proportion of global shark bite incidents result in human fatalities (Neff & Hueter 2013). By contrast, recreational water users, such as surfers, are much more likely to die from drowning (Wetherbee et al. 1994; Caldicott et al. 2001; Curtis et al. 2012).

Although rare, unprovoked shark bites increased globally between 1982 and 2011 (McPhee 2014; Chapman & McPhee 2016). Shark bites during this period were recorded in 56 countries with six of these (United States, Australia, South Africa, Brazil, Bahamas and Réunion Island) accounting for 84.5% of all incidents. The US recorded more than half of all bites, but South Africa and Australia had more fatalities. Réunion experienced the highest proportion of unprovoked bites resulting in fatalities, with South Africa in third position. One possible reason for higher shark bite incidents are larger numbers of people entering the water (Kock & Johnson 2006). A study in Florida (US), for example, identified areas of high shark risk based on the number of beach attendees (Amin et al. 2012). Other factors linked to an increase in shark bite incidents include habitat destruction or modification, water quality / clarity, climate change and the distribution and/or abundance of prey (Chapman & McPhee 2016).

In South Africa, the frequency of unprovoked shark bites remained unchanged over the 32-year period from 1982-2013, with an average of 4.4 per year. The only anomaly was in 1998 when 16 unprovoked bites were recorded. This anomaly corresponded with an El Niño phenomenon throughout the Indian Ocean, resulting in warmer sea surfaces temperatures (SSTs) in the Western Indian Ocean and decreased rainfall in South Africa, both of which can lead to declines in biological productivity and prey availability (Wetz et al. 2011; Chapman & McPhee 2016). Increasing SSTs have been linked to increased bull shark activity in beach areas (Werry et al. 2018). Lower non-human food availability and a shift in shark distributions closer to shore could also explain higher shark bite incidences during this time. By contrast, over the 32-year period, the US experienced an average of 16.6 unprovoked bites and Australia had an average of 6.03 (Chapman & McPhee 2016).

Some believe that unprovoked shark bites are completely random, independent events (Neff 2014). Others have argued that unprovoked shark bites are influenced by conditions that increase the probability of human encounters with sharks (Chapman & McPhee 2016). Such conditions include those that increase the number recreational water users such as good weather; or condition that increase shark activity such as the presence of a whale carcass. Although South Africa has not experienced an increase in the number of water users, the US and Australia have (Chapman & McPhee 2016). Whether the number of potential water users is a contributing factor to rising numbers of shark bite incidents globally remains therefore equivocal.

1.4 Public perception of sharks

Studies investigating public perceptions of sharks typically focus on whether people have a positive or negative view of sharks. A ‘positive’ perception or attitude is when people like and care about sharks. A ‘negative’ perception or attitude refers to a dislike of sharks, fear sharks, or belief that sharks are not important.

Sensationalised media reports and cultural representation of sharks in films such as the *Jaws* franchise present sharks as a threat to humans and provoke fear of sharks (Friedrich et al. 2014), even suggesting sharks deliberately target humans for food and all human-shark interactions result in human fatalities (Neff 2015). But, sharks do not pursue people as prey and if they did, the number of people killed by sharks would be substantially higher (Gross 2014). Even so, rising numbers of reported shark bites contribute to fear of sharks (Neff 2014).

A survey of beach goers in Australia found respondents overestimated the number shark bite incidents worldwide and in Australia (Crossley et al. 2014). Incorrectly estimating the number of shark bite incidents is indicative of a lack of knowledge of shark bite history and a belief that the probability of being bitten by a shark is greater than in reality. A study conducted in the United Kingdom (UK) showed children and young people within the age range of four to 13 identified jumping into a “shark-infested” space when asked to write or draw an example of “doing something risky” (McWhirter & Weston 1994), showing they immediately associated sharks with risk. A study of 11-12 year old primary school students in Hong Kong revealed that the children saw sharks as the main threat to swimmers in the sea (Tsoi et al. 2016). Given there is a greater likelihood of drowning, these findings suggest an inflation in perception of shark risk compared to other more likely risks. However, a recent study of beach goers in South Africa found that 83% of respondents believed that sharks do not represent the greatest risk to people in the water (Lucrezi et al. 2019). This indicates that perceptions are changing, or water users perceive lower risk from sharks than other groups of people.

It has always been assumed that perceptions of sharks and shark management would be at their most negative following a shark bite incident. However, one of the first before and after shark bite surveys concluded that this is not always the case (Neff & Yang 2013). Levels of “pride” in white shark populations in Cape Town, South Africa remained steady after a shark bite occurred, with no statistical difference between the response before and after the incident. Confidence in local beach safety was also unchanged following the shark bite. These previously undocumented insights led Neff and Yang (2013) to conclude that shark bite incidents alone do not always result in overwhelming and purely negative reactions towards sharks.t

It is important to understanding public knowledge of sharks, as this knowledge can impact perceptions towards the species. Tsoi et al. (2016) found students in Hong Kong demonstrated a good knowledge of shark ecology. The students knew humans were not the main diet of sharks, but incorrectly thought sharks could shift their diet to be herbivorous. Although 80% agreed that the balance of the ecosystem would be interrupted if sharks were removed from the ecosystem, the students displayed poor understanding of the biological interactions within the ecological system and 30% did not understand the predatory role of sharks. Overall, Tsoi et al. (2016) found the students had a positive perception towards sharks. The authors also found a strong, positive correlation between the students' knowledge of sharks, the ecological system, and their value orientation (i.e., biocentric, anthropocentric or utilitarian) towards sharks. The overall positive perception displayed by the students suggests a changing public perception of sharks, as younger generations do not always share the traditional negative view. Recent research into public perceptions of sharks in Australia and South Africa also suggested that the traditional negative view of sharks as human-eaters and threatening is shifting (Pepin-Neff & Wynter 2018b, 2019; Lucrezi et al. 2019).

1.5 Influences on shark perception and shark risk perception

Media coverage can amplify perceptions of wildlife and wildlife-associated risks (Gore & Knuth 2009). In New York in 2002 following a black-bear related human fatality, residents felt their risk of an attack had increased (Gore et al. 2005). Media coverage of black bears increased during this time and highlighted the rarity of human fatalities in such incidents, but this had little effect on resident risk perceptions (Gore et al. 2005). The focus of the media on conflict events creates the perception that wildlife-conflict management is reactive, as it is only discussed in the context of an event (Siemer et al. 2007). In reality, the majority of wildlife-conflict management works on mitigating risk most of the time. The tone of articles is also important, as negative articles focusing on human fatalities or 'attacks' encourage negative attitudes towards the species in question. A recent study found that people who had a positive perception of sharks felt that sharks are perceived adversely by the media (Lucrezi et al. 2019), suggesting the media portrays sharks negatively.

Placement of blame in conflict incidents can influence how people feel about the incident. Traditionally, the animal has been mostly blamed. More recently, however, the media and public have moved towards placing the onus on people such as the person involved, the laws addressing the species or the governing body for the area and public safety (Neff 2014). Neff

(2014) provided a media analysis of newspaper coverage following shark bite incidents in Australia, the US and South Africa where he identified the primary ‘problem variable’ of each article, such as the shark or additional factors such as overfishing, weather or seal migrations. Following shark bite incidents in Australia in 2000, 56% of media reports blamed the shark, 8% blamed laws protecting the sharks and 24% blamed additional factors. By comparison, in the US following a series of shark bites in Florida in 2001, sharks were identified as the primary problem variable in 40% of the articles. Factors indicative of increased shark activity (e.g., bait fish, fish waste) were identified as the problem in 22% of the articles and 14% put the incident down as a case of mistaken identity on the part of the shark due to bad weather and water turbidity. The third case came from Cape Town in 2004 following a fatal shark bite. The shark took the blame in 47% of articles following the bite. Collectively, 15% of the articles identified contextual, human-centred problems including chumming of water in the area by shark cage dive operations, poaching in the area, and the swimmer being in deep water far from shore. Lastly, 10% of the articles said a lack of knowledge of why sharks attack was a problem, which showed up in 9% of articles in the US, but none in Australia. Overall, sharks were predominately blamed in all three case studies from the early 2000s. However, human-centred factors were also mentioned in all cases. Importantly, none of the US articles discussed killing sharks as a solution to human-shark conflict, compared with 18% in South Africa (second most popular solution following shark spotting/flags on the beach) and 41% in Australia (Neff 2014). The results indicated that blaming sharks for bite incidents can positively influence support for lethal management. This was supported by Acuña-Marrero et al. (2018) who found the perceptions that sharks are vulnerable and important to the environment were the most important variables in predicting support for the protection of sharks. Non-lethal management is probably more likely to gain popularity if people perceive sharks positively, even after shark bite incidents. Keeping people away from sharks entirely (i.e., closing/clearing beaches, keeping people out of the water) was proposed by 33% of Australian articles, 69% from the US, and zero from South Africa. These approaches may not promote coexistence, but also do not promote killing sharks, and are suggestive of greater fear of sharks.

Furthermore, actions people take to secure their own safety or at least increase their own feeling of safety could influence their perception towards shark risk. Using a paddle board or a long surf board (≥8ft long) might increase perception of safety, or using a personal electric shark repellent device.

1.6 Shark management

To address human conflict with sharks, management agencies implement measures aiming to reduce the risk posed by sharks, placate the public, and / or provide information for water users that allows them to make more informed decisions regarding their own safety (Chapman & McPhee 2016). Devising policies for mitigating human conflict with sharks is complex in nature due to potentially fatal consequences and emotional responses (Neff 2012). Furthermore, balancing human safety and shark conservation has proved difficult.

1.6.1 Lethal policies

Catch-and-kill programmes were the traditional approach to mitigate shark risk and remain popular today. These strategies aim to deplete local shark populations with the hope of minimizing the spatial overlap between people and sharks, reducing the likelihood of a negative interaction (Meeuwig & Ferreira 2014). Gill nets (hereafter referred to as shark nets') were first used in the 1930s in New South Wales, Australia, and were added to Queensland, Australia and KZN, South Africa in the 1960s (Meeuwig & Ferreira 2014). These nets were introduced to many bathing beaches in KZN following shark bites in the 1950s and 1960s (Atkins et al. 2013) following a period known as "Black December" (December 1957 to April 1958) where nine shark bites occurred, six of which were fatal, along the Durban coast line. These incidents sparked increased fear of sharks and led to people leaving Durban and cancelling holidays, causing a decline in tourism and revenue for the area during this time (Dudley & Cliff 2010).

Most nets used in South Africa are 213.5m long by 6.3m deep and are permanently anchored parallel to the coast, approximately 300–500m offshore in 10–14m depth of water (Atkins et al. 2013). Nets are checked 15-20 times a month, and all species caught are removed (Atkins et al. 2013). As the depth of the water exceeds the depth of the nets, they leave a gap of roughly 6m between the bottom of the net and the sea floor. Thus, the nets do not act as a complete barrier to sharks. In fact, one third of sharks caught in the nets in KZN are caught on the shoreward side (KZNSB 2019).

These nets are designed specifically to catch large sharks, but a great number of other marine elasmobranchs get caught and killed in the nets too, including rays and non-target shark species. Three species of dolphin are also commonly caught: bottlenose (*Tursiops aduncus*), long-beaked common (*Delphinus capensis*) and humpback dolphins (*Sousa plumbea*) (Atkins et al. 2013). Humpback dolphins are rare and hence mortality linked to gill nets in KZN represents a substantial ongoing threat to the species (Atkins et al. 2013), contributing to the permanent loss of resident and transient humpback dolphins (Atkins et al. 2016). Incidental by-catch from the nets in KZN of bottlenose dolphins is double the level suggested by the International Whaling Commission (IWC) as the maximum sustainable capture rate for a cetacean population (Natoli et al. 2008). Sea turtles also fall victim to the shark nets in KZN. Loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) turtles have all been caught (Brazier et al. 2012).

The removal of apex predators from a system has ecological impacts, regardless of method of removal. Tiger sharks possess large ecological functional values and exercise a strong influence over lower trophic levels (Bornatowski et al. 2014). The loss of predators can lead to trophic cascades and the trophic downgrading of ecosystems (Ripple et al. 2013; Heupel et al. 2014). Declines of apex predators can result in 'mesopredator release', whereby smaller carnivores increase in numbers due to the absence of predation and/or a decline in competition. Mesopredator release has been documented to lead to the decline and extinction of prey species (Palomares et al. 1995; Crooks & Soulé 1999). For example, the decline of top carnivores in North America is a contributing factor to declines in ground-nesting birds because mesopredators, such as racoons, have increased in abundance and predate on nests (Rogers & Caro 1998). Despite frequent inabilities to observe community responses to changes in marine environments, certain shark species, including white sharks (Fallows et al. 2013), bull sharks (O'Connell et al. 2007), and tiger sharks (Sulikowski et al. 2016) are accepted as apex predators based on the same definitions and classifications as terrestrial apex predators (Heupel et al. 2014). Shark species targeted by lethal interventions are some of the most vulnerable shark species worldwide (Meeuwig & Ferreira 2014). Thus, the persecution of large sharks using lethal shark control methods causes negative ecological and environmental impacts.

A recent study exploring attitudes towards shark hazard mitigation in South Africa, surveying people in Cape Town, Durban, Mossel Bay, Jeffrey's Bay, and Port Elizabeth found no significant difference in the respondent knowledge, attitudes, and behaviour towards sharks and shark hazard mitigation across sites (Lucrezi et al. 2019). However, this study did not assess respondent understanding of shark hazard mitigation strategies and it is still unclear whether water users in KZN understand how gill nets work. If most people think the nets are a non-lethal barrier, then realising they are fishing devices that kill sharks and many other species may significantly alter their perception.

Drumlines have been introduced specifically to reduce by-catch of cetaceans and turtles. Drumlines are large baited hooks suspended from an anchored surface float (Sumpton et al. 2011), designed to attract sharks actively feeding. Drumlines were tested as an alternative to shark nets in KZN in 1998, and they demonstrated greater species selectivity (Dudley et al. 1998). The major initiative to introduce drumlines in KZN began in 2005, and in 2007 drumlines replaced almost half of the nets at the 17 southernmost protected beaches (KZNSB 2019). The KZN Sharks Board (2019) claimed that the capture of non-target species has reduced by 47.5% following the installation of drumlines. Additionally, survival of marine animals once caught has been shown to be higher with drumlines than nets (Sumpton et al. 2011). Thus, arguably drumlines have a lower environmental impact than shark nets. However, in KZN there has been no significant difference in the Catch-Per-Unit-Effort (CPUE) or mean annual catch of white, tiger or bull sharks caught by the KZNSB between when they just used nets and now using a combination of nets and drumlines (KZNSB 2019). However, drumlines do not appear to catch bull sharks as effectively as nets, so the KZNSB still uses a combination of both (KZNSB 2019).

