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Public Perception and Understanding of Shark Attack Mitigation Measures in Australia

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Human–wildlife conflict (HWC) is a significant and growing problem, with mitigation measures being increasingly dependent on sociopolitical landscapes. We surveyed 766 people from two Australian states to assess their understanding of shark attack mitigation measures. Although beach users were relatively aware of existing mitigation measures, the efficacy of aerial patrol was overestimated, as was the risk of shark attack. The latter, as well as the innate fear of shark attacks, is likely to explain the high level of worry related with shark attack and fits within the affect heuristic that can influence how people respond to risk situations. Beach users did not, however, choose beaches based on existing mitigation measures. Results highlight the need for improved education about the risks of shark attack and for further research into the emotional response from low probability–high consequences incidents.

Keywords human–wildlife conflict, beach meshing, aerial patrols, public awareness, Australia

Introduction

Human–wildlife conflict (HWC) is a significant and growing problem that puts both humans and wildlife at risk (Berchielli, Dente, & Renar, 2003). The potential for injuries to, or death of, humans from wildlife has led to concerns from the general public and a pressing need to minimize HWC (West, 2011). Government agencies and the general public may rely on the development and use of mitigation measures to reduce the likelihood of encounters between humans and wildlife (Conover, 2002). The use of HWC mitigation measures, however, can result in detrimental impacts on wildlife populations, which may be a serious problem for species of conservation concern (Conover, 2002; Woodroffe, Thirgood, & Rabinowitz, 2005). Although the development of HWC mitigation measures has been based on their efficacy taking into account the biology and ecology of the species of concern,

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mitigation strategies are also influenced by the sociopolitical landscape, where political and economic factors may affect decision-making (Treves & Karanth, 2003). Human–wildlife conflict management has become a political challenge as much as a scientific one (e.g., voters have punished governments for spikes in shark attacks (Achen & Bartels, 2004)). As a result, HWC management must include investment in public outreach and study of public understanding of management approaches.

Although interactions potentially impacting human safety occur with different terrestrial (e.g., lions, wolf, bears) and marine organisms (e.g., jellyfish, crocodiles), few species are more feared than sharks. Sharks, like many apex predators, suffer from a negative public image (Driscoll, 1995; Thompson & Mintzes, 2002; Woods, 2000), in part because of their ability to pose threats to human safety (Philpott, 2002). These negative perceptions of sharks and shark attack risk have been identified as a barrier to global shark conservation efforts (Ferguson, 2006). In this context, human–shark conflict poses an urgent challenge worldwide because such conflict pits human communities against sharks and against other humans who seek to conserve or restore wildlife populations (Karanth & Madhusudan, 2002; Torres, Mansfield, Foley, Lupo, & Brinkhaus, 1996). For example, the species responsible for the greatest number of fatal attacks (white shark *Carcharodon carcharias*) is now protected in many countries as well as by international agreements. This protection leads to debates within communities subsequent to a shark attack and may lead to organized culls (Curtis et al., 2012).

Globally, the number of shark attacks has been increasing (Burgess, Buch, Carvalho, Garner, & Walker, 2010; Curtis et al., 2012). In Australia, reported incidents have more than doubled from 6.5 per year in 1990–2000 to 15 incidents per year in 2000–2010 (West, 2011). Spikes in the number of shark attacks have led government agencies to review their beach protection programs (Anonymous, 2006a, 2006b; Green, Ganassin, & Reid, 2009; Nel & Peschak, 2006). In these reviews, the need for more information about mitigation measures is often highlighted, with recommendations for educating the general public and improving understanding of shark attack risk, the role of beach protection programs, and the costs associated with these programs (Curtis et al., 2012; Green et al., 2009; Nel & Peschak, 2006).

Studies of risk perception examine the judgments people make when they are asked to characterise and evaluate hazardous activities (Slovic, 1987). Risk perception is hard to understand and many of the suggested models (e.g., the psychometric model (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978) or cultural theory (Douglas & Wildavsky, 1982)) only explain a small fraction of risk perception (Sjöberg, 2000). Studies, however, have recognized that risk perceptions and society's responses to risk can be strongly linked to the degree to which a hazard evokes feelings of dread (Fischhoff et al., 1978; Slovic, 1987). This implies that people base their judgments of an activity or a risk, such as the likelihood of being bitten by a shark, not only on what they think about it but also on how they feel about it (Loewenstein, Weber, Hsee, & Welch, 2001). Assessing risks based on feelings or affect can be easier and more efficient than weighing the pros and cons of various reasons or retrieving relevant examples from memory (Slovic, Finucane, Peters, & MacGregor, 2004). This characterisation of a mental shortcut led to the use of affect as heuristic (Finucane, Alhakami, Slovic, & Johnson, 2000). The affect heuristic and risk as feelings have been shown to predict and explain numerous aspects of perceived risk (Loewenstein et al., 2001; Slovic & Peters, 2006; Slovic et al., 2004). Considering the negative and emotive public perception of sharks and shark attacks (Driscoll, 1995; Neff, 2012; Woods, 2000), the perception of risk associated with shark attacks is a good model to test the importance of affect heuristic to explain the attitude and behavior of the general public at beaches in relation to shark attack mitigation measures.

