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Research

Navigating transdisciplinary waters to protect both sharks and bathers in KwaZulu-Natal, South Africa: diverse stakeholders propose potential actions

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ABSTRACT. In human–wildlife conflicts, stakeholders have varied perspectives, and improving mutual understanding of these perspectives may improve conservation outcomes. Positive outcomes are more likely if scientists work in the research-implementation space, embedding themselves in collaborative social and decision-making processes. We aimed to do this in the bather–shark conflict in KwaZulu-Natal, South Africa, where lethal methods are used to reduce the risk of shark bites. We created a social learning platform and invited 44 stakeholders whose work intersects with this conflict to develop a mutual understanding of the issues and consider a way forward to reduce the impact on sharks without compromising bather safety. We investigated who would use the platform, why, and what they found beneficial, while describing next steps suggested by transdisciplinary stakeholders from science, policy, and management. We found high levels of interest, motivated by a desire to see change and explore management options, and an appreciation of collective intent. Stakeholders recommended (i) collaborating (initiating a working group and working closely with decision makers, especially champions); (ii) using what already exists (collating information, leveraging existing legislation, tapping into existing programs, aligning with government frameworks); and (iii) weighing up costs and benefits (analyzing site-specific circumstances, evaluating multiple alternatives, and exploring different funding models). These recommendations offer transferable lessons for addressing human–wildlife conflicts in other regions, where building trust and co-developing locally appropriate solutions remain key challenges. Although these recommendations support others managing human–wildlife conflicts, we highlight that much of their value lay in forging tighter stakeholder links, sharing diverse views, and witnessing the willingness to work and learn together. The next steps require further collaborative transdisciplinary learning to find mutually acceptable solutions that allow both sharks and people to swim safely. By demonstrating a participatory approach that balances safety and conservation goals, this work contributes to global efforts to manage human–wildlife conflict more sustainably.

Key Words: *bather protection; bather–shark conflict; drumlines; human–wildlife conflict; knowledge café; participatory research; shark nets*

INTRODUCTION

Multiple valid perspectives exist in human–wildlife conflicts, and improving the collective understanding among those who hold these diverse perspectives can improve conservation outcomes (Knight et al. 2019). Human–wildlife conflicts may result when actions by people and wildlife have an adverse effect on the other, especially when wildlife causes threats (actual or perceived) to human life, well-being, economic security, or recreation (Nyhus 2016). Adverse effects on wildlife may include injuries, loss of life, and indirectly, loss of biodiversity and ecosystem changes—e.g., farmers may deliberately kill Vulnerable African lions (*Panthera leo*) following livestock depredation (Ogada et al. 2003). Managing these conflicts can create a subtly different "conservation conflict" between those focused on conserving wildlife and those focused on safeguarding human activities, especially livelihoods (Redpath et al. 2015). For example, changes in land-use permissions to protect Critically Endangered mountain gorillas (*Gorilla beringei beringei*) resulted in conflict between Ugandan villagers and protected-areas staff (Baker et al. 2012). Although conservationists have often focused on wildlife and sought technical solutions to mitigate human–wildlife conflicts (Dickman 2010), such approaches alone have proven insufficient. Over the past two decades, there has been growing recognition that meaningful progress requires grappling with the social, cultural, historical, political, economic, and legal dimensions of the conflict (Madden 2004, Pooley et al. 2017).

Despite this broader recognition, traditional conservation efforts often fall short when practitioners fail to engage meaningfully with the human dimensions of human–wildlife conflicts. As a result, well-intentioned conservation recommendations may go unimplemented, contributing to the so-called research–implementation gap (Knight et al. 2008). An operational model to increase the likelihood of implementing conservation recommendations suggests creating social learning platforms for stakeholders to engage with the issue and empower relevant partners (Knight et al. 2006). Toomey et al. (2017) assert that

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conservation scientists should reconceptualize the "gap" as a productive working "space" by changing how they relate with society regarding conservation problems and embed themselves into collaborative social and decision-making processes because conservation is a social process that engages science, not a scientific process that engages society.