Another lethal shark control measure is so-called 'shark hunts'. These often arise as a response to a shark bite incident. A shark hunt is a targeted expedition with the purpose of killing either the shark responsible for the bite, or any sharks in the area. The concept of targeting specific sharks involved in biting incidents stems from the notion of a 'rogue shark' theory (i.e., a shark that has supposedly developed a taste for humans and will continue to bite people unless killed), which gained momentum following the *Jaws* movie franchise (Neff 2015). However, there is no evidence to support this theory due to the inability to conclusively say the same shark was responsible for multiple bites. Equally, the likelihood of finding the shark responsible on a hunt confidently enough to warrant killing it is slim. Shark hunts are thus probably best understood as a form of theatre aimed to control fear.

A key argument in favour of lethal shark control methods is that the tourism industry would suffer if people do not feel safe in the water (Pepin-Neff & Wynter 2018a), and such lethal shark control may be necessary for people to feel safe. 'Black December' is often cited as evidence in favour of this argument. More residents of Ballina, Australia, believed that protecting tourism is a the primary purpose of lethal shark control measures than protecting the public (Pepin-Neff & Wynter 2018a). Similar beliefs have been stated for KZN:

> "*The reason that nets were installed in Durban in 1952 and along the rest of the coast in the early 1960s was that shark attacks at popular recreational beaches were*

adversely affecting coastal tourism." – Greg Thomson, Acting Head of Operations of KZNSB (Kelly 2019)

1.6.2 Non-lethal policies

An improved understanding of sharks, including their behaviour, ecological importance, and economic value associated with tourism are together compelling reasons to seek non-lethal strategies to protect people (Meeuwig & Ferreira 2014). The most systematic and sustained non-lethal shark programme globally is the Shark Spotters Programme in Cape Town, South Africa. The programme commenced in 2004 following a series of shark bite incidents and increasing shark sightings. Spotters are trained to detect sharks from a vantage point and in providing first response assistance to shark bite victims (Kock et al. 2012). The Shark Spotters meet the criteria of Slovic's (1987) psychometric paradigm by creating the impression of control and promoting trust amongst beach goers. Coloured flags are displayed at beaches where Shark Spotters are operating, denoting the level of risk and spotting conditions (Table 1). No flag means no spotter is on duty, and only one flag is up at a time. A siren is also set off when a shark is spotted in the vicinity of water users and is posing a potential threat (white flag).

Table 1: Details of the Shark Spotters coloured flag warning system.

Flag Colour	Meaning	Description
Green	Good spotting conditions	Majority of the water column is visible to the spotter
Black	Poor spotting conditions	Glare, cloud cover, water clarity/turbidity, swell, wind chop
Red	High shark alert	Shark seen in the last hour; shark spotted far from water users posing no potential threat; five sharks sighted at one beach in one day; sharks nearby spotted exhibiting hunting behaviours; and/or conditions present conductive of increased shark activity
White	A shark has been spotted	Shark seen in the vicinity of water users posing a potential threat. Everyone evacuated from the water.

Individual level non-lethal methods are also widely used and most seek to deter sharks from approaching water users through understanding the sensory cues that sharks use for catching prey and interacting with their environment (Hart & Collin 2015). Sharks have specialised receptors that allow them to detect weak electrical potentials generated by other animals or objects that they use for hunting and locating prey (Hart & Collin 2015). Sharks navigate and orientate themselves through detecting electric fields produced by their bodies or water currents in their surroundings as they move through the Earth's magnetic field (Paulin 1995). Thus, electric repellent devices have been developed to be aversive to sharks. Such devices can be individual or extend across coastlines.

One of the first successful electric repellent device was called the "Shark Shield" and was developed in the US for scuba divers and to prevent damage to the cod-ends of shrimp-trawl nets (Hart & Collin 2015). In aquarium tests, the shield proved effective at deterring sharks and field tests showed the shield kept sharks more than 3m from the device. Further research into the use of electrical shields to repel sharks by the KZNSB led to the development of SharkPOD (Protective Oceanic Device; now patented by an Australian company, SharkShield), a device largely used by scuba divers, but has since been developed for use by surfers and kayakers (Hart & Collin 2015). SharkPOD has proven effective in deterring various shark species, including *C. Carcharias*. A study showed *C. Carcharias* attacked bait attached to activated devices at a significantly lower frequency compared to controls where the device was switched off (Smit & Peddemors 2003).

Electric repellents are now being trialled at the landscape level with the goal of establishing safe zones through the use of cables placed along stretches of coastline. In South Africa, an anti-shark electric cable deployed in the St. Lucia estuary and off Margate Beach was effective at deterring sharks (Hart & Collin 2015). Devices such as these are physically harmless to sharks, but can damage reefs during installation and are expensive to install and maintain. Nevertheless, research into this option is promising and ongoing.

Exclusion nets that function as a barrier to sharks have also been successfully trialled around the world. In South Africa, the first exclusion net was trialled at Fish Hoek beach in Cape Town, South Africa. The net is deployed on a daily basis in a sheltered corner of the beach where the water does not exceed a depth of 5m. The net is removed at night to minimise the risk of marine wildlife entanglement (Davison & Kock 2014). The design of the net minimises entanglement and because it extends throughout the entire water column, it creates a complete barrier to sharks.

Other advances include wetsuits that, through colours and patterns, seek to reduce the wearer's visibility to sharks, which have poor colour vision (Hart & Collin 2015). Monochrome wetsuits and surfboard stickers have also been used to mimic dangerous marine organisms such as orcas or sea snakes.

1.6.3 Perception of shark management

Since the 1930s, there has been a general public perception that sharks must be killed to reduce the threat they pose to people (Neff 2015). However, a study of white shark population status and composition in False Bay, Cape Town, stated that is was unlikely that an increase in white shark abundance was the reason for an increase in shark bite incidents (Kock & Johnson 2006). If having more sharks around does not mean more shark bites, then lethal measures do not necessarily ensure greater safety of water users. However, this study was published 14 years ago and lethal measures still exist in South Africa. This suggests there is another reason for their use in South Africa, which could be support for lethal control, or people are unaware of said lethal control.

The study of primary school children by Tsoi et al. (2016) found the students largely disagreed with killing sharks to ensure the safety of water users. A study investigating the opinions of people in two locations in Australia that have been directly impacted by shark bite incidents found the majority of people favour non-lethal policies (Pepin-Neff & Wynter 2018a). However, fear of sharks influenced opinions of shark management, as those who greatly feared sharks or those who thought sharks target people intentionally were more supportive of lethal shark policies. Equally, support for non-lethal shark management is correlated with positive attitudes and biocentric value orientations towards sharks (Acuña-Marrero et al. 2018). Thus, shark conservation benefits from positive and biocentric responses towards sharks.

Public opinion in Australia appears to be changing from one in which management should protect people from sharks, to one where sharks need protection from people (Simpfendorfer et al. 2011; Whatmough et al. 2011). Recent research in Australia and South Africa has found greater trends towards positive perceptions of sharks and lack of support for lethal control (Pepin-Neff & Wynter 2018b; Lucrezi et al. 2019). This shift in perception is altering the landscape of shark management.

1.7 Shark Behaviour

As mentioned, the three main shark species of safety concern in South Africa are white sharks, bull sharks, and tiger sharks. Therefore, this section reviews the ecology and behaviour of these species.

1.7.1 Spatial ecology of white sharks

White sharks engage in broad-scale coastal and oceanic migrations (Domeier & Nasby-Lucas 2008a; Jorgensen et al. 2010; Kock et al. 2013). White sharks tagged in New Zealand crossed open ocean to the tropical islands of New Caledonia and Vanuatu, which are journeys of 1000 to 3000km, respectively (Bonfil et al. 2010). White sharks tagged in California travelled up to 3,800km, during which time they remained exclusively pelagic (Boustany et al. 2002). Sharks tagged in Australia travelled throughout the Austral-Asian region, spending most of their time in water less than 100m deep, and some mostly within 5m depth (Bruce et al. 2006). Equally, sharks tagged in California at a coastal-residence site spent most of their time in water shallower than 30m depth, and the deepest dive recorded was only 75m (Boustany et al. 2002). The same sharks showed preference for depths of 0.5m and Bonfil et al. (2010) reported white sharks spending most their time in the top 1m of water. During oceanic large-scale migrations, results of depth preference varies between studies from 300-500m to periodic dives of 900m (Boustany et al. 2002; Bonfil et al. 2010).

White sharks exhibit strong diurnal patterns of movement. A study of a young female white shark in California revealed a preference for shallower water (50m) at night and deeper water (240m) during the day (Dewar et al. 2004). In False Bay, South Africa, however, white shark presence peaked along the shallow inshore around midday (Kock et al. 2018). There is clearly considerable variation in how white sharks utilise the oceans, and they can clearly tolerate a broad range of temperatures and environmental conditions (Boustany et al. 2002). There is general agreement in the literature that white sharks spend considerable time in shallow water, including coastal areas, where they present the greatest threat to people.

White sharks show clear seasonal aggregations mostly around islands with large pinniped populations, suggesting aggregations form in response to preferred food availability (Domeier & Nasby-Lucas 2008b). Guadalupe Island is an important aggregation site for white sharks in the eastern Pacific (Domeier & Nasby-Lucas 2008b). Juvenile white sharks arrive here from nursey grounds along mainland Mexico, and remain there for several months, most likely to take advantage of the wide variety of prey available (Hoyos-Padilla et al. 2016). Seal Island in False Bay is another known aggregation site of white sharks (Martin et al. 2005), as the island is home to the largest breeding colony (up to 80,000 individuals) of Cape fur seals (*Arctocephalus pusillus pusillus*) in South Africa (Kock et al. 2013). False Bay is considered to have the highest proportion of large white sharks in South Africa (Kock & Johnson 2006) where large means their total length exceeds 3m (Lowe et al. 1996; McCord & Lamberth 2009; Kock et al. 2013, 2018).

Within False Bay, female sharks aggregate along inshore regions during summer and spring (Kock et al. 2013), often in very shallow water (2m) and at popular recreational beaches including Muizenberg (Kock et al. 2013; Kock et al. 2018). Similar seasonal patterns of inshore shallow water use in summer have been reported in other coastal regions of South Africa (Gansbaai and Mossel Bay) and California, US (Kock & Johnson 2006).
More recently, white shark sightings have declined dramatically in False Bay with no confirmed white shark sighting by Shark Spotters in 2019 and one so far in 2020. Opinions as to the cause of white shark absence vary, but the increase in predation by orcas (*Orcinus orca*) is considered the single most likely driver of their absence (Engelbrecht et al. 2019).

1.7.2 Spatial ecology of bull and tiger sharks

Bull sharks are euryhaline and are often found near estuaries (Heupel & Simpfendorfer 2008). Pregnant females migrate to estuaries to give birth, where the juveniles stay until the water temperature drops below optimal levels and they move into warmer offshore waters (Simpfendorfer & Burgess 2009). They favour murky waters, where they can ambush prey (Snelson et al. 1984; Simpfendorfer & Burgess 2009; Meynecke et al. 2015). Bull sharks are found in warm, nearshore waters of KZN and in Mozambique.
Tiger sharks also favour warm, coastal waters, inhabiting shelf, reef, slope habitats, and sometimes coral reefs. They also occasionally embark on long-distance excursions into the pelagic zone (Lea et al. 2015; Ferreira & Simpfendorfer 2019). They show a clear preference for surface waters, spending most of their time at depths less than 20m (Holmes et al. 2014; Afonso & Hazin 2015). The deepest a tiger shark has been recorded is 1,136m (Werry et al. 2014). Neither bull nor tiger sharks are found in Cape Town due to the colder water.

1.8 Shark diet

Sharks are carnivorous and their prey diversity increases as they get bigger (Lowe et al. 1996). White sharks demonstrate a dietary shift as their size increases with larger individuals consuming more mammalian prey and less teleosts and elasmobranch prey (Domeier et al. 2012). An analysis of the stomach content of white sharks caught in the shark nets in KZN showed the smallest shark to consume seals was 2.09m in precaudal length (Domeier et al. 2012). The same analysis found seals to be the most common prey item of large white sharks (here defined as >2.85m precaudal length), with whales being the biggest prey contribution by mass. White sharks have been shown to forage in both coastal and offshore regions

(Carlisle et al. 2012), with an apparent preference for simple, uncluttered foraging environments (Gotceitas & Colgan 1989; Wcisel et al. 2015).

Bull sharks have a varied diet, including turtles, dolphins, teleost fishes, crustaceans, and elasmobranchs (Last & Stevens 2009). They have also been shown to shift their diet as they grow to include consistently higher trophic level prey from a greater foraging range (Daly et al. 2013). This shift is likely due to increased mobility with size. Bull sharks exploit a more diverse range of habitats and prey species than predatory teleost fish (Daly et al. 2013). Thus, bull sharks, and particularly adult bull sharks, play an important predatory role.

Tiger sharks are opportunistic and generalist feeders that target abundant and easily captured prey (Lowe et al. 1996; Dicken et al. 2017). Tiger sharks exhibit diel variation in their hunting behaviours, hunting near the sea floor at night and the surface during the day (Lowe et al. 1996) when more people are likely to be in the water. Tiger sharks also shift their diet as they grow. Prey similar in size to humans enters the shark's diet when they reach a length of 2.3m of greater (Lowe et al. 1996). Therefore, it is only the larger tiger sharks that most likely present a potential threat to people, and this is greatest during the day.

2. Aims and hypotheses

The main research question of this study is: what factors most strongly relate to water users' perception of sharks risk? To answer this question, I assessed people's attitudes and value orientations towards sharks; their opinions of shark management; their risk sensitivity; their knowledge of shark behaviour, ecology, and human-shark conflict interventions currently in use in Durban, Cape Town, and worldwide; and their support for such interventions. Additionally, I determined whether there was a difference in how people perceived risks from sharks compared to other risks (e.g., getting in a car accident) and in respondent answers between Cape Town and Durban. I also explored whether support for different human shark conflict interventions varied based on risk sensitivity and the extent that shark presence was related to people's decisions to enter the water.

Based on the above literature review and research aims, I tested the response variable (perception of shark risk) in relation to the following explanatory variables: perception of other risks, perception of sharks, knowledge about sharks, age, gender, surf board length, and site. I assessed the extent that perceived risks from sharks were related to people's decision to go in the water compared with the additional factors of surf/sea conditions, spotting conditions, and whether there were other people in the water.

Understanding how risk perceptions associated with sharks are related to various other factors is important for informing shark management. As the main argument in favour of lethal shark control is to minimise harm to tourism, my study aimed to assess whether lethal control is necessary for people to feel safe in the water. Slovic (1987) said: "those who promote and regulate health and safety need to understand the ways in which people think about and respond to risk." I hypothesised that perceptions of risk from sharks would be related to knowledge about sharks, value orientations toward sharks and lethal shark control and perception regarding other risks. I predicted that respondents with a low perception of risk toward sharks would have high knowledge about sharks, biocentric value orientations related to sharks, and oppose lethal shark control. I predicted those who perceive shark risk as high would also perceive other risks highly. Furthermore, I predicted that the presence of sharks and poor surf conditions would be the most important factors influencing respondent decisions to go in the water.