Several authors have investigated the public view of sharks from a wildlife tourism perspective (Dobson, 2006; Theberge & Dearden, 2006; Topelko & Dearden, 2005; Ziegler, Dearden, & Rollins, 2011), but none have investigated risk perception of shark attacks or how much the public know about mitigation measures. Those who promote and regulate safety need to understand the ways in which people think about and respond to risk (Slovic, 1987). The present study focused on two Australian States where shark attack mitigation measures are used as case studies to assess risk perception and the level of understanding and perceived efficacy of human–wildlife conflict mitigation measures related to shark attack. This article aims to aid risk analysis and policymaking by determining: (a) risk perception of shark attacks in relation to beach goer behavior and the assumed number of shark attacks and (b) the understanding and perceived efficacy of current shark attack mitigation measures and influencing factors.

Methods

Study Sites

Public understanding and perceived efficacy of shark attack mitigation measures were determined from beaches in New South Wales (NSW) and South Australia (SA). These two Australian States were chosen because of the different shark attack mitigation measures in place and the differing types of shark attacks occurring in those States. South Australia had about 70% more fatalities per capita in 1990–2010 than any other Australian State or Territory (Australian Shark Attack File, unpublished data). Conversely, ∼40% of the unprovoked attacks that occurred in Australia from 1990 to 2009 took place in NSW (West, 2011). New South Wales and SA also use different shark attack mitigation measures. New South Wales pioneered the use of anchored, large-mesh gill-nets as a preventive measure (Reid, Robbins, & Peddemors, 2011) in 1937 and these are now in place on 51 beaches from Newcastle to Illawara. Fixed-wing and helicopter aerial patrols off Sydney beaches have also been used. Aerial patrols were, however, intermittent and not always supported by the NSW Government due to concerns of their effectiveness. South Australia does not have a beach meshing or drumline program, but instead uses a few closed enclosures at specific locations (e.g., Streaky Bay) and a combination of aerial-based spotter programs (plane and helicopter).

Survey

A questionnaire was designed to assess the public understanding and perceived efficacy of shark attack mitigation measures. The questionnaire was administered to participants in both States. Slight differences were introduced to take into account the survey location and the mitigation methods used in each state.

The following questions provided information about respondents' awareness of shark attack numbers, their level of concern at the beach and other factors that influence beach selection. In each State, participants indicated their frequency of visiting the beach (daily, twice a week, weekly, fortnightly, monthly, every few months, annually, or hardly ever) for each season (summer, winter), and activities participated in while at the beach (swimming, surfing, fishing, diving, running or walking, beach sports, sunbathing, or other).

Respondents then ranked the three most important factors they look for when choosing a beach: ease of access, landscape and views, size of the beach, activities offered, popularity, facilities available, shark attack control measures, and presence of lifeguards. They also ranked the three types of risks they are most worried about: drowning, slipping off rocks, jellyfish stings, shark attack, injuries on the beach, or sunburns. Participants estimated the average number of fatal and non-fatal shark attacks per year worldwide and in Australia; whether they had heard of a recent attack; and if they had a close experience with shark attacks (i.e., themselves, or friend/relation). Finally, respondents rated how safe they felt from shark attacks when in the water at beaches in their state on a scale of 1 (not at all safe) to 10 (completely safe).

The understanding of shark attack mitigation measures was assessed in two parts. Participants first listed mitigation measures being used in Australia and around the world, and identified the most efficient method to reduce shark attacks. Respondents were then asked a series of questions regarding their knowledge of the two mitigation measures predominantly used in Australia: aerial patrols and beach meshing. For aerial patrols, closed-ended questions assessed the number of observers inside the helicopter or plane, probability of seeing a shark, average time spent over a beach, and regularity of patrols; area covered was asked as an open question. For beach meshing, closed-ended questions assessed the layout and depth of the nets, and how often nets are checked were carried out; an open question gauged the geographic range of the protected beaches. A knowledge score was calculated by summing correct answers by each respondent. Correct answers were allocated 10 points, with other answers allocated fewer points depending on their relative closeness to the correct answer. Respondents also assessed the perceived efficacy of each method to reduce shark attacks, using a scale from 1 (*not at all efficient*) to 10 (*very efficient*).