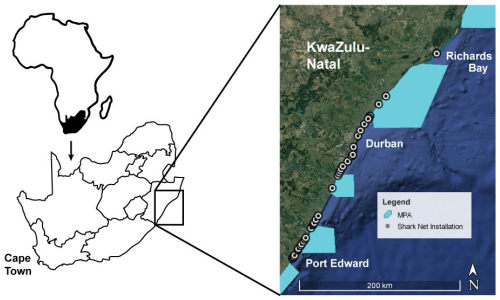
By definition, human–wildlife conflicts are social-ecological systems, so applying systems thinking is useful. Systems thinking is a tool for devising change and investigates the relationships among a system's elements (Reynolds and Holwell 2010, Arnold and Wade 2015). Recognizing pluralism, a diversity of views or standpoints, is vital for systems thinking and, within conservation conflicts, attending to the diverse perspectives of those involved is key to resolving the conflicts (Reynolds and Holwell 2010, Knight et al. 2019).

Most human–wildlife conflicts are terrestrial, but conflicts also occur in marine spaces. As on land, conflicts in the ocean can be classified as threats to resources or to public safety (Guerra 2019). For example, in the Baltic Sea, fishers and seals compete for resources because they consume similar fish species; some fishers believe that growing populations of predators impact fish stocks so are calling for culling programs (Hansson et al. 2018). The conflict becomes more intense when marine wildlife remove fish from fishing gear—resulting in economic losses and damage to fishing gear for fishers, and entanglement injuries, bycatch (incidental catches), or retaliatory killing of marine megafauna (Tixier et al. 2021).

Humans have a particularly complicated relationship with large carnivores, and this is especially true for large sharks: humans and sharks can be one another's predators, prey, and competitors (Simpfendorfer et al. 2021). The bites of three shark species—white (*Carcharodon carcharias*), bull (*Carcharhinus leucas*), and tiger (*Galeocerdo cuvier*)—can pose serious risk to humans because they may cause significant injury or death (Midway et al. 2019). Although the risk is extremely low, shark bites are extremely traumatic—not only for the victim, but also for the wider community. These events typically attract media and public attention that can cause a ripple effect on tourism, impacting people's livelihoods (Oelofse 2006, Sabatier and Huveneers 2018). Due to public concerns and the potential risk to public safety, in some places, authorities have implemented shark control programs, setting fishing gear to catch potentially dangerous sharks. In four shark-bite hotspots (two Australian states, Reunion Island, and one South African province), large-mesh gillnets and/or baited hooks are set to reduce the numbers of these three target sharks (Dudley 1997, Guyomard et al. 2019, McPhee et al. 2021). In theory, lethal control of sharks might reduce the risk to bathers, but in practice, this has been difficult to prove (Huveneers et al. 2024). Although the research on this human–wildlife conflict has traditionally focused on sharks, researchers have begun to investigate the human dimensions (Crossley et al. 2014, Hardiman et al. 2019, Lucrezi et al. 2019) and assess social and ecological layers of the conflict more holistically (Gibbs et al. 2020, Shabtay et al. 2020).

In KwaZulu-Natal, a South African hotspot, there was a series of shark bites, with 21 incidents during the 1940s (2.3 incidents/year), including seven fatalities (0.7 fatalities/year; Cliff and Dudley 1992). The community reached a tipping point and demanded the authorities intervene. Copying Australia's strategy, Durban's municipality deployed "shark nets" in 1952, and since then, no serious incidents have occurred (Dudley 1997, KwaZulu-Natal Sharks Board 2022). By the 1990s, there were 44 km of gillnets fishing at 40 beaches in KwaZulu-Natal, and they caught 120 target sharks annually, along with 1,600 animals caught incidentally, including non-target sharks, cetaceans, turtles, and rays; 70% of these died (Cliff and Dudley 2011, Plön et al. 2020). Various measures have been taken to reduce the ecological impact, and now 85 target sharks are caught annually, with 480 incidental catches, in 13 km of shark nets and 177 baited hooks fishing at 37 beaches (Fig. 1; Cliff and Dudley 2011; https://shark.co.za/wp-content/uploads/2023/11/RMD