3. Methods

3.1 Study Sites

Surfers were surveyed in-person at three recreational beaches in two of South Africa's major coastal cities. Muizenberg beach (34.1087° S, 18.4702° E) near the city of Cape Town, and North Beach and Bay of Plenty Beach (29.8476° S, 31.0349° E) near the city of Durban. These beaches were selected because they are popular with surfers of all abilities, have a history of shark bite incidents, and have active management to reduce human interactions with sharks. Muizenberg beach has Shark Spotters operating daily from sunrise to sunset, and the Durban beaches have a combination of gill nets and drumlines. I chose to conduct surveys in both Cape Town and Durban due to the differing approaches towards shark safety management of the two cities.

Muizenberg beach is a situated in the north-western portion of False Bay approximately 14km from Seal Island, a known white shark aggregation site during the winter months. Sea temperatures range from 14-21°C, peaking in January and at their lowest in July. Muizenberg is an exposed beach with prevailing north-westerly winds in the winter months and south-easterly winds in the summer months. The beach is microtidal and is characterised by a Mediterranean climate (Lucrezi & van der Walt 2016).

North Beach and Bay of Plenty beach in Durban are adjacent to one another 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 than 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 access the backline of the waves (Preston-Whyte 2001). Sea temperatures range from 20°C in early August to 27°C in early February.

There have been five shark bite incidents at Muizenberg beach since 1960 (in 1964, 1983, 1984, 2004, 2014). All victims were surfers and none of these incidents were fatal. Between 1940 and 1990, there were eight shark bite incidents at North Beach, Durban: in 1943 (fatal), three in 1944 (all fatal, one surfer), 1947 (non-fatal), 1950 (fatal), 1971 (non-fatal), and 1986 (non-fatal).

3.2 Questionnaire Structure

A structured questionnaire with predominantly closed-ended questions (see Appendix 2) was used to survey beach users at both study sites. Respondents were asked what activity they would be doing at the beach that day, and to estimate their skill level and level of recreational specialisation in that activity. This estimation involved answering questions related to how important the activity is to them and how often they engage in the activity, their perceived skill level, and whether they read articles about the activity in their spare time. Surfers and paddle boarders were asked what length board they use. They were also asked how many days in the last year and for how many years they have visited that beach. Gender, age, highest level of education, and city and country of residence were the only demographic questions asked.

The majority of the questionnaire took the form of statements to which the respondent was asked to agree or disagree with, on a 1 to 5 scale (where 1 represented strongly disagree, 2 represented disagree, 3 represented neither, 4 represented agree, and 5 represented strongly agree). These statements addressed knowledge of shark ecology and behaviour, perceived risks, opinions about lethal shark management, and value orientations associated with sharks. Statements regarding support for conflict interventions used a similar scale from 1 (strongly oppose) to 5 (strongly support). Open-ended questions were used for gauging the respondent knowledge of lethal shark control measures used in KZN. Risk perceptions were asked on a scale between one and four, where one represented no risk, two a slight risk, three a moderate risk and four an extreme risk. The focus on quantitative techniques allowed for the questionnaire to be shorter, and for analysis to be objective and more accurate.

The questionnaire used in Durban was the same as that used in Cape Town, except for questions asking about the human-shark conflict interventions specific to the area. In Durban, respondents were asked whether they understood the function of drumlines. Both questionnaires asked whether respondents knew how shark nets function to reduce shark risk to water users. Despite shark nets not being used in Cape Town, the goal here was to determine whether the lethal action of shark nets was better understood where they are used (Durban) compared to Cape Town where only non-lethal methods are used.

3.2.1 Conjoint measures

The questionnaire also included a series of scenarios designed to allow for conjoint analysis. Hypothetical scenarios presented combinations of four factors that might influence people's decision to enter the water. Each factor had two levels, except 'Shark presence', which had four. The factors and levels were:

1. Shark presence
   - Shark being seen right now
   - Shark seen in last hour
   - Shark seen in last 24 hours
   - No shark seen in 24 last hours
2. Number of people in the water
   - No people are in the water
   - People are in the water
3. Conditions for being able to spot sharks
   - Good conditions to spot sharks (e.g., water clarity / turbidity, visibility, glare)
   - Poor conditions to spot sharks (e.g., water clarity / turbidity, visibility, glare)
4. Surf / sea conditions
   - Good surf / sea conditions (e.g., swell height, wind direction, tide)
   - Poor surf / sea conditions (e.g., swell height, wind direction, tide)

These factors and factor levels were informed by discussions held in focus groups with surfers. The levels of shark presence were based on the flag system of the Shark Spotters Programme where "shark in the water now" is represented by the white flag and "shark seen in last hour" by the red flag (see Table 1). "Poor" and "good" shark spotting conditions, which are a combination of the variables listed, were denoted by a black and a green flag, respectively. Spotting conditions also influence human safety, especially the effectiveness of the Sharks Spotters in Cape Town, but also as bull sharks frequently found in Durban favour murky waters. Surf/sea conditions were more subjective factors because perceptions of what might constitute good surfing conditions are expected to differ markedly between individuals according to their skill levels and activity (e.g., kayakers, surfers). The number of people in the water was restricted to a binary answer given the potential error for any number >1. The presence of other people in the water might not be preferable for surfing, but for safety, water users are advised not to enter the water alone (Shark Spotters 2019).

A total of 32 possible scenarios would be required for a full factorial design. To minimize the burden on respondents, a subset of scenarios was generated using an orthogonal fractional factorial design (SPSS software's Conjoint Module). This process produced eight different scenarios that were included in the survey (Table 2). Responses to these scenarios were measured on scales from 1 (very unlikely) to 9 (very likely), with 5 representing neither likely or unlikely. Responses to these eight scenarios can then be used for estimating responses to all scenarios that were not presented in the questionnaires. Analysis was conducted in SPSS software's separate Conjoint Module.

Table 2: Orthogonal fractional factorial design with varying combinations of factors and levels showing the scenarios used in the survey.

Scenario	Shark presence	Number of people	Spotting conditions	Surf conditions
1	No shark	No people	Poor	Poor
2	Shark seen in last 24 hours	No people	Good	Good
3	Shark seen now	No people	Poor	Good
4	Shark seen in last hour	People in water	Poor	Good
5	No shark last 24 hours	People in water	Good	Good
6	Shark seen in last hour	No people	Good	Poor
7	Shark seen in last 24 hours	People in water	Poor	Poor
8	Shark seen now	People in water	Good	Poor

3.3 Sampling

Questionnaires were administered on-site (i.e., face-to-face) between 07:30 and 17:00 over eight consecutive days in both Cape Town (3 Oct 2019 – 10 Oct 2019) and Durban (22 Oct 2019 – 30 Oct 2019). Water users were approached as they were coming out of the water and invited to participate in the study. Although targeting water users does not gain a representative sample of the entire population, people who use the water in areas affected by shark bite incidents have been targeted by studies on perception of sharks and shark management as this sector of the population is most likely to be affected (Gibbs & Warren 2015; Gray & Gray 2017; Pepin-Neff & Wynter 2018a; Simmons & Mehmet 2018; Lucrezi et al. 2019). A limitation of this study design is that it failed to sample people who had come to the beach intending to enter the water, but had opted not to, or people who had opted not to come to the beach at all, both perhaps because they were worried about sharks. Thus, the sample was possibly focused on the more risk-loving or risk-neutral individuals on the beach that day. Even so, I expected there to be variation in answers and in risk perception amongst those who had opted to enter the water. Participants 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 5 and 15 minutes to complete. An informed consent was provided verbally by the participants prior to completing the questionnaire, and participants were made aware they could stop answering questions at any time and were guaranteed anonymity.

3.4 Statistical Analyses

Analyses were performed in SPSS version 25.0 (IBM Corp 2017), the SPSS Conjoint module, and R Studio version 3.3.3 (R Core Team 2017). I performed independent sample t-tests between the mean scale scores of respondents from Cape Town and Durban to test the null hypothesis that there is no difference in attitudes between Cape Town and Durban respondents. Preliminary analyses revealed a statistically significant difference between how surfers and swimmers perceived risks from sharks ($t(196.8) = 2.573$, $p = 0.011$). Given the key research question of this study centres on the perceptions of risk from sharks and there is a significant difference in how different water user groups perceive risk, I focussed almost all of the analysis on surfers and only included other water users when beach activity could be controlled in the analysis. For each explanatory variable, the questionnaire contained multiple scaled questions. I performed Cronbach alpha reliability tests in SPSS on the scale statements for each explanatory variable to determine if there was justification in combining variables. I used a Cronbach alpha value > 0.65 as my cut-off, after which additional analysis (e.g., cluster or factor analysis) could be performed on the combined indices.

The questionnaire contained seven scale questions assessing respondent beliefs and value orientations about sharks, adapted based on Needham's (2010) variables (Appendix 2: Q21). Three items were protectionist/biocentric towards sharks, and four were anthropocentric and incited negative beliefs about sharks. The Cronbach alpha reliability test for these statements gave a value of 0.790. Factor analysis combined the three biocentric questions together and the four anthropocentric questions together resulting in Cronbach alpha values of 0.820, and 0.654 for respectively. When excluding the statement "the needs of humans are more important than sharks," the Cronbach alpha value for the anthropocentric variables increased to 0.678. As the Cronbach alpha score was higher without this variable, I excluded it from further analysis. To create a single composite variable for how respondents value sharks, I reverse coded the anthropocentric variables, and derived an average score for each respondent: the biocentric value orientation towards sharks index. The higher the score, the more biocentric towards sharks.

Statements assessing respondent support for or opposition to lethal shark control (Appendix 2: Q20) outlined seven conditions that included the killing of sharks, and asked respondents to state the extent they agreed or disagreed with the statements. Statements included pro- and anti-lethal shark control situations. Prior to running the Cronbach alpha reliability test, I reverse coded answers for pro-lethal statements so that all seven variables were projecting in the same direction (i.e., the higher the number, the more anti-lethal the answer). The Cronbach alpha value on these variables was 0.766, allowing me to combine these seven variables into a single composite of 'opposition to lethal management', by taking the mean response of each contributing variable. Thus, the higher the score, the more opposed the respondent is to lethal management.

For assessing respondent knowledge of sharks, only scale knowledge questions (Appendix 2: Q12 and Q13) with clear correct or incorrect answers were included in analyses (Appendix 1). Any incorrect statements were reverse coded. Each respondent's answers for these items were summed, giving each respondent a score between 7 and 35; the higher the score, the greater knowledge about sharks. Using the frequencies command in SPSS to create cut points for three equal groups, I split the respondents into three non-overlapping knowledge groups: lowest, middle, and highest knowledge. This variable 'knowledge of sharks' was used in subsequent analyses. I performed chi-square tests of independence to test for differences between Cape Town and Durban on this variable.

For the variables of risk perceived by respondents in relation to being in a car accident, other accident, natural disaster, other disaster, or getting a potentially life-threatening disease or illness (Appendix 2: Q10), the Cronbach alpha value was 0.715. For responses to variables of risk perceived in encountering a shark or being bitten by a shark while in the water, the Cronbach alpha value was 0.750. I thus calculated the average responses across respondents to create two new indices; perception of risk from sharks and perception of other risks, where the higher the score, the greater risk perceived. I performed paired t-tests to test for differences between Cape Town and Durban in both variables. I ran a single linear regression to see if perception of shark risk is a significant predictor of opposition to lethal shark control.

To assess respondents' overall risk sensitivity, I ran a K-means cluster analysis on all seven risk perception variables. This identified three subgroups of people with similar risk sensitivity levels: low (score 1), medium (score 2), and high (score 3). I ran an one-way ANOVA to test for differences among risk sensitivity groups in their support for human-shark conflict interventions. Where there were statistically significant differences, I ran post-hoc tests to determine which groups differed. Where there was a statistically significant difference in variance of the means, I used Tamhane's T2 post-hoc test. Where there was no statistically significant difference in the variance of the means, I used Scheffe's post-hoc test. The more liberal Games-Howell post-hoc test was used when Tamhane's could not discern a difference between groups.

I tested for differences between Cape Town and Durban respondents in correctly identifying how shark nets reduce shark risk using a chi-square test. I also determined whether there was a difference in respondents who correctly identified the purpose of drumlines and shark nets and whether there was a statistically significant relationship between respondents on these two questions. These tests used binary variables (1 – correct and 0 – incorrect) that I created based on answers to open-ended questions on how shark nets reduce shark risk and the function of drumlines (Appendix 2: Q15-16). Correct knowledge of shark nets meant the respondent had identified that the nets are designed specifically to catch and/or kill large sharks. Correct knowledge of the function of drumlines meant the respondents understood that they are baited hooks designed to attract and kills large sharks.

3.4.1 Multiple Linear Regression Models

I ran a multiple linear regression model in R Studio using a backwards elimination selection process to explore the relationship between perceptions of risk associated with sharks and nine explanatory variables: perception of other risks, biocentric value orientations index, knowledge about sharks, age, gender, surf board length, beach activity, and site (Cape Town or Durban). Beach activity was included so that all respondents could be included in the model, and potential differences between user groups was controlled. Board length was included to test the hypothesis that surfers feel safer with a longer board. Variables were removed after each run using the backwards elimination selection process, until only terms statistically significant at the 10% level remained. I ran the same model for Durban surfers only, with the inclusion of two new binary explanatory variables: knowledge of the function of shark nets work and drumlines. This model allowed me to explore the effect of understanding lethal shark control on the perception of shark risk.

4. Results

I approached a total of 434 people in Cape Town and had a response rate of 85.3%, resulting in a final sample size of 370 respondents from Cape Town. In Durban, I approached 235 people, with an 87.2% response rate and a final sample of 205 respondents. Thus, my total sample size across both sites combined was 575 respondents (85.9% response rate). Not all questionnaires were complete (i.e., not all questions were answered), so item response rates and sample sizes vary slightly between analyses. Table 3 shows the demographic characteristics included in the questionnaire of the respondents.

Table 3: Demographic characteristics of respondents.