Questionnaire Administration

Questionnaires were administered during May and June 2011 between 9 a.m. and 5 p.m. In Adelaide, sampling was carried out on beaches from Semaphore to Victor Harbour. In Sydney sampling occurred on ocean and harbor beaches with and without nets from North Curl Curl to Maroubra. Sampling occurred over 17 days in Adelaide and 14 days in Sydney. About 85% of the approached people (330 and 430 in Sydney and Adelaide, respectively) completed the survey.

Questionnaires were also sent by email to 19 diving, sailing, swimming, and surfing sports clubs. Questionnaires were only sent to clubs within the same postcode as participants from face-to-face surveys. The potential biases introduced by targeting individuals with a potential interest in marine conservation were taken into account by including in the analyses participants' main activities and regularity of beach visits.

A total of 766 questionnaires were completed with 359 responses completed in Sydney (285 and 74 through one-on-one and Web-based questionnaire, respectively) and 407 responses completed in Adelaide (368 and 39 through one-on-one and Web-based questionnaire, respectively).

Statistical Analysis

Differences in the demographics between the two areas and perceived efficacy of methods were assessed using Chi-squared or *t*-tests as appropriate. The factors affecting the knowledge score of the two mitigation methods were assessed for each region independently using analyses of covariance. Maximal models containing the ten available explanatory

Table 1
Details of explanatory variables used in the analysis of covariance model to assess factors affecting the understanding of shark attack mitigation measures

Explanatory variable	Nature
Education	Three-level factor (high school, tertiary, graduate)
Sex	Two-level factor (male or female)
Age	Integer
Shark concern	Three-level factor (low, intermediate, high)
Attack experience	Two-level factor (yes or no)
Summer beach use	Four-level factor (none, rare, regular but occasional, regular and frequent)
Winter beach use	Four-level factor (none, rare, regular but occasional, regular and frequent)
Activities	Three-level factor (water, land, water and land)
Security concern (includes lifeguards)	Three-level factor (low, intermediate, high)
Attack awareness	Two-level factor (yes or no)

variables (Table 1) were fit to the data, with identification of significant terms through stepwise model simplification, removing non-significant variables and collapsing levels within factors where these were not significantly different from each other. This resulted in a minimally adequate models containing only the explanatory variables and factors that explained a significant amount of the variation in the knowledge score (Crawley, 2007).

Results

Respondent Demographics and Beach Use Patterns

In both regions, 35% of respondents were between 18 and 25 years old. In South Australia, 22% were between 26 and 35 and in New South Wales 30% were between 26 and 35. Individuals aged over 45 made up 27% and 21% of South Australian and NSW samples, respectively. Both sexes were equally represented and the regions did not differ in this regard ($\chi^2 = 0.37$, $df = 1$, $p = .54$). The demographics of the regions differed in terms of education ($\chi^2 = 11.3$, $df = 2$, $p < .01$); in New South Wales, there were more respondents in the upper educational levels compared to South Australia, with 11% more (SA: 63%, NSW: 72%) at university level and 12% less (23% SA and 13% NSW) at high school level. The middle portion was similar with 14% (SA) and 15% (NSW) having completed a trade or apprenticeship.

Most respondents were regular beach users with 60–75% of respondents visiting the beach at least once a month in winter, whereas ~85% visited the beach at least once a month in summer. The main beach activities identified were swimming, running, walking, having a picnic, and sunbathing.

Concerns of Respondents and Shark Attack Estimations

The main concern of respondents in both regions while visiting the beach was sunburn (51% SA and 43% NSW). In SA, the second and third main worries were the risk of shark attack and jellyfish stings (19% and 10%, respectively). However, in NSW, the risk of jellyfish stings ranked second (22%), whereas the risk of shark attack was fourth (13%). Although shark attack was the main concern of nearly 20% of South Australian respondents, only 0.5% ranked the presence of shark attack mitigation measures as their main reason to choose a beach. Similarly, in NSW, only 0.9% of respondents ranked the presence of shark attack mitigation measures as their principal driver for beach selection. In both regions, the landscape/views, and popularity of the beach were the two principal drivers of beach choice.

Both SA and NSW respondents over-estimated the number of fatal and non-fatal shark attacks at 7–9 and 20–30, respectively. Both regions were equally inaccurate in their perception of the number of shark attacks (fatal: $t_{739} = 0.80$, $p > .05$, non-fatal: $t_{739} = 1.21$, $p > .05$), but were correct in estimating a higher relative number of fatal attack in SA and non-fatal attack in NSW. Respondents in both regions felt equally well protected from shark attacks at their favorite beach (7.8/10), however, the perceived safety from shark attack at beaches in general was higher in NSW than in SA (7.73/10 and 7.33/10 respectively, ($t_{759} = 2.42$, $p < .01$)). There was no correlation between the perceived level of safety from shark attacks both on SA and NSW beaches and the respondents' knowledge of shark attack mitigation measures (SA: $n = 406$, Slope: $t_{405} = 1.32$, $p > .05$; NSW: $n = 355$, Slope: $t_{354} = 1.63$, $p > .05$).

Understanding and Perceived Efficacy of Shark Attack Mitigation Measures

Most respondents (90%) were aware that nets are used as shark attack mitigation measures, and 92% of NSW respondents correctly identified that nets are being used in their State. In SA, however, 41% of respondents incorrectly believed that nets were used in their State. About 50% of respondents knew that aerial patrols (either fixed-wings or helicopters) were used as shark attack mitigation measures. Sixty percent of SA respondents correctly identified that aerial patrols are being used in their State, with lifeguards, acoustic telemetry, boats, enclosures, and education being some of the other mitigation measures known by SA respondents.

In both regions, respondents knew more about aerial patrols than beach meshing: in South Australia aerial patrol knowledge scored 74/100 versus 57/100 for meshing ($t_{812} = 15.00$, $p < .05$), in NSW aerial patrol knowledge was 76/100 versus 65/100 for meshing ($t_{716} = 7.46$, $p < .05$). Aerial patrol knowledge did not vary with region ($t_{764} = 1.23$, $p > .05$), but knowledge of beach meshing did, with NSW respondents scoring higher than South Australian respondents ($t_{764} = 6.41$, $p < .05$).

The perceived efficacy of beach mitigation measures was rated at 5.8/10. Respondents in both regions thought beach meshing (6.18/10) more efficient than aerial patrols (5.4/10) at reducing shark attacks (SA: $t_{763} = 6.11$, $p < .05$; NSW: $t_{700} = 3.73$, $p < .05$). Additionally, South Australians thought that beach meshing was more efficient (6.45/10) than NSW respondents (5.97/10) ($t_{730} = 2.93$, $p < .05$). The gender of the respondents had little effect with only one method varying in perceived efficacy between the sexes: more men (4%) rated acoustic telemetry as the most efficient method than did women (<1%) ($\chi^2 = 8.6$, $df = 1$, $p < .01$), although the efficacy of this method was rated as low for both sexes. Education level had no effect on what methods were perceived as efficient ($\chi^2 = 17.2$, $df = 16$, $p = .37$). The level of worry, or assessment of how concerned people were about shark attacks when going to the beach, affected the perception of the most efficient method ($\chi^2 = 54.9$, $df = 16$, $p < .001$), with boat spotting being perceived as a more efficient method by people who worried the most compared to those who worried least.

Drivers Underpinning Knowledge Score Variations

There was much variation in the level of knowledge of both mitigation measures in both States, but little of this was accounted for by the factors assessed. For beach meshing in NSW, the maximal model only explained 7% of the variation and the minimally adequate model, which contained two factors of interest, explained 5%. These two factors were direct experience of a shark attack (which led to a 12% better score, $F_{1349} = 5.1$, $p < .05$) and winter beach use. Those who used the beach rarely or never during the winter months knew marginally more (7%) about meshing than those who used it on a monthly or more regular basis ($F_{2349} = 5.47$, $p < .01$).

As with meshing, few of the measured factors explained the variation in aerial patrol score and the maximal model only accounted for 11% of the variance in knowledge. Aerial patrols were affected by the age of the respondent, with older people knowing more than younger people (3% rise in score/10 years over the sample range, $F_{1352} = 16.6$, $p < .001$), and by the winter use of the beach. Conversely to the beach meshing score, people who never used the beach in winter knew less of aerial patrols than those who used the beach in winter (9% lower score, $F_{1352} = 5.3$, $p < .05$). The minimally adequate model containing these factors only explained 8% of the variation in the data.

As with NSW, the variation in knowledge about meshing in South Australia was great and the maximal model only accounted for 11% of this. There were five significant factors identifiable in the minimally adequate model, which explained 7% of the variation. The effect of how concerned people were about beach security was subtle, people who either rated it highly or paid it little attention were both 21% less accurately informed than those who had an intermediate level of worry ($F_{1371} = 4.87$, $p < .05$). The opposite pattern was true of people who worried about shark attacks, the extremes were 23% better informed than those in the middle ($F_{1371} = 3.9$, $p < .05$). People who were aware of a specific shark attack were 8% less accurate in their knowledge of meshing than the general level ($F_{1371} = 4.1$, $p < .05$). University educated respondents were 10% better informed than those who had completed school or secondary-level classes ($F_{1371} = 6.9$, $p < .01$). People who used the water were also 10% better informed than those who stay dry ($t_{371} = 2.15$, $p < .05$).