Category	**Options**	**Respondents**		
		All (n=575)	**Cape Town (n=370)**	**Durban (n=205)**
Age (years)	Mean	35.5	33.8	38.6
	Range	14 - 80	14 - 80	16 - 76
Gender (%)	Women	31.7	37.6	21.0
	Men	59.3	54.3	68.3
	Non-binary	0.35	0	0.98
	No answer	8.70	8.11	9.76
Education (%)	None	0.35	0.27	0.49
	Primary	0.17	0.27	0
	Secondary	2.26	2.16	2.44
	Matric	17.4	17.8	21.5
	Diploma	20.5	23.0	16.1
	Degree	47.5	47.6	47.3
	Prefer not to say	1.91	2.16	1.46

	No answer	8.17	6.76	10.7
Activity (%)	Surfer	69.7	73.2	63.4
	Paddle boarder	4.5	4.9	3.9
	Kayaker	0.5	0.3	1.0
	Swimmer	23.1	19.7	29.3
	Scuba diver	0.3	0.3	0.5
	No answer	1.7	1.6	2.0

4.1 Perceptions regarding sharks

Based on the scale used in this study, a mean score greater than 3.5 indicates agreement with a higher score indicating stronger agreement. A score less than 2.5 indicates disagreement, with a lower score, indicating stronger disagreement. The mean scores for biocentric value orientation questions relating to the perception of sharks were all high ($M > 4.5$), indicating most of the surfers strongly agree with the statements and feel positively towards sharks (Table 4). The mean scores for the three anthropocentric or anti-shark questions (Q4-7, Table 4) were low ($M < 1.5$) indicating most of the surfers strongly disagreed with these statements. Respondents were less strong in their response to “The needs of humans are more important than the needs of sharks” (Q6, Table 4), although a score of $M = 2.11$ suggests the surfers largely disagree with the statement. There were no statistically or substantially significant differences between Cape Town and Durban for these variables. There was also no significant difference ($t(380) = -0.247$, $p = 0.805$) between Cape Town and Durban surfers regarding the aggregated ‘biocentric shark index’.

Table 4: Proportion of surfers’ answers to each shark perception question, and mean scores for each question for all surfers, Cape Town surfers, and Durban surfers. Questions were asked on a scale between 1 and 5: 1 - Strongly Disagree (SD), 2 - Disagree (D), 3 - Neither (NE), 4 - Agree (A) and 5 - Strongly Agree (SA).

Q	**Perception of sharks**	**% Frequency of responses on scale (all surfers; n=401)**					**Mean scores (SD)**		
		SD	**D**	**NE**	**A**	**SA**	**All (n=401)**	**Cape Town (n=271)**	**Durban (n=130)**
1	It makes me sad to know that sharks are being killed.	3.2	1.2	4.5	11.0	75.3	4.62 (0.91)	4.61 (0.95)	4.63 (0.81)

2	Sharks should be protected for their own sake rather than to meet the needs of humans.	1.0	2.2	3.0	10.5	77.8	4.71 (0.73)	4.68 (0.78)	4.78 (0.63)
3	I believe that protecting sharks is important.	1.5	1.7	3.2	6.5	82.0	4.75 (0.75)	4.74 (0.78)	4.77 (0.68)
4	I do not care about sharks.	77.3	9.5	4.7	2.2	1.5	1.33 (0.81)	1.34 (0.81)	1.32 (0.81)
5	The needs of humans are more important than the needs of sharks.	47.1	10.7	20.4	9.7	6.0	2.11 (1.30)	2.04 (1.27)	2.28 (1.37)
6	Protecting sharks is a waste of time, as we should be protecting people's jobs instead.	70.3	10.0	9.0	3.0	2.5	1.49 (0.97)	1.48 (0.99)	1.52 (0.94)
7	The world would be better off without sharks.	83.5	5.5	2.5	1.0	2.7	1.26 (0.81)	1.24 (0.75)	1.29 (0.92)

4.2 Opposition to lethal shark control

Seven statements assessing how the surfers felt about lethal shark control were included in the questionnaire (Table 5). Five were 'pro-lethal' (Table 5: Q1-5) and two were anti-lethal (Table 5: Q6-7). Table 5 shows the anti-lethal statements had much higher mean scores ($M >$ 4), compared to pro-lethal statements ($M < 1.5$). There was a statistically significant difference for both Q6 ($t(181.3) = -2.425$, $p = 0.016$) and Q7 ($t(179.2) = -2.477$, $p = 0.014$) between Cape Town and Durban surfers, although both had a mean score greater than 4 for both statements, so the substantive differences were small. However, Cape Town surfers strongly agreed ($M > 4.5$) for both Q6 and Q7, whereas Durban surfers only agreed ($M <$ 4.5). There were also statistically significant differences between Cape Town and Durban for Q1, Q4, and Q5 (Table 5) with surfers strongly disagreeing that lethal policies keep water users safer than non-lethal policies ($M = 1.34$; $M = 1.28$ for Cape Town; $M = 1.49$ for Durban).

Table 5: Proportion of surfers' answers to each question on perception of lethal shark control, and mean scores for each question for all surfers, Cape Town surfers, and Durban surfers. Questions were asked on a scale between 1 and 5: 1 - Strongly Disagree (SD), 2 - Disagree (D), 3 - Neither (NE), 4 - Agree (A) and 5 - Strongly Agree (SA). Statistically significant results derived from independent sample t-tests denoted by * ($\alpha < 0.05$ *; $\alpha < 0.01$ **, $\alpha < 0.001$ ***).

Q	Perception of Shark Control	% Frequency of responses on scale (all surfers; n=401)					Mean scores (SD)		
		SD	D	NE	A	SA	All (n=401)	Cape Town (n=271)	Durban (n=130)
1	Killing sharks makes it safer for water users.	75.8	7.5	4.2	4.2	3.5	1.45 (1.02)	1.37 (0.92) *	1.62 (1.21) *
2	I support the killing of sharks only after a shark bite incident.	81.5	7.0	3.0	1.5	1.2	1.24 (0.71)	1.21 (0.69)	1.29 (0.75)
3	I support the killing of sharks at any time (not just after a bite incident).	86.0	3.7	3.0	0.7	1.0	1.17 (0.62)	1.12 (0.54)	1.27 (0.74)
4	Killing sharks is justified to lower the probability of a shark bite.	82.0	5.2	4.2	1.2	1.5	1.25 (0.74)	1.19 (0.65) *	1.38 (0.90) *
5	Lethal shark policies (killing sharks) keep water users safer than non-lethal policies (e.g., exclusion nets, inform users, repellent devices).	76.1	6.0	6.5	1.5	2.0	1.34 (0.85)	1.28 (0.80) *	1.49 (0.95) *
6	I do not support the killing of sharks as a safety measure.	9.0	2.2	0.7	4.0	79.1	4.49 (1.24)	4.61 (1.10) *	4.24 (1.48) *
7	I do not support the killing of sharks under any circumstances.	7.2	2.0	1.7	8.5	75.6	4.51 (1.15)	4.62 (1.01) *	4.27 (1.40) *

The mean score of respondents to the lethal shark control combined index was 4.65 (strongly oppose). There was a statistically significant difference between Cape Town and Durban in opposition lethal shark control ($t(196.2) = 2.994$, $p = 0.003$), where the surfers from Cape

Town were slightly more opposed to lethal shark control (*M* = 4.72) compared to those from Durban (*M* = 4.50), but the substantive difference was small.

4.3 Knowledge about sharks

The surfers correctly recognised that sharks play an important role in the marine ecosystem (*M* = 4.85) and cannot shift from eating meat to eating marine plants and grasses (*M* = 1.73*;* Table 6). There was a statistically significant difference between Cape Town and Durban in the surfers answers to whether the abundance of sharks close to shore in the area is constant year-round (Table 6). In Cape Town, this statement would be incorrect, whereas it would be correct in Durban. Thus, a difference would be expected. However, a mean score of 2.49 from Cape Town suggests the surfers mildly disagreed, and 3.15 from Durban suggests the surfers neither agreed nor disagreed, so both were not confident in their answers.

The surfers mostly disagreed that people are bitten by sharks in South Africa more than 18 times a year (*M* = 1.98; Table 6), which is correct. The average number of shark bites in South Africa per year is six. A score of 1.98 suggests the surfers were reasonably confident disagreeing with this statement, but do not strongly disagree. The surfers showed good knowledge on whether all shark species are dangerous to humans (*M* = 1.27; largely strongly disagree) and some are more dangerous than others (*M* = 4.17; largely agree).

There was a statistically significant and substantial difference in respondents' feeling of safety between Durban and Cape Town ($t(390) = 3.083$, $p = 0.002$) with surfers from Durban having a greater feeling of safety than those in Cape Town (*M* = 4.08 and *M* = 3.69 respectively).

Table 6: Proportion of surfers' answers to each question about shark ecology and human-shark conflict, and mean scores for each question for all surfers, Cape Town surfers, and Durban surfers. Questions were asked on a scale between 1 and 5: 1 - Strongly Disagree (SD), 2 - Disagree (D), 3 - Neither (NE), 4 - Agree (A) and 5 - Strongly Agree (SA). Statistical significance derived from independent sample t-tests denoted by * (α < 0.05 *; α < 0.01 **, α < 0.001 ***).

Q	**Knowledge of sharks**	**% Frequency of responses on scale (all surfers; n=401)**					**Mean scores (SD)**		
		SD	**D**	**NE**	**A**	**SA**	**All (n=401)**	**Cape Town (n=271)**	**Durban (n=130)**
1	Sharks play an important role in the marine ecosystem.	0.2	1.0	2.2	6.7	89.5	4.85 (0.52)	4.83 (0.56)	4.89 (0.40)
2	Sharks can shift from eating meat to eating marine plants and grasses.	58.9	14.2	16.7	4.2	2.5	1.73 (1.06)	1.78 (1.07)	1.63 (1.03)
3	Sharks spend most of their time in deep waters (more than 50m depth).	16.2	22.4	18.5	31.9	8.7	2.94 (1.26)	3.05 (1.22) *	2.73 (1.31) *
4	Sharks often swim near beaches.	2.7	20.2	17.0	34.7	23.7	3.57 (1.14)	3.44 (1.11) ***	3.86 (1.16) ***
5	The abundance of sharks close to shore in this area is constant year-round.	21.4	27.7	17.5	20.9	10.5	2.71 (1.31)	2.49 (1.24) ***	3.15 (1.34) ***
6	Sharks only bite because they mistake people for seals.	3.5	15.0	11.2	42.9	25.4	3.73 (1.11)	3.80 (1.07)	3.60 (1.18)
7	People are frequently bitten by sharks in South Africa (i.e. more than 18 bites per year).	40.4	31.2	13.5	10.5	1.5	1.98 (1.06)	2.00 (1.10)	1.96 (0.98)
8	Sharks pursue people as prey.	64.3	20.4	6.0	4.5	2.7	1.58 (0.99)	1.60 (0.98)	1.55 (1.02)
9	All shark species present a danger to humans.	82.0	8.2	2.2	1.7	2.0	1.27 (0.78)	1.27 (0.78)	1.26 (0.77)
10	Some shark species are a greater threat to humans than others.	7.0	4.5	4.0	32.2	50.1	4.17 (1.17)	4.11 (1.16)	4.28 (1.18)
11	I feel safe from a shark bite at this beach.	4.2	12.7	13.2	33.7	33.9	3.82 (1.17)	3.69 (1.11) **	4.08 (1.24) **

The variables used to create the ‘knowledge about sharks’ scale were Q1, Q2, Q4, Q6, Q7, Q9, and Q10 (Table 6). The lowest possible knowledge score was 7, and the highest 35. Results showed that the lowest knowledge score was 18 (39.3%) and only one surfer scored 35 (100% correct). The average score was 21 (75%). Of the three non-overlapping knowledge groups (lowest, middle, and highest knowledge comprising the categorical ‘knowledge about sharks’ scale), there was no statistically significant difference in knowledge about sharks between Cape Town and Durban ($\chi 2$ (2, n = 401) = 5.908, p = 0.052). However, Durban had a higher frequency of surfers in the highest knowledge group (36.2%) compared with Cape Town (26.2%), and Durban had a lower frequency in the lowest knowledge group (20.8%) compared with Cape Town (30.3%).

4.4 Risk perceptions

There was no significant difference in perception of different risks between Cape Town and Durban surfers (Table 7). Being in a car accident was the most highly perceived risk (M = 2.98), a moderate risk. Being in disasters such as nuclear accidents or chemical spills were the lowest perceived risks (M = 1.45), no-to-slight risk. The surfers perceived encountering a shark (M = 2.23) as riskier than being bitten by a shark (M = 1.73).

Table 7: Proportion of the surfers' answers to each risk perception question, and mean scores for each question for all surfers, Cape Town surfers, and Durban surfers. Questions were asked on a scale between 1 and 4: 1 - No Risk (NR), 2 - Slight Risk (SR), 3 - Moderate Risk (MR), and 4 - Extreme Risk (ER).

Q	Risk	% Frequency of responses on scale (all surfers; n=401)				Mean scores (SD)		
		NR	SR	MR	ER	All (n=401)	Cape Town (n=271)	Durban (n=130)
1	Being in a car accident	2.7	19.7	53.4	23.4	2.98 (0.74)	2.93 (0.76)	3.09 (0.71)
2	Being in other accidents (e.g. fall, get knocked out, bit by a dog)	8.5	39.2	38.7	9.2	2.51 (0.79)	2.56 (0.78)	2.41 (0.80)
3	Being in a natural disaster (e.g. earthquake, hurricane, tsunami, cyclone)	55.1	34.7	6.0	1.5	1.53 (0.68)	1.56 (0.71)	1.45 (0.61)
4	Being in other disasters (e.g. nuclear accident, chemical spill)	59.1	29.7	4.2	1.5	1.45 (0.66)	1.48 (0.69)	1.39 (0.58)
5	Getting a potentially life-threating disease or illness	13.5	43.4	34.3	6.0	2.34 (0.79)	2.36 (0.77)	2.29 (0.83)
6	Encountering a shark while in the water.	17.7	48.1	23.4	8.2	2.23 (0.84)	2.19 (0.78)	2.31 (0.95)
7	Being bitten by a shark while in the water	39.2	48.1	7.2	2.7	1.73 (0.72)	1.75 (0.72)	1.68 (0.72)

The variables listed in Table 7 were combined into two new combined variables, namely shark risks (Q6 and Q7) and other risks (Q1-5), and there were no significant differences between how surfers from Durban and Cape Town perceived shark risks ($t(227.9) = 0.411$, $p = 0.661$) or how they perceive other risks ($t(392) = -1.051$, $p = 0.294$). However, there was a small, but statistically significant difference between how surfers perceived shark risks compared with other risks ($t(391) = -7.715$, $p < 0.001$) with other risks perceived as higher ($M = 2.17$) than shark risks ($M = 1.98$).

As risk sensitivity increases (i.e., three groups from the cluster analysis), so too does the perception to shark risk and other risks (Table 8), and differences between risk sensitivity groups were statistically significant. Both the Scheffe and Tamhane post-hoc tests revealed statistically significant differences between all three risk sensitivity groups for both risk indices (Table 8). Based on Vaske's (2008) classification, the differences between the lowest and medium, and medium and highest risk sensitivity groups for perceptions of shark risks were typical (>0.3); and between the lowest and highest groups were substantial (>0.5). Furthermore, the differences in perceptions of other risks among all three risk sensitivity groups were substantial.

Table 8: Results of one-way ANOVAs between risk sensitivity and surfers' perception of shark risk and other risks. The F-statistic, p value and Eta-squared are also given. The results of a Tamhane test on shark risks found statistically significant differences between all three risk sensitivity groups (denoted by [a], [b], and [c]). The results of a Scheffe test on other risks found statistically significant differences between all three risk sensitivity groups (denoted by [a], [b], and [c]).

	Risk sensitivity					
	Low	Medium	High	F	p	Eta
Shark risks	1.7738[a]	2.2208[b]	2.6112[c]	92.211	< 0.001	0.876
Other risks	1.1810[a]	2.0230[b]	3.0286[c]	639.937	< 0.001	0.567

4.4.1 Multiple Linear Regression Model: All respondents

Based on the multiple linear regression model and backward elimination selection, six variables were removed from the full model, leaving three in the final model examining predictors of perceptions of shark risks (Table 9; $F(6,511) = 22.44$, $p < 0.001$, $R^2 = 0.209$). Perception to other risks was the most statistically significant predictor of perception to shark risk. For every increase in perception to other risks by one, perception to shark risks increases by 0.590. Biocentric shark index and beach activity both remained in the model. Although not statistically significant ($p > 0.05$), biocentric shark index was nearly significant, and there was also a near-significant relationship between surfers and swimmers in their perception of shark risk. The effect of the biocentric shark index on shark risk perception is small, with shark risk perception declining only by 0.091 for every increase by one in respondents' biocentric shark index. Swimmers perceive shark risk lower than surfers by 0.177.

Table 9: Multiple linear regression model for perception of shark risks for all respondents. Statistically significant results are denoted by * (α < 0.001 ***). Standard error, t-statistic and p-value are also given. Indented explanatory variables were removed using backward stepwise elimination when α = 0.1. Different categories for categorical variables are also indented below their variable name. The removed variables are listed in the table in the order they were removed. The non-indented variables represent my final model. Knowledge of sharks groups were coded as: 1 – lowest, 2- moderate, 3 – high. Activity groups were coded as: 1 – surfer, 2 – stand-up paddle boarder, 3 – kayaker, 4 – swimmer, 5 – scuba diver.

Response	**Explanatory**	**Coefficient**	**SE**	**t-Statistic**	**p**
Shark risks	Other risks	0.590	0.054	10.913	< 0.001 ***
	Biocentric shark index	-0.091	0.048	-1.908	0.057
	Activity				
	1-2	0.116	0.141	0.821	0.924
	1-3	-0.317	0.373	-0.850	0.915
	1-4	-0.177	0.068	-2.604	0.071
	1-5	0.760	0.457	1.663	0.046
	2-3	-0.432	0.396	-1.093	0.810
	2-4	-0.293	0.149	-1.962	0.286
	2-5	0.645	0.476	1.355	0.657
	3-4	0.140	0.376	0.371	0.996
	3-5	1.077	0.588	1.831	0.357
	4-5	0.938	0.460	2.038	0.249
	Gender				
	M-F	0.064	0.086	0.749	0.734
	M-NB	0.174	0.662	0.263	0.963
	F-NB	0.110	0.666	0.165	0.985
	Knowledge of sharks				
	1-2	-0.027	0.091	-0.301	0.951
	1-3	0.051	0.095	0.534	0.855
	2-3	0.078	0.084	0.923	0.626
	Surfboard length	0.012	0.025	0.476	0.635
	Age	-0.003	0.002	-1.188	0.235
	Site	0.083	0.060	1.383	0.167
R^2	0.209	**Adjusted R^2**	0.199		
F	22.44 ***				

There is a positive, linear relationship between perception of shark risk and perception of other risks (Figure 1A). Respondents who perceive shark risk highly, also perceive other risks highly. Perception of shark risk remains low (<3, moderate risk), even when perception to other risk increases above 3.5 (extreme risk). The biocentric shark index has limited effect on perception of shark risk, shown in Figure 1C by the limited range of the y-axis. Figure 1B shows that the difference between swimmers and surfers in perception to shark risk is small.

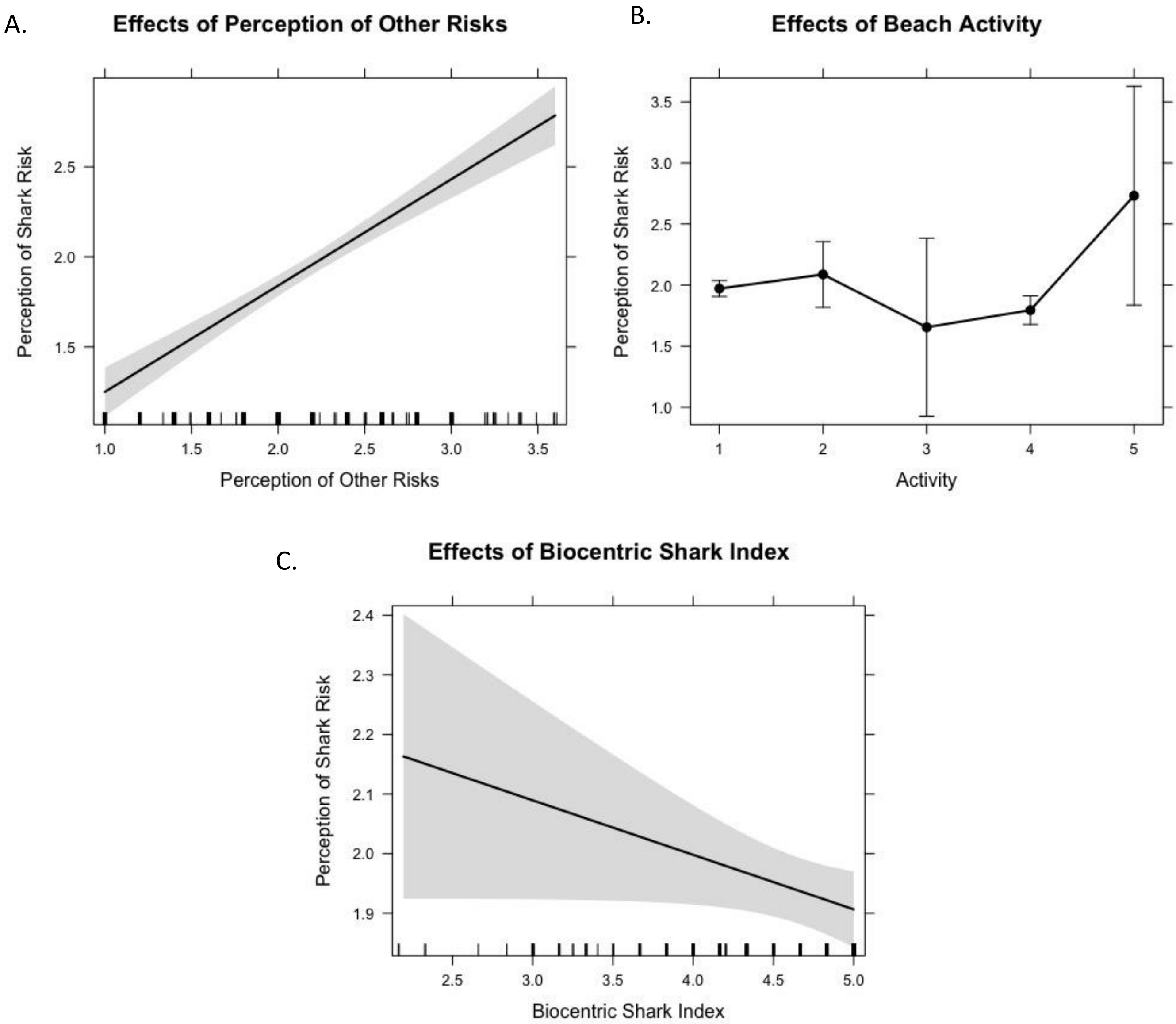

Figure 1: The effects of the statistically significant predictors from a multiple linear regression model on the response variable: perception to shark risk. Part A shows the effect of perception to other risks; Part B shows the effects of Beach Activity where Activity was coded as: 1 – surfer, 2 – stand-up paddle boarder, 3 – kayaker, 4 – swimmer, 5 – scuba diver. (B). Part C shows the effect of the Biocentric Shark Index. Perception to other risks was statistically significant at $p < 0.001$.

4.4.1 Multiple Linear Regression Model: Durban respondents

Based on the multiple linear regression model and backward elimination selection, five variables were removed from the full model, leaving four in the final model on perception of shark risk (Table 10; $F(8,154) = 6.823$, $p < 0.001$, $R^2 = 0.262$). Three variables that remained were statistically significant: perception to other risks, biocentric shark index and knowledge of sharks. Respondents with a moderate knowledge of sharks perceive the risk by 0.328 less than the lowest knowledge group, denoting a small difference. There is a moderate difference in how Durban respondents perceive other risks compared with shark risks: as perception of shark risk increases by one, perception of shark risk increases by 0.626.

Neither understanding what drumlines are or how shark nets work were significant predictors of shark risk perception for respondents in Durban, but both showed a positive relationship.

Table 10: Multiple linear regression model for perception of shark risks for Durban respondents only. Statistically significant results are denoted by * ($\alpha < 0.05$ *, $\alpha < 0.01$ **, $\alpha < 0.001$ ***). The indented explanatory variables were removed using stepwise backward elimination when $\alpha = 0.1$. The removed variables are listed in the table in the order they were removed. The non-indented variables represent my final model. Knowledge of sharks groups were coded as: 0 – lowest, 1- moderate, 2 – high. Activity groups were coded as: 1 – surfer, 2 – stand-up paddle boarder, 3 – kayaker, 4 – swimmer.

Response	Explanatory	Coefficient	SE	t-Statistic	p
Shark risk	Other risks	0.626	0.124	5.066	< 0.001 ***
	Biocentric shark index	-0.267	0.116	-2.321	0.022 *
	Knowledge of sharks				
	0-1	-0.328	0.138	-2.374	0.049 *
	0-2	-0.091	0.145	-0.627	0.805
	1-2	0.238	0.132	1.800	0.173
	Activity				
	1-2	0.427	0.304	1.405	0.626
	1-3	-0.560	0.711	-0.789	0.934
	1-4	-0.289	0.126	-2.288	0.154
	1-5	1.598	0.709	2.256	0.165
	2-3	-0.987	0.771	-1.280	0.704
	2-4	-0.716	0.309	-2.314	0.146
	2-5	1.171	0.762	1.536	0.541
	3-4	0.271	0.715	0.379	0.996
	3-5	2.159	0.997	2.164	0.199
	4-5	1.888	0.709	2.663	0.064
	Gender				
	M-F	0.096	0.249	0.385	0.922
	M-NB	-0.031	0.697	-0.045	0.999
	F-NB	-0.127	0.722	-0.176	0.983
	Age	-0.005	0.005	-0.923	0.358
	Nets correct	0.234	0.186	1.259	0.211
	Board length	0.041	0.043	0.955	0.342
	Drumlines correct	0.041	0.125	0.332	0.740

R^2	0.262	**Adjusted R^2**	0.223
F	6.823 ***		

Figure 2 shows the effects of the variables retained in the final Durban model on perception of shark risk. In Figures 2B and 2C, shark risk remains relatively low (between 1: no, and 3: moderate risk). The more biocentric respondents' perception of sharks is, the lower they perceive shark risk, although the difference in shark risk perception is small. The moderate knowledge group has the lowest perception of shark risk, and the lowest knowledge group has the highest.

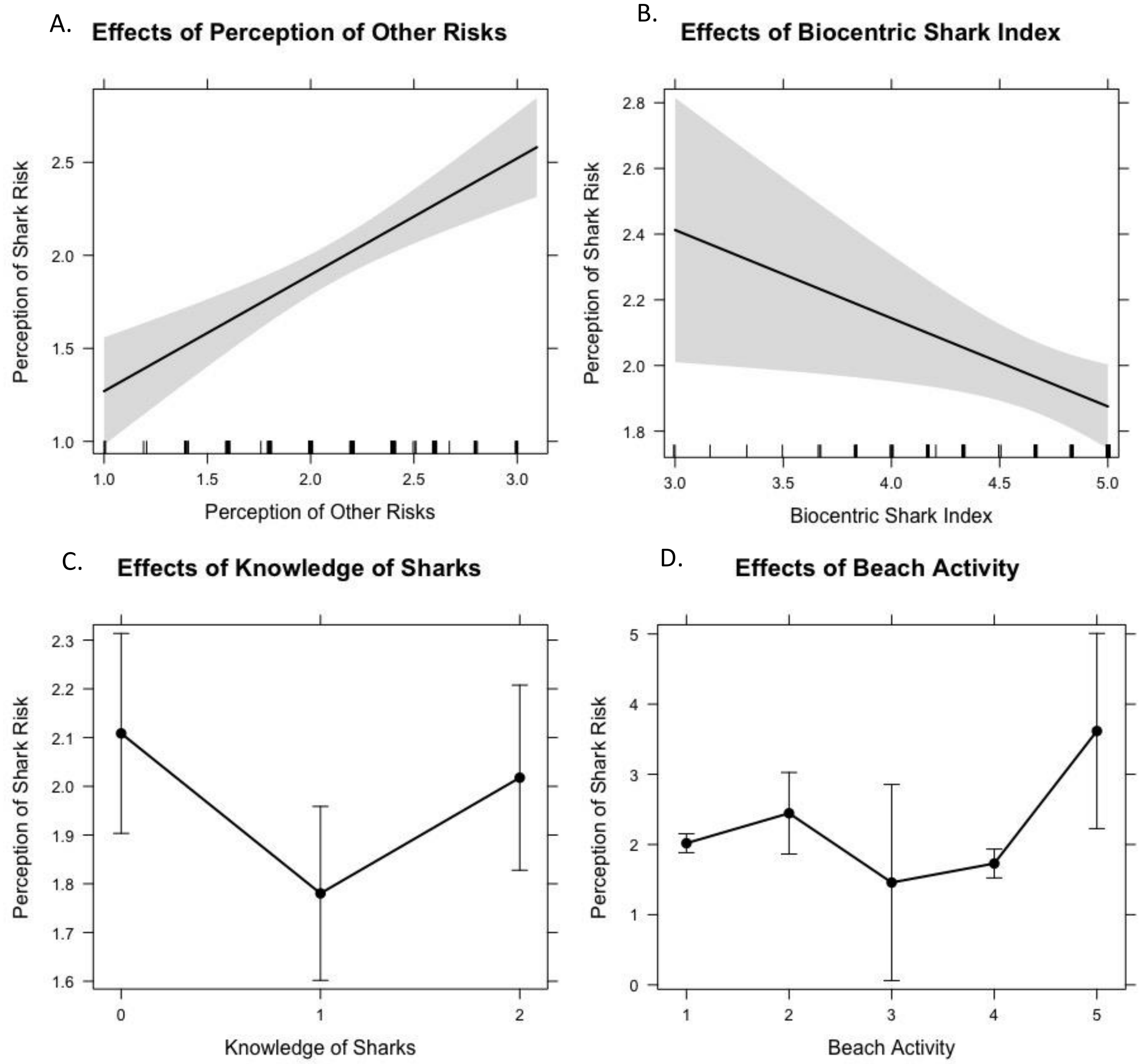

Figure 2: Effects plots of predictors of the final multiple linear regression model of Durban respondents. Knowledge of sharks groups were coded as: 0 – lowest, 1- moderate, 2 – high. Activity groups were coded as: 1 – surfer, 2 – stand-up paddle boarder, 3 – kayaker, 4 – swimmer. Perception to other risks was a statistically significant predictor of perception of shark risk at $p < 0.001$ (A). Biocentric shark index (B) and knowledge about sharks (C) were statically significant at $p < 0.05$.