The maximal model for aerial patrols in South Australia also did not explain much of the variation in the knowledge score (9%), and the three factors found to account for significant proportions together only account for 5% of the variation. In this region, men had a 4% more accurate understanding of aerial patrols than women ($F_{1380} = 7.5$, $p < .01$), as did those who had a post school-level education (5%, $F_{1380} = 6.8$, $p < .01$). Those who rated beach security low had a 4% poorer understanding of the method ($F_{1380} = 4.1$, $p < .05$).

Discussion

Managers dealing with HWC report that human dimensions of such conflicts are the most difficult to understand and manage (Decker & Chase, 1997). This article provides the first quantitative assessment of public perception and understanding of shark attack risk and mitigation measures. The results show some discrepancies between belief and facts, and disparities between the respondents' perception of shark attack risk and the use of mitigation measures.

Concerns About Shark Attacks

The risk of shark attack being one of the main worries when going to a beach is not consistent with the low number of shark attack taking place yearly. In risk perception, responses to low probability events, such as shark attacks, can be quite sensitive to the possibility of strong negative consequences, regardless of its probability (Loewenstein et al., 2001). Shark attacks are considered low probability–high consequence incidents whose vivid nature skews risk perceptions (Sunstein, 2002). Skewed risk perception was evidenced in the finding that respondents were more worried about shark attack than drowning regardless of the respective number of deaths from each (in Australia ∼1 death year^{-1} due to shark attack, averaged between 1990 and 2010 (West, 2011) versus ∼95 deaths year^{-1} due to drowning at beaches, and in the ocean or harbours, averaged between 2002/03 and 2011/12 (Royal Life Saving Society, 2012)). Public perceptions of outcomes from shark bite incidents have been socially constructed by causal stories in movies, myths, and media driving a primal rejection and fear of sharks. Most media coverage emphasises the risks that sharks pose to people, with shark attacks being the focus of over half the U.S. and Australian newspaper articles related to sharks (Muter, Gore, Gledhill, Lamont, & Huveneers, 2013). Frequent media exposure, as seen following most shark attacks, has also been shown to increase the perceived level of risk (Slovic et al., 2004). The vivid picture of the consequences from a human–shark conflict is embedded and available in the mind of the public (Neff, 2012). The complex role of emotions such as these in determining individuals' beliefs, perceptions, attitudes, and actions regarding wildlife and human–wildlife interactions is only recently coming to light (Manfredo, 2008; Slovic, 2004; Slovic & Peters, 2006). A better understanding of peoples' emotions surrounding sharks and the potential for shark attack at public beaches will be necessary for understanding and predicting public perceptions about and reaction to shark control measures and changes to shark control policy.

Results also indicated that the general public grossly overestimates the number of non-fatal and fatal shark attacks, doubling the number of non-fatal and quadrupling the number of fatal shark attacks. It has also been shown that highly publicized causes of death (e.g., homicides, tornadoes, shark attacks) are overestimated, while under-publicized causes (e.g., diabetes, stroke, asthma, tuberculosis) are underestimated (Lichtenstein, Slovic, Fischhoff, Layman, & Combs, 1978). Highly publicized causes appear to be more sensational and more affectively charged, which may account for both their prominence in the media and their relatively overestimated frequencies. The cumulative impact of the cognitive processes linked with low probability–high consequences incidents and the overestimation of the number of shark attacks can leave the public convinced of an outcome that seems more likely than it actually is and connects negative feelings about these events (Neff, 2012). Other types of stimuli that evolution may have prepared us to fear, such as spiders, snakes, or heights, evoke strong visceral responses even when we recognize them, cognitively, to be harmless (Loewenstein et al., 2001). This may explain why the general public place the risk of shark attacks in the top three of their main worries, higher than the risk of drowning, although the risk of drowning is greater than the risk of shark attacks. However, empirical evidence has shown that when potential outcome evokes strong negative effect, as with shark attacks, its unattractiveness is relatively insensitive to variation in probability as great as from 0.99 to 0.01 (Rottenstreich & Hsee, 2001). If this is the case, improving the knowledge of the actual shark attack risks might not affect the perceived risks and behavior of beach goers.