4.5 Understanding of lethal shark control

Of all respondents surveyed, 48 (8.3%) correctly identified that shark nets reduce shark risk by catching and/or killing sharks (28 (7.6%) from Cape Town; 20 (9.8%) from Durban). The difference between the sites was not significant ($\chi2$ (1, n = 489) = 0.105, p = 0.746). There was no difference between sites ($\chi2$ (1, n = 346) = 1.904, p = 0.164) in the number of surfers who understood the function of shark nets with only 19 (7.0%) in Cape Town and 14 (10.8%)

in Durban answering the question correctly (total: n = 33, 8.2%). Furthermore, significantly more ($\chi2$ (1, n = 489) = 19.552, p < 0.001) respondents from Cape Town (n = 101, 33.0%) thought that shark nets function by forming a barrier to sharks, compared with Durban (n=28, 15.3%). This difference was apparent for surfers only with 34.7% (n = 106) of Cape Town surfers and 14.9% (n = 27) of Durban surfers describing the nets as physical barriers ($\chi2$ (1, n = 346) = 16.465, p < 0.001). More respondents believed that shark nets form a barrier to sharks than know shark nets are a killing device ($\chi2$ (1, n = 489) = 31.232, p < 0.001). This result was similar when analysed by site (Durban: $\chi2$ (1, n = 183) = 6.696, p = 0.010; Cape Town: $\chi2$ (1, n = 306) = 24.705, p < 0.001).

Only 37.1% of Durban respondents understood that the function of drumlines is to attract, catch and kill large sharks. There was no significant difference in the proportion of Durban respondents who understood the function of both drumlines and of nets: $\chi2$ (1, n = 174) = 2.192, p = 0.139.

4.6 Support for human-shark conflict interventions

Shark Spotters was the most supported intervention among all the surfers, with 55.6% of the surfers strongly supporting the measure and the highest mean score for all respondents and for both sites (Table 11). Gill nets were the least supported option with a mean score of 1.31 and 82.8% of respondents strongly opposing them. There was a significant difference between support for Shark Spotters and support for shark nets, the two main interventions used in the South Africa (t(386) = 49.457, p < 0.001).

Q1-7 in Table 11 are interventions that are not lethal to sharks, whereas items 8-10 are lethal to sharks. The mean scores are all higher for Q1-7, than for Q8-10, where mean scores drop below 1.5 for all the surfers suggesting that, overall, the surfers strongly disagreed with these lethal interventions. Significant differences between study sites were apparent with, for example, more support for drumlines and shark nets in Durban than in Cape Town: drumlines (t(175.6) = 4.029, p < 0.001) and gill nets (t(208) = 2.294, p = 0.023). There was also more support for Shark Spotters in Cape Town than Durban (t(385) = -2.110, p = 0.036; Table 11).

Table 11: Proportion of surfers' answers to what extent they support different human-shark conflict interventions, and mean scores for each question for all surfers, Cape Town surfers, and Durban surfers. Questions were asked on a scale between 1 and 5: 1 - Strongly Oppose (SO), 2 - Oppose (O),

3 - Neither (NE), 4 - Support (S) and 5 - Strongly Support (SS). Statistical significance derived from independent-tests denoted by * * ($\alpha < 0.05$ *; $\alpha < 0.01$ **, $\alpha < 0.001$ ***).

Q	Intervention	% Frequency of responses on scale (all surfers; n=401)					Mean scores (SD)		
		SO	O	NE	S	SS	All (n=401)	Cape Town (n=271)	Durban (n=130)
1	Heat sensor cameras	7.7	6.5	23.2	33.9	25.7	3.65 (1.17)	3.62 (1.14)	3.73 (1.24)
2	A shark spotter programme	0.7	2.5	7.2	30.4	55.6	4.43 (0.80)	4.48 (0.78) *	4.30 (0.84) *
3	Personal electric shark repellent devices	19.0	17.5	20.9	23.7	15.2	2.99 (1.36)	2.74 (1.32) ***	3.50 (1.32) ***
4	'Cryptic' wetsuits	10.7	10.5	26.4	29.2	19.2	3.37 (1.24)	3.32 (1.25)	3.48 (1.19)
5	Permanent shark exclusion nets	33.9	26.2	17.0	13.0	6.5	2.29 (1.26)	2.17 (1.23) **	2.55 (1.29) **
6	Shark exclusion nets that are removed each night	20.2	20.4	13.7	25.4	16.5	2.97 (1.42)	3.02 (1.43)	2.95 (1.41)
7	Electric shark deterrent cables	23.9	16.0	17.5	24.2	16.0	2.92 (1.43)	2.61 (1.35) ***	3.58 (1.39) ***
8	Shark hunts	76.1	9.0	5.5	3.2	2.7	1.42 (0.95)	1.42 (0.97)	1.42 (0.91)
9	Drumlines	79.3	6.5	5.7	3.0	2.7	1.39 (0.94)	1.24 (0.77) ***	1.70 (1.17) ***
10	Gill nets	82.8	6.5	4.0	1.7	2.7	1.31 (0.86)	1.24 (0.80) *	1.47 (0.99) *

Knowledge about the function of shark nets correlated negatively with support for their use ($F(1,474) = 4.414$, $p = 0.036$) with support declining by a factor of 0.3 for respondents who correctly identified the purpose of shark nets. Knowledge about shark nets was also a statistically significant predictor of support for temporary exclusion nets ($F(1,466) = 6.388$, p 0.012) with support increasing by 0.544 for respondents who understood how shark nets function. However, knowledge about shark nets was not a statistically significant predictor of support for permanent exclusion nets ($F(1,468) = 0.694$, $p = 0.405$).

Shark Spotters received the most support of all human-shark interventions, and for all risk sensitivity groups (Table 12). Lethal measures received the least support. In general, the highest risk sensitive group was more supportive of all measures than the lower risk groups, with the exception of heat sensor cameras and Shark Spotters. For the Shark Spotters, the moderate risk sensitive group showed the most support ($M = 4.53$) and the most risk sensitive group showed the least support ($M = 4.28$). There were statistically significant differences between groups for support of Shark Spotters, and the three lethal measures. The most risk sensitive people were more supportive of lethal measures. Statistically significant differences were found between the moderate and highest risk sensitive groups for support for drumlines and gill nets by Tamhane's T2 test and by Games-Howell's test for shark hunts. These differences were between typical and substantial based on Vaske's (2008) classification. Equally, the difference between the moderate and highest groups and the moderate and lowest groups in support for Shark Spotters were between minimal and typical based on Vaske's (2008) classification. The difference between the highest and lowest group for support for Shark Spotters was minimal based on Vaske (2008).

Table 12: Results of an n-way ANOVA between different risk sensitivity groups and their extent of support for different human-shark conflict interventions. The results of post-hoc tests are denoted by superscript letters: different letters signify differences between the means. The variables drumlines and gill nets used Tamhane's T2 test and shark hunts used Games-Howell's test. Neither showed differences for Shark Spotters. Statistical significance levels are denoted by * ($\alpha < 0.05$ *; $\alpha < 0.01$ **, $\alpha < 0.001$ ***).

Interventions	**Risk sensitivity (*M*)**					
	Low	**Moderate**	**High**	**F**	**p**	**Eta**
Heat sensor cameras	3.76	3.56	3.75	1.376	0.254	0.085
Shark Spotters	4.30	4.53	4.28	3.979	0.019 *	0.144
SharkShield	2.95	2.92	3.18	0.932	0.395	0.070
Cryptic wetsuits	3.45	3.27	3.51	1.274	0.281	0.082
Permanent exclusion nets	2.26	2.24	2.57	1.811	0.165	0.098
Temporary exclusion nets	2.82	2.97	3.26	1.925	0.147	0.101
Electric deterrent cables	2.85	2.93	3.00	0.220	0.802	0.034
Shark hunts	1.38^{ab}	1.35^{a}	1.75^{b}	4.595	0.011 *	0.154
Drumlines	1.42^{ab}	1.27^{a}	1.75^{b}	6.823	0.001**	0.186
Gill nets	1.32^{ab}	1.22^{a}	1.64^{b}	6.243	0.002 *	0.78

Furthermore, there was a statistically significant, negative relationship between opposition to lethal shark control and perception of shark risk ($F(1,572) = 14.34$, $p < 0.001$, $R^2 = 0.026$). The less respondents perceive shark risk, the greater their opposition to lethal shark control.

4.7 Conjoint analysis

Of the 401 surfers, only 361 could be used for the conjoint analysis; those excluded had submitted either incomplete responses (e.g., answered some of the scenarios, but not all) or had answered the same response for every scenario. Table 13 shows the utility values generated by the conjoint analysis for each situational factor and its respective levels for each site and for all the surfers. The utility values are averages across the surfers assessing how situational factor levels influence the likelihood of going into the water. The magnitude and sign of the utility values (positive, negative) indicate the relative influence of each factor level on the mean likelihood rating. A positive utility indicates that the situational factor level increased mean likelihood of entering the water (constant + factor level utility); a negative utility shows that the factor level decreased the likelihood (constant - factor level utility). For example, the mean likelihood of all surfers entering the water when there is no shark present would be calculated as: Mean rating = $\beta_{constant} + \beta_{(none\ shark\ presence)}$ = 4.3885 + 1.7154 = 6.1039 (on the p-point scale where 1 = very unlikely and 9 = very likely). Whereas, the mean likelihood of all surfers entering the water if a shark was being seen right now would be calculated as: Total utility = $\beta_{constant} + \beta_{(now\ shark\ presence)}$ = 4.3885 + (-1.7929) = 2.5956. A score below five suggests that surfers were unlikely to go in the water given the scenario presented, whereas above five suggests they were likely to (five is neither / neutral).

Table 13: Mean likelihood ratings and utility values of going in the water for each site by situational factor levels by conjoint analysis. The model goodness of fit statistic is the Pearson's *R* correlation between predicted and observed likelihood ratings. All values were statistically significant at p<0.001.

Factor	**All surfers (n=361)**		**Cape Town (n=246)**		**Durban (n=115)**	
	Averaged Utility	**Mean rating**	**Averaged Utility**	**Mean rating**	**Averaged Utility**	**Mean rating**
Shark presence						
None	1.7154	6.1039	1.6799	5.9350	1.7913	6.4652
Last 24 hours	0.4522	4.8497	0.5132	4.7683	0.3217	4.9956
Last hour	-0.3747	4.0138	-0.3404	3.9147	-0.4478	4.2261
Now	-1.7929	2.5956	-1.8526	2.4025	-1.6652	3.0087
People in the water						
People	0.2943	4.6828	0.3699	4.6250	0.1326	4.8065
No people	-0.2943	4.0942	-0.3699	3.8852	-0.1326	4.5413
Spotting conditions						
Good	0.6482	5.0367	0.6626	4.9177	0.6174	5.2913
Poor	-0.6482	3.7403	-0.6626	3.5925	-0.6174	4.0565
Surf/sea conditions						
Good	1.4072	5.7957	1.4004	5.6555	1.4217	6.0956
Poor	-1.4072	2.9813	-1.4004	2.8547	-1.4217	3.2522
Constant	4.3885		4.2551		4.6739	
Model fit	0.999		1.000		0.997	

Among all surfers were most likely to go in the water if no shark had been seen for the last 24 hours (*M* = 6.1039), there were good conditions to spot sharks (*M* = 5.0367), and good surf/sea conditions (*M* = 5.7957). Results were relatively consistent for both Cape Town and Durban respondents.

If a shark is present or has been seen in the last hour, surfers are far less likely to go in the water, but if a shark has only been seen in the last 24 hours or not at all in the last 24 hours, then surfers are more likely to go in the water. Surfers from Durban are more likely to go in the water than surfers from Cape Town under all shark presence situations.

The effect of surf conditions is slightly greater for Durban surfers compared with Cape Town surfers (±1.4217 and ±1.4004, respectively). However, the effect of whether people are in the water is higher for Cape Town surfers (±0.3699) than Durban surfers (±0.1326), as is the effect of sea/spotting conditions (Cape Town: ±0.6626, Durban: ±0.6174). However, the mean likelihoods of the surfers entering the water under different situational factor levels and the patterns of the effect of these levels are similar between Cape Town and Durban surfers, with the exceptions of “no people” and “poor spotting conditions”, under which Durban surfers are relatively more likely than Cape Town surfers to go in the water.

The relative importance of each situational factor for all the surfers Cape Town and from Durban is displayed in Table 14.

Table 14: Averaged importance (%) of each factor by site.

	All surfers (n=361)	**Cape Town (n=246)**	**Durban (n=115)**
Factor	**Averaged Importance**	**Averaged Importance**	**Averaged Importance**
Shark presence	41.56	42.01	40.60
People in the water	11.58	11.91	10.86
Spotting conditions	15.89	16.58	14.41
Surf/sea conditions	30.97	29.50	34.12

For all the surfers, shark presence was the most important factor related to the likelihood entering the water (41.56%), and this pattern held across sites (Cape Town 42.01% and Durban 40.60%). Surf conditions was the next most important factor (30.97% for all respondents), and whether there were people in the water was the least important factor (11.58%). Surf conditions were slightly more important in Durban than Cape Town (surf conditions: 34.12% and 29.50%, respectively). Conversely, whether people were in the water, spotting conditions, and shark presence were slightly less important in Durban than Cape Town (people in the water: 10.86% and 11.91%, respectively; spotting conditions: 14.41% and 16.58%, respectively; shark presence 40.60% and 42.01%, respectively). However, the overall pattern of ranking importance of the four factors was the same at both sites.

5. Discussion

Perception of shark risks was positively correlated with perceptions of other risks, such as a car crash or natural disaster. Surfers, who historically have a higher incidence of shark bites amongst water users, perceive other risks such as car accidents as having a greater risk than sharks. Moreover, the more surfers' perception to other risks increases, the less their perception to shark risk increases. Therefore, despite the positive correlation, surfers' attribute greater weight to other risks and as such the weight attached to shark risk tends to fall. This suggests surfer perceptions are influenced by frequency data as on average (between 2001 and 2006), there were 4,815 deaths per year attributed to road traffic accidents in South Africa (Lehohla 2009). By comparison, there has been an average of only six shark bites a year (year to year). Natural and other disasters (e.g., nuclear accidents, chemical spills) were perceived as having little to no risk or only a slight risk, and encountering a shark while in the water was perceived as a much higher risk than being bitten by a shark. Together, these results suggest respondents were primarily focussing on the likelihood of each risk happening.

Despite different water conditions, shark species, and shark management, there is no difference in how surfers in Durban and Cape Town perceived shark risk. What is unclear, however, is whether respondent who evaluate their objective or actual risk (e.g. 1 in 1 million) similarly to their subjective perceived risk. By asking respondents to quantify risk, there may have been differences found between Cape Town and Durban. However, there was a significant and reasonable difference in responses to "I feel safe from a shark bite at this beach" between Cape Town and Durban. Both agreed ($3.5 < M < 4.5$), but Durban respondents were stronger in their agreement ($M > 4$). More research is needed to see if the shark management programmes are influencing this result and the risk perceptions at each site, or what other factors could explain this finding.

Another important finding of this study is that there was minimal support for lethal human-shark conflict interventions. Respondents largely agreed with the anti-lethal statements and strongly disagreed with pro-lethal statements and all three common methods of lethal shark control (shark nets, drumlines, shark hunts) were strongly opposed by respondents. Gills nets were the least supported intervention, with 82.8% of surfers strongly opposing this method. Furthermore, Shark Spotters was the most supported intervention in this study, showing that the two primary methods of shark safety management at the study sites were at the opposite ends of the scale in terms of respondent support with significantly more support for Shark

Spotters. Similar results were found in Australia where non-lethal approaches were preferred over lethal approaches by 85% of respondents from Ballina and 78% of respondents from Perth (Pepin-Neff & Wynter 2018a). Together, these and other recent studies suggest a global trend of limited support for lethal shark policies and increasing concern for shark conservation and protecting sharks (Simpfendorfer et al. 2011; McCagh et al. 2015; Pepin-Neff & Wynter 2018a, 2019).

Of great concern is the finding that only 8.3% of the surfers surveyed were aware that the shark nets used in Durban are lethal gill nets, and only 37.1% of respondents from Durban knew what drumlines were. Substantially and significantly more people believe the shark nets form a physical barrier than are a method of culling sharks. This might explain why there is limited public and water user opposition to the use of 'shark nets' in Durban. Respondents who knew that shark nets are in fact lethal gill 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 (Gray & Gray 2017). The same study found that respondents supported the shark nets at their local beaches, but were overwhelmingly against the general culling of sharks. My results also show that respondents were opposed to the general culling of sharks, and thus would presumably be opposed to the use of these 'shark nets' and drumlines in KZN.

The much higher proportion of correct respondents from Durban in their knowledge of drumlines compared to shark nets is likely explained by the media attention surrounding the installation of drumlines (e.g. ZigZag 2019; Govender 2019). In the 1970s, public pressure led to the ban of using poison for wildlife management following protests and adverse media coverage (van Eeden et al. 2017). Following a documentary criticising the captive cetacean industry, 'Blackfish', laws were introduced to phase out captive orca exhibits and SeaWorld, a theme park and oceanarium featured heavily in the documentary, announced it was ending its orca breeding programme (Parsons & Rose 2018). The "Blackfish Effect" is a term used for describing the immense public pressure and subsequent decline in theme park visitors following the release and viewing of the documentary that exposed how cetaceans are treated in captivity and how this may impact on their conservation (Parsons & Rose 2018). Clearly, education through documentaries and media campaigns can change public perceptions ultimately leading to a change in legislation and environmental policies. The poor levels of understanding as to the function of shark nets in Durban and other parts of the world needs to be addressed as a matter of urgency if alternative methods are to be prioritised and the ongoing culling of sharks and other marine organisms is to be reduced.

There was strong opposition to lethal shark control in both Durban and Cape Town with opposition marginally greater in Cape Town. Long term exposure to particular management has been suggested to influence support (Gray & Gray 2017). Thus, Durban respondents could be more accustomed and hence weaker in their opposition to lethal shark management. However, given that more than 90% of respondents were unaware that shark nets are a lethal intervention, this explanation seems unlikely. Rather, it is possible that the familiarity of Cape Town's respondents to successful non-lethal management (e.g., Shark Spotters) that may explain their stronger opposition to lethal management. Knowing the probability of a shark incident is low at beaches with non-lethal management could foster a belief that lethal management is unnecessary and, given the negative ecological impacts, worth opposing. Nevertheless, the difference between Cape Town and Durban in opposition to lethal shark control is small, and the most notable outcome of these findings is there was a clear division between the opinions and beliefs of water users in Durban, and those actively managing sharks. Similar division has been documented in Australia (Gray & Gray 2017), and should be addressed.

Previous research has documented a positive relationship between fear of sharks and support for lethal shark control (Pepin-Neff & Wynter 2018a, 2018b, 2019; Lucrezi et al. 2019). The respondents here showed a similar relationship as, on average, they perceived sharks as only a slight risk (M = 1.98) and were strongly opposed to lethal shark management. Further, perception of shark risk is a significant predictor of opposition to lethal shark control: the lower their risk perceptions of sharks, the more respondents opposed lethal shark control. This finding supports the notion that with less fear of sharks comes less support for lethal management. Moreover, the biocentric shark index was a significant predictor of perception of shark risk, with a positive correlation. Many suspect that negative attitudes towards sharks result from fear (Acuña-Marrero et al. 2018). My results support this through showing the inverse relationship: positive attitudes towards sharks correlate with lower perception of risk. However, support for lethal human-shark conflict mitigation measures (gill nets, drumlines, shark hunts) was lowest for the moderate risk sensitivity group, rather than the lowest; and as risk sensitively increased from moderate to high, support for lethal measures also increased. As the lowest risk sensitivity group did not show the greatest opposition to lethal measures, it cannot be concluded that risk sensitivity increases opposition to lethal shark control. It is unclear why the moderate risk sensitivity group opposes lethal management more so than the others, but the average scores of all three groups still indicated opposition ($M < 2$). These statistically significant differences among risk sensitivity groups were not found for non-lethal measures, except Shark Spotters (support was greatest for the moderate group), suggesting that levels of support were consistent despite risk sensitivity. The differences among risk sensitivity groups for Shark Spotters were between minimal and typical, but were between typical and substantial for the lethal measures. Therefore, risk sensitivity has a greater effect on support for lethal measures than for Shark Spotters. However, although support increases more for lethal measures as risk sensitivity changes, support for lethal measures remains well below support for non-lethal measures.

Respondents having a strong opposition to lethal shark control coupled with a low perception of shark risk suggest they might think the risks do not outweigh the threat to shark conservation. Similar findings were reported by Pepin-Neff and Wynter (2018a) with residents of Ballina in Australia identifying the primary purpose of shark nets as a method for calming the public and hence protecting tourism rather than as a method to protect the public from sharks. Alternatively, respondents who perceive shark risk as low may not consider lethal control as necessary and thus although their response towards lethal control may be a significant predictor of risk perceptions associated with sharks, it may not be a direct cause of the relationship. During the 1960s, the prevailing assumption in the literature was that if people perceived high likelihood of adverse events occurring, they were more likely to support or take measures themselves to minimise or prevent such events (O'Connor et al. 1999). Thus, since respondents in this study perceived shark bites to be unlikely, it is possible they do not support lethal control because they may not see it as a necessary precaution. Furthermore, respondents strongly disagreed that lethal policies keep water users safer than non-lethal policies. If people do not feel that lethal shark control contributes to their safety, then arguably the use of lethal management is not necessary, which might reflect the limited support.

Respondents who understood the goal of shark nets were less likely to support their use, and more likely to support exclusion nets that are removed each night to prevent by-catch. Lethal shark control programs, and particularly shark nets, have been heavily criticised in the past due to their lack of selectivity and have been encouraged to reduce by-catch (Paterson 1990; Sumpton et al. 2010; Cliff & Dudley 2011). Drumlines are designed specifically to reduce the impacts on non-target species while still removing large sharks. However, opposition to drumlines has been clearly documented in the past (Meeuwig 2014; Meeuwig & Bradshaw 2014; McCagh et al. 2015; ZigZag 2019) and this opposition centres around killing sharks. Neither correct knowledge of what drumlines are nor how shark nets work to reduce shark risk were statistically significant predictors of perception of shark risk for Durban respondents. These findings contest the argument that lethal management is necessary to enable water users to feel safe, as knowledge of lethal management does alter risk perception of sharks.

Overall, surfers in this study had excellent knowledge of sharks and a good understanding that sharks play an important role in the marine ecosystem. Similar results have been obtained in other parts of the world (Friedrich et al. 2014; Garla et al. 2015; Lucrezi et al. 2019). A good knowledge of sharks has been shown to be positively associated with support for shark conservation (Tsoi et al. 2016). Shark conservation depends on the ability of the scientific community to communicate to the public the importance of sharks in marine ecosystems, as this understanding promotes a positive perception of sharks, leading to increased support for their conservation (Simpfendorfer et al. 2011; Garla et al. 2015). A greater proportion of Durban respondents were in the top knowledge group compared with Cape Town respondents, indicating respondents from Durban had slightly more knowledge about sharks, although no statistically significant difference was found. Neither surfers from Cape Town nor Durban were confident as to whether shark abundance inshore varies seasonally. In Cape Town, sharks mainly visit the inshore during the summer months (Kock et al. 2018), whereas in Durban the tiger shark population in the area is relatively constant year round (Wintner & Kerwath 2017). Cape Town respondents did disagree with the statement, but only mildly. These results identify a gap in public knowledge for shark safety management and educators to target. Durban surfers neither agreed nor disagreed, which either indicates the respondents did not know, or they correctly identified that sharks are consistently close to shore. It is important that surfers are aware of shark risk, including when the shark risk is highest (i.e., summer in Cape Town). Overall, the knowledge demonstrated by the respondents in this study is reassuring for shark conservation in South Africa.

A negative perception of sharks can hamper conservation efforts (Neff & Yang 2013; Garla et al. 2015) and consequently the finding that respondents in this study had a positive and biocentric perception of sharks is important for their future management and conservation. These findings support the growing evidence that public perceptions of sharks may be shifting away from the traditional negative view centred around fear, to a more positive view (Gibbs & Warren 2014; Pepin-Neff & Wynter 2018b, 2019; Lucrezi et al. 2019). For example, the statement “Protecting sharks is a waste of time, as we should be protecting people’s jobs instead” received a mean score below 1.5 indicating unanimous disagreement. However, for the statement, “The needs of humans are more important than the needs of sharks”, the mean score was 2.11 revealing weaker disagreement. This suggests respondents were not comfortable directly comparing humans and sharks. A study that used similar statements to measure value orientations towards coral reefs also showed that respondents were less strong in their opinions when directly comparing coral reefs and human needs (Needham 2010).

The conjoint analysis revealed that shark presence was the most important factor influencing surfers' decisions to enter the water. Conjoint analysis accounts for the multi-attribute complexity in decision making and recognises that multiple situational factors influence decisions (Needham & Szuster 2011). The situational factors used in this study relate to human safety and/or recreational water use.

The effect of shark presence was only high for two situational factor levels: when a shark is being seen right now (highest), or there is no shark (second). Surfers were somewhat unlikely to go in the water for all shark presence situational levels other than if no shark has been seen for 24 hours. However, for two situational levels of shark presence, namely a shark seen in the last hour or last 24 hours, both surf conditions and spotting conditions had a greater effect on surfer decisions to go in the water. Thus, although shark presence was the most influential factor, surf conditions were not far behind. Furthermore, unless a shark is being seen right now, with good surf conditions and good spotting conditions people will go in the water regardless of how recently a shark has been seen. These findings contradict the longstanding argument in favour of lethal management – that people would not go in the water if there is a risk of encountering a shark.

Shark presence was slightly more important in influencing surfer decisions to go in the water in Cape Town than in Durban. Although, in total, KZN has experienced more shark bite incidents than the Western Cape (Shark Spotters 2019), Cape Town has experienced more shark bite incidents in recent years than Durban, which could be explain this result. Different shark species and/or different shark management strategies may also be influencing the differences, but it is unclear based on these results and more research would be needed to explain these differences. In Durban, surf conditions were more influential for surfers deciding whether to go in the water than in Cape Town, whereas spotting conditions were slightly more important in Cape Town. This is likely to be because of the established Shark Spotter programme. Spotting conditions are indicated by the green and black flags. Being made aware of these conditions prior to getting in the water is more likely to put them on surfers' minds, and thus makes them more likely consider them when deciding whether to go in the water. Furthermore, the success of the Shark Spotters programme relies on their ability to spot sharks, which is enhanced with good conditions. However, as discussed previously, bull sharks favour turbid water. As bull sharks inhabit South African waters in Durban, but not in Cape Town, it would be expected that spotting conditions, which includes water turbidity, would be an important consideration for surfers in Durban. As this was not the case, it suggests that some of these surfers are unaware of the hunting behaviours of bull sharks. This is something that could be addressed by shark management in the area to ensure that water users are briefed on what conditions could be indicative of greater risk or more shark activity. Whether there were people in the water was the least important factor influencing surfer decisions to go in the water, but they showed a slight preference for having people versus no people. This preference for having people around could reflect a sense of safety in numbers.

6. Conclusions and Recommendations

This study of active recreational water users (those who had entered the water on the day of being surveyed) in Cape Town and Durban revealed that neither the presence nor perceived risk of a shark incident deters them from entering the sea. Encouragingly, these water users in South Africa do not perceive sharks to pose a high risk and substantially less risk than for some other risks such as car accidents. This result, in addition to a good understanding of shark biology and behaviour, may explain the strong opposition to lethal shark control among the respondents.

One of the most alarming results in this study was that 90.2% of respondents in Durban were unaware that shark nets are a lethal shark management intervention. It is not clear whether this is the result of a deliberate communication strategy on behalf of the relevant authorities and the KZN sharks board or simply an absence of effective communication between the public and wildlife managers. However, there is an urgent need for the public to be informed as to the true ecological cost and goal of shark nets. Given that this study provides strong evidence that Cape Town and Durban water users strongly oppose lethal management of sharks, it is likely that exposing the lethal shark control currently used by the KZNSB will result in them facing a serious public backlash.

Although respondent knowledge about sharks, particularly their ecological importance, was impressive, it was nevertheless apparent that important gaps such as seasonal patterns of risk need to be addressed moving forward.