Understanding and Perceived Efficacy of Mitigation Measures

Beliefs and values are often strongly correlated and psychologically interdependent, leading people to mostly see bad properties in the concepts that they dislike (Sjöberg, 2000).

Conventional attitude theory also assumes attitude to be a function of beliefs and values (Fishbein & Ajzen, 1975). As a result, it was expected that the negative emotional response to shark attack (Neff, 2012) and high level of worry about shark attacks, combined with mitigation measures perceived as moderately efficient, would lead to respondents being likely to select beaches according to mitigation measures available. However, this study found no relationship between respondents' selection of beaches and the type of mitigation measures available. This result suggests that although the risk of shark attacks is on the respondents' mind, the current shark attack mitigation measures do not provide respondents any incentive to choose a beach based on these measures.

Although respondents, in general, had a good understanding of the operation of mitigation measures, there were some discrepancies between the beliefs of the respondents regarding beach mitigation measures and the facts. More than 50% of SA respondents believed that spotter planes have between 50–75% chance of spotting a shark. This probability of sighting is greater than the actual 17% maximum probability of spotting a shark during aerial patrol (Robbins, Peddemors, & Kennelly, 2012). In addition, a third of SA respondents believed aerial patrols spend 30 minutes over each beach per day. This is greater than the average two minutes spent above a beach per day based on a study carried out in Western Australia (Green et al., 2009). These results suggest that beach users may overestimate the efficacy of aerial patrols as a shark attack mitigation measure. Considering that beach users perceived this mitigation measure as moderately efficient (5.4/10), it is possible that the perceived efficacy of aerial patrols would be reduced to below average if they were aware of the actual time spent over a beach and likelihood of sighting sharks.

About 40% of SA respondents also incorrectly believe that nets are used in SA, whereas only 60% knew about aerial patrols. Beach meshing is not currently used in SA; consequently, this result suggests that improved communication about the current type of shark attack mitigation measures and efficacy of aerial patrols might be needed to inform the general public that beach meshing are not currently used in SA and about the actual likelihood of detecting sharks using aerial patrol.

Although it was attempted to determine what factors influence the understanding or perceived efficacy of mitigation measures, the variation explained by the models for both regions and mitigation measures was low. This suggests that the factors affecting the understanding or perception of beach users were not identified or recorded through the questionnaire, or that most of the variation was random. Further research using appropriate exploratory methods (e.g., open-ended qualitative questions) is needed to understand how people construct and share knowledge about shark attack mitigation measure and their effectiveness.

New South Wales residents have been exposed to more education and awareness campaigns about the importance of sharks and their low resilience to fishing pressure than South Australian residents. Following the introduction of the National Plan of Action for the Conservation and Management of Sharks (Shark Advisory Group & Lack, 2004), organizations (including governmental and nongovernmental agencies) were encouraged to educate and increase public awareness of shark conservation and the actual risk of shark attacks (Green et al., 2009). The 2009 report into the NSW Shark Meshing (Bather Protection) Program also highlights the need for a broader shark education and awareness program to be implemented through educational strategies and media disseminated information to draw on new emerging shark attack prevention measures resulting from research (Green et al., 2009). The present study indicates that although respondents are not fully aware of all the methods used worldwide and in their own state, respondents understand the general operations of shark attack mitigation measures and their purpose, shark meshing acting as a semi-physical barrier to sharks and aerial patrols as a surveillance scheme. Awareness campaigns, especially in NSW where the respondents' knowledge of mitigation measures is higher, have thus been efficient in educating individuals on current shark attack mitigation measures and the conservation status of sharks. Further awareness campaigns, especially in SA, should be carried out to ensure individuals understand which type of shark attack control measures are used, their effectiveness, and about the actual risk of shark attacks.

Conclusion

Developing strategies that integrate informed stakeholder input and involvement into decision-making is one of the greatest challenges facing wildlife management. Human dimensions specialists maintain that although traditional biological considerations are essential, managing people is equally important and an essential part of the management equation (Decker & Chase, 1997; Decker et al., 1992; Riley et al., 2002). Research has also shown that stakeholders are more likely to consider a public issue resolved or problem solved acceptably when they have had a voice in the decision-making process (Lind, Kanfer, & Earley, 1990). This study presents quantitative data to inform wildlife managers and politicians and assist with decision-making about shark attack mitigation measures. The article highlighted that although the general public was relatively aware of the mitigation measures in place and of the deployment of beach meshing, the efficacy of aerial patrols was overestimated as is the risk of shark attack. The latter as well as innate fear of shark attacks is likely to explain the high level of worry of shark attack when going to the beach and fits within the affect heuristic that can influence how people respond to risk situations (Slovic & Peters, 2006). Respondents did not, however, select beaches according to mitigation measures in place. The present study highlights the need for improved public education about the risks of shark attack and for further research into the emotional response toward low probability–high consequences incidents, which will help improving the effectiveness of education strategies.

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References

Achen, C., & Bartels, L. (2004) *Blind retrospection: Electoral responses to drought, flu, and shark attacks*. Madrid, Spain: Instituto Juan March de Estudios e Investigaciones.

Anonymous. (2006a). *A report on the Queensland shark safety program*. Brisbane, Australia: Queensland Department of Primary Industries.

Anonymous. (2006b). *Scientific shark protection summit*. Sydney, Australia: NSW Department of Primary Industries and Sydney aquarium.

Berchielli, L. T., Dente, C., & Renar, E. (2003). *New York status report. 17th eastern black bear workshop*. Mt. Olive, NJ: New Jersey Division of Fish and Wildlife and New York State Department of Environmental Conservation.

Burgess, G. H., Buch, R. H., Carvalho, F., Garner, B. A., & Walker, C. J. (2010). Factors contributing to shark attacks on humans: A Volusia County, Florida, case study. In J. C. Carrier, J. A. Musick, & M. R. Heithaus (Eds.), *Sharks and their relatives: II. Biodiversity, adaptive physiology, and conservation* (pp. 541–565). Boca Raton, FL: CRC Press.

Conover, M. (2002). *Resolving human–wildlife conflicts: The science of wildlife damage management*. Boca Raton, FL: CRC Press.

Crawley, M. J. (2007). *The R book in justification*. West Sussex, UK: John Wiley & Sons.

Curtis, T. H., Bruce, B. D., Cliff, G., Dudley, S. F. J., Klimley, A. P., Kock, A. A., . . . West, J. (2012). Recommendations for governmental organizations responding to incidents of white shark attacks on humans. In M. L. Domeier (Ed.), *Global perspectives on the biology and life history of the great white shark* (pp. 477–510). Boca Raton, FL: CRC Press.

Decker, D. J., Brown, T. L., Connelly, N. A., Enck, J. W., Pomerantz, G. A, Purdy, K. G., & Siemer, W. F. (1992). Toward a comprehensive paradigm of wildlife management: Integrating the human and biological dimensions (pp. 33–54). In W. R. Mangun (Ed.), *American fish and wildlife policy: The human dimension*. Carbondale and Edwardsville, IL: Southern Illinois University Press.

Decker, D. J., & Chase, L. C. (1997). Human dimensions of living with wildlife – a management challenge for the 21st century. *Wildlife Society Bulletin*, *25*, 788–795.

Dobson, J. (2006). Sharks, wildlife tourism, and state regulation. *Tourism in Marine Environments*, *3*, 15–23.

Douglas, M., & Wildavsky, A. B. (1982). *Risk and culture: An essay on the selection of technical and environmental dangers*. Berkeley, CA: University of California Press.

Driscoll, J. W. (1995). Attitudes towards animals: Species ratings. *Society and Animals*, *3*, 39–150.

Ferguson, K. (2006). Submerged realities: Shark documentaries at depth. *Atenea*, *26*, 115–129.

Finucane, M. L., Alhakami, A., Slovic, P., & Johnson, S. M. (2000). The affect heuristic in judgments of risks and benefits. *Journal of Behavioral Decision Making*, *13*, 1–17.

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences*, *9*, 127–152.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intension, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.

Green, M., Ganassin, C., & Reid, D. D. (2009). Report into the NSW shark meshing (bather protection) program. *NSW Department of Primary Industries*. Orange, Australia: NSW DPI Fisheries Conservation and Aquaculture Branch.

Karanth, K. U., & Madhusudan, M. D. (2002). Mitigating human wildlife conflicts in southern Asia. In J. Terborgh, C. P. Van Schaik, M. Rao, & L. C. Davenport (Eds.), *Making parks work: Identifying key factors to implementing parks in the tropics* (pp. 250–264). Covelo, CA: Island Press.

Lichtenstein, S., Slovic, P., Fischhoff, B., Layman, M., & Combs, B. (1978). Judged frequency of lethal events. *Journal of Experimental Psychology: Human Learning and Memory*, *4*, 551–578.

Lind, E. A., Kanfer, R., & Earley, P. C. (1990). Voice, control, and procedural justice: Instrumental and non-instrumental concerns in fairness judgments. *Journal of Personality and Social Psychology*, *59*, 952–959.

Loewenstein, G. F., Weber, E. H., Hsee, C. K, & Welch, E. S. (2001). Risk as feelings. *Psychological Bulletin*, *127*, 267–286.