Overall, understanding how people perceive sharks and risks from this species is an important aspect of shark safety management and shark conservation. Water users are a key stakeholder in shark safety management, so understanding their perspective is important. The findings of this study may influence shark management in South Africa by demonstrating that water users strongly favour non-lethal approaches perhaps because they are largely unafraid of sharks.

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8. Appendix

Appendix 1: Variables used to create the 'Knowledge of Sharks' variable

Incorrect variables were reverse-coded so that all variables were projecting in the same direction: the higher the score, the better the knowledge of sharks of the respondent.

Variable	Answer
Sharks play an important role in the marine ecosystem.	Correct
Sharks can shift from eating meat to eating marine plants and grasses.	Incorrect
Sharks often swim near beaches.	Correct
Sharks only bite because they mistake people for seals.	Incorrect. To say sharks only bite people for this reason would be false.
People are frequently bitten by sharks in South Africa (i.e. more than 18 bites per year).	Incorrect. On average, there are six shark bites in South Africa per year.
All shark species present a danger to humans.	Incorrect
Some sharks species are a greater threat to humans than others.	Correct

Appendix 2: The questionnaire.

The questionnaire used for water users in Durban. The only questions different in Cape Town were Q16 and Q17, which were replaced by questions related to the Shark Spotters programme. These questions were not analysed in this thesis.

Your Opinions About Sharks Near Durban

We are conducting this survey to learn about you and your opinions about sharks and their management. Your input will assist managers. Participation is voluntary and responses are confidential. ***Please complete this survey and return it to the researcher***.

1. Which ***ONE*** of the following best describes the main activity that you are doing today? **(check *ONE*)**

   ☐ Surfer ☐ Paddle boarder ☐ Kayaker ☐ Swimmer ☐ Scuba diver

2. How would you rate your skill level in this activity? **(check *ONE*)**

   ☐ Beginner ☐ Intermediate ☐ Advanced ☐ Professional ☐ Instructor

3. In total, about how many ***days*** have you participated in this activity ***in the last 12 months***? **(write response)** ________ day(s)

4. In total, about how many ***years*** have you participated in this activity ***in your life***? **(write response)** ________ year(s)

5. Which ***ONE*** of the following best describes your level of involvement in this activity? **(check *ONE*)**

   ☐ This is an enjoyable, but infrequent activity that is incidental to my other outdoor interests. I am not highly skilled in this activity, rarely read articles about this activity, and do not own much equipment beyond the basic necessities.

   ☐ This activity is an important, but not exclusive outdoor activity. I sometimes read articles about this activity and purchase additional equipment, occasionally participate in this activity, and am moderately skilled in this activity.

   ☐ This is my primary outdoor activity. I purchase ever-increasing amounts of equipment for this activity, participate every chance that I get, consider myself to be highly skilled, and frequently read articles about this activity.

6. In total, about how many ***days*** have you visited this beach area ***in the last 12 months***? **(write response)** ________ day(s)

7. In total, about how many ***years*** have you been visiting this beach area ***in your life***? **(write response)** ________ year(s)

8. While in the water, do you typically stay within the breakers (i.e., where waves are breaking)? **(check *ONE*)** ☐ No ☐ Yes

9. While in the water, do you typically stay close to other people (i.e., within 5m)? **(check *ONE*)** ☐ No ☐ Yes

10. How much risk do you perceive with each of the following happening to you during your life? **(circle one number for *EACH*)**

	No Risk	Slight Risk	Moderate Risk	Extreme Risk
Being in a car accident.	1	2	3	4
Being in other accidents (e.g., fall, get knocked out, bit by a dog).	1	2	3	4
Being in a natural disaster (e.g., earthquake, tsunami, cyclone).	1	2	3	4
Being in other disasters (e.g., nuclear accident, chemical spill).	1	2	3	4
Getting a potentially life-threatening disease or illness.	1	2	3	4
Encountering a shark while in the water.	1	2	3	4
Being bitten by a shark while in the water.	1	2	3	4

11. Have you ever seen a large shark (i.e., longer than 3m) while you were in the water? **(check *ONE*)** ☐ No ☐ Yes ☐ Unsure

12. Do you disagree or agree with each of the following statements? **(circle one number for *EACH*)**

	Strongly Disagree	Slightly Disagree	Neither	Slightly Agree	Strongly Agree
Sharks play an important role in the marine ecosystem.	1	2	3	4	5
Sharks can shift from eating meat to eating marine plants / grasses.	1	2	3	4	5
Sharks spend most of their time in deep waters (more than 50m depth).	1	2	3	4	5
Sharks often swim near beaches.	1	2	3	4	5
The abundance of sharks close to shore in this area is constant year-round.	1	2	3	4	5

13. Do you disagree or agree with each of the following statements? **(circle one number for *EACH*)**

	Strongly Disagree	Slightly Disagree	Neither	Slightly Agree	Strongly Agree
Sharks only bite because they mistake people for seals.	1	2	3	4	5
People are frequently bitten by sharks in South Africa (i.e., more than 18 bites per year).	1	2	3	4	5
Sharks pursue people as prey.	1	2	3	4	5
All shark species present a danger to humans.	1	2	3	4	5
Some shark species are a greater threat to humans than others.	1	2	3	4	5
I feel safe from a shark bite in the water at this beach.	1	2	3	4	5

14. What conditions do you check ***before*** coming to the beach? **(check *ALL THAT APPLY; for "Other," write response*)**

☐ Swell ☐ Wind ☐ Shark activity ☐ Lifeguard on duty ☐ Water temperature ☐ Other ______________

15. How do you think shark nets used in the Durban area reduce the risk of a shark bite? **(write response)** ____________________

16. What do you think drumlines are? **(write response)**

____

17. Do you disagree or agree with each statement about shark nets used in the Durban area? **(circle one number for *EACH*)**

	Strongly Disagree	Slightly Disagree	Neither	Slightly Agree	Strongly Agree
Only large sharks (i.e., longer than 3m) are caught in shark nets.	1	2	3	4	5
Shark nets are the most effective form of preventing shark bites.	1	2	3	4	5
Drumlines (baited buoys to catch and kill sharks) are better for the environment than shark nets.	1	2	3	4	5
Shark nets extend from the top of the sea down to the sea floor, preventing sharks from entering the area between the nets and beach.	1	2	3	4	5
Other animals (e.g., whales, turtles) are caught in the shark nets.	1	2	3	4	5
Animals found caught in the shark nets are released alive.	1	2	3	4	5

18. If there were ***no*** nets or drumlines present would you go in the water? **(check *ONE*)** ☐ No ☐ Yes ☐ Unsure

19. Do you oppose or support each of the following strategies for reducing shark bites? **(circle one number for *EACH*)**

	Strongly Oppose	Slightly Oppose	Neither	Slightly Support	Strongly Support
Heat sensor cameras to detect sharks moving close to water users.	1	2	3	4	5
A shark spotter programme with flags indicating spotting conditions and level of shark risk.	1	2	3	4	5
Personal electric shark repellent devices for water users.	1	2	3	4	5
'Cryptic' wetsuits that camouflage the wearer with the background colours in the water based on a shark's visual system.	1	2	3	4	5
Shark exclusion nets that remain in place permanently.	1	2	3	4	5
Shark exclusion nets that are removed each night to prevent other species being caught.	1	2	3	4	5
Electric shark deterrent cables that do not kill sharks placed along stretches of coastline.	1	2	3	4	5
Shark hunts following a shark bite incident.	1	2	3	4	5
Drumlines (baited buoys to catch and kill sharks).	1	2	3	4	5
Gill nets set across beaches to catch and kill sharks.	1	2	3	4	5

Please turn over page **→**

20. Do you disagree or agree with each of the following statements? **(circle one number for *EACH*)**

	Strongly Disagree	Slightly Disagree	Neither	Slightly Agree	Strongly Agree
Killing sharks makes it safer for water users.	1	2	3	4	5
I support the killing of sharks only after a shark bite incident.	1	2	3	4	5
I support the killing of sharks at any time (not just after a bite incident).	1	2	3	4	5
Killing sharks is justified to lower the probability of a shark bite.	1	2	3	4	5
Lethal shark policies (killing sharks) keep water users safer than non-lethal policies (e.g., exclusion nets, inform users, repellent devices).	1	2	3	4	5
I do ***not*** support the killing of sharks as a safety measure.	1	2	3	4	5
I do ***not*** support the killing of sharks under any circumstances.	1	2	3	4	5

21. Do you disagree or agree with each of the following statements? **(circle one number for *EACH*)**

	Strongly Disagree	Slightly Disagree	Neither	Slightly Agree	Strongly Agree
It makes me sad to know that sharks are being killed.	1	2	3	4	5
Sharks should be protected for their own sake rather than to meet the needs of humans.	1	2	3	4	5
I believe that protecting sharks is important.	1	2	3	4	5
I do ***not*** care about sharks.	1	2	3	4	5
The needs of humans are more important than sharks.	1	2	3	4	5
Protecting sharks is a waste of time, as we should be protecting people's jobs instead.	1	2	3	4	5
The world would be better off without sharks.	1	2	3	4	5

The next 8 shaded boxes each contain hypothetical scenarios describing possible conditions at this beach area.
NO SCENARIOS ARE THE SAME. ***Carefully read EACH scenario and then answer the question following EACH scenario.***

Scenario 1: Imagine ***all four*** of the following conditions are happening at this beach area:

- **NO SHARK** seen in last 24 hours
- **NO PEOPLE** are in the water
- **POOR** conditions to spot sharks (e.g., water clarity / turbidity, visibility, glare)
- **POOR** surf / sea conditions (e.g., swell height, wind direction, tide)

22. If ***all*** conditions in Scenario 1 above are happening at this beach area, how likely would you go in the water? **(circle number)**

1	2	3	4	5	6	7	8	9
Very Unlikely		Somewhat Unlikely		Neither		Somewhat Likely		Very Likely

<u>**Scenario 2**</u>: Imagine <u>***all four***</u> of the following conditions are happening at this beach area:

- **SHARK** seen in **LAST 24 HOURS**
- **NO PEOPLE** are in the water
- **GOOD** conditions to spot sharks (e.g., water clarity / turbidity, visibility, glare)
- **GOOD** surf / sea conditions (e.g., swell height, wind direction, tide)

23. If ***all*** conditions in Scenario 2 above are happening at this beach area, how likely would you go in the water? **(circle number)**

1	2	3	4	5	6	7	8	9
Very Unlikely		Somewhat Unlikely		Neither		Somewhat Likely		Very Likely

<u>**Scenario 3**</u>: Imagine <u>***all four***</u> of the following conditions are happening at this beach area:

- **SHARK** being seen **RIGHT NOW**
- **NO PEOPLE** are in the water
- **POOR** conditions to spot sharks (e.g., water clarity / turbidity, visibility, glare)
- **GOOD** surf / sea conditions (e.g., swell height, wind direction, tide)

24. If ***all*** conditions in Scenario 3 above are happening at this beach area, how likely would you go in the water? **(circle number)**

1	2	3	4	5	6	7	8	9
Very Unlikely		Somewhat Unlikely		Neither		Somewhat Likely		Very Likely

<u>**Scenario 4**</u>: Imagine <u>***all four***</u> of the following conditions are happening at this beach area:

- **SHARK** seen in **LAST HOUR**
- **PEOPLE** are in the water
- **POOR** conditions to spot sharks (e.g., water clarity / turbidity, visibility, glare)
- **GOOD** surf / sea conditions (e.g., swell height, wind direction, tide)

25. If ***all*** conditions in Scenario 4 above are happening at this beach area, how likely would you go in the water? **(circle number)**

1	2	3	4	5	6	7	8	9
Very Unlikely		Somewhat Unlikely		Neither		Somewhat Likely		Very Likely

<u>**Scenario 5**</u>: Imagine <u>***all four***</u> of the following conditions are happening at this beach area:

- **NO SHARK** seen in last 24 hours
- **PEOPLE** are in the water
- **GOOD** conditions to spot sharks (e.g., water clarity / turbidity, visibility, glare)
- **GOOD** surf / sea conditions (e.g., swell height, wind direction, tide)

26. If ***all*** conditions in Scenario 5 above are happening at this beach area, how likely would you go in the water? **(circle number)**

1	2	3	4	5	6	7	8	9
Very Unlikely		Somewhat Unlikely		Neither		Somewhat Likely		Very Likely

<u>**Scenario 6**</u>: Imagine <u>***all four***</u> of the following conditions are happening at this beach area:

- **SHARK** seen in **LAST HOUR**
- **NO PEOPLE** are in the water
- **GOOD** conditions to spot sharks (e.g., water clarity / turbidity, visibility, glare)
- **POOR** surf / sea conditions (e.g., swell height, wind direction, tide)

27. If ***all*** conditions in Scenario 6 above are happening at this beach area, how likely would you go in the water? **(circle number)**

1	2	3	4	5	6	7	8	9
Very Unlikely		Somewhat Unlikely		Neither		Somewhat Likely		Very Likely

<u>**Scenario 7**</u>: Imagine <u>***all four***</u> of the following conditions are happening at this beach area:

- **SHARK** seen in **LAST 24 HOURS**
- **PEOPLE** are in the water
- **POOR** conditions to spot sharks (e.g., water clarity / turbidity, visibility, glare)
- **POOR** surf / sea conditions (e.g., swell height, wind direction, tide)

28. If ***all*** conditions in Scenario 7 above are happening at this beach area, how likely would you go in the water? **(circle number)**

1	2	3	4	5	6	7	8	9
Very Unlikely		Somewhat Unlikely		Neither		Somewhat Likely		Very Likely

Scenario 8: Imagine ***all four*** of the following conditions are happening at this beach area:

- **SHARK** being seen **RIGHT NOW**
- **PEOPLE** are in the water
- **GOOD** conditions to spot sharks (e.g., water clarity / turbidity, visibility, glare)
- **POOR** surf / sea conditions (e.g., swell height, wind direction, tide)

29. If ***all*** conditions in Scenario 8 above are happening at this beach area, how likely would you go in the water? **(circle number)**

1	2	3	4	5	6	7	8	9
Very Unlikely		Somewhat Unlikely		Neither		Somewhat Likely		Very Likely

30. If you are a surfer or paddle boarder, what length of board do you use? **(write response or leave blank)** ________ feet long

31. What is your gender (e.g., male, female, transgender, non-binary)? **(write response)** ______________________________

32. What is your age? **(write age)** ________ years old

33. What is the highest level of education that you have completed? **(check *ONE*)**

☐ None ☐ Primary ☐ Secondary ☐ Matric ☐ Diploma ☐ Degree ☐ Prefer not to answer

34. Where do you live? **(write responses)** City / town ________________________ Country ________________________

Thank you, your input is important! ***Please return this survey to the researcher immediately*.**