Manfredo, M. J. (2008). *Who cares about wildlife: Social science concepts for exploring human-wildlife relationships and conservation issues*. New York, NY: Springer Science + Business Media.

Muter, B., Gore, M., Gledhill, K., Lamont, C., & Huveneers, C. (2013). Australian and U.S. news media portrayal of sharks and their conservation. *Conservation Biology*, *27*, 187–196.

Neff, C. (2012) Australian beach safety and the politics of shark attacks. *Coastal Management*, *40*, 88–106.

Nel, D. C., & Peschak, T. P. (2006). *Finding a balance: White shark conservation and recreational safety in the inshore waters of Cape Town*, South Africa. (WWF South Africa *Report Series 2006/Marine/001)*. Cape Town, South Africa: WWF.

Philpott, R. (2002). Why sharks may have nothing more to fear than fear itself: An analysis of the effect of human attitudes on the conservation of the white shark. *Colorado Journal of International Environmental Law & Policy*, *13*, 445–472.

Reid, D. D., Robbins, W. D., & Peddemors, V. M. (2011). Decadal trends in shark catches and effort from the New South Wales, Australia, Shark Meshing Program, 1950–2010. *Marine and Freshwater Research*, *62*, 1–18.

Riley, S. J., Decker, D. J., Carpenter, L. H., Organ, J. F., Siemer, W. F., Mattfield, G. F., & Parsons, G. (2002). The essence of wildlife management. *Wildlife Society Bulletin*, *30*, 585–593.

Robbins, W. D., Peddemors, V. M., & Kennelly S. J. (2012). *Assessment of shark sighting rates by aerial beach patrols*. Cronulla, Australia: NSW Department of Primary Industries.

Rottenstreich, Y., & Hsee, C. K. (2001). Money, kisses, and electric shocks: An effective psychology or risk. *Psychological Science*, *12*, 185–190.

Royal Life Saving Society (2012). *National drowning report 2012*. Retrieved from: http://www.royallifesaving.com.au/__data/assets/pdf_file/0006/4002/2012-Drowning-Report.pdf

Shark Advisory Group, & Lack, M. (2004). *National plan of action for the conservation and management of sharks*. Canberra, Australia: Pirion Pty Ltd.

Sjöberg, L. (2000). Factors in risk perception. *Risk Analysis*, *20*, 1–11.

Slovic, P. (1987). Perception of risk. *Science*, *236*, 280–285.

Slovic, P. (2004). What's fear got to do with it? It's affect we need to worry about. *Missouri Law Review*, *69*, 971–990.

Slovic, P., Finucane, M. L., Peters, E., & MacGregor, D. G. (2004): Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality. *Risk Analysis*, *24*, 311–322.

Slovic, P., & Peters, E. (2006). Risk perception and affect. *Current directions in psychological science*, *15*, 322–325.

Sunstein, C. (2002). Probability neglect: Emotions, worst case scenarios, and law. *The Yale Law Journal*, *112*, 61–107.

Theberge, M., & Dearden, P. (2006). Detecting a decline in whale shark sightings in the Andaman Sea, Thailand, using ecotourist operator-collected data. *Oryx*, *40*, 337–342.

Thompson, T. L., & Mintzes, J. J. (2002). Cognitive structure and the affective domain: On knowing and feeling in biology. *International Journal of Science Education*, 24, 645–660.

Topelko, K. N., & Dearden, P. (2005). The shark watching industry and its potential contribution to shark conservation. *Journal of Ecotourism*, *4*, 108–128.

Torres, S. G., Mansfield, T. M., Foley, J. E., Lupo, T., & Brinkhaus, A., (1996) Mountain lion and human activities in California: testing speculations. *Wildlife Society Bulletin*, *24*, 457–460.

Treves, A., & Karanth, K. (2003). Human-carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology*, *17*, 1491–1499.

West, J. G. (2011). Changing patterns of shark attacks in Australian waters. *Marine and Freshwater Research*, *62*, 744–754.

Woodroffe, R., Thirgood, S., & Rabinowitz, A. (2005) The impact of human-wildlife conflict on natural systems. In R. Woodroffe, S. Thirgood, & A. Rabinowitz (Eds.), *People and wildlife, conflict or co-existence* (pp. 1–12). Cambridge, UK: Cambridge University Press.

Woods, B. (2000). Beauty and the beast: Preferences for animals in Australia. *Journal of Tourism Studies*, *11*, 25–35.

Ziegler, J., Dearden, P., & Rollins, R. (2011). But are tourists satisfied? Importance-performance analysis of the whale shark tourism industry on Isla Holbox, Mexico. *Tourism Management*, *33*, 692–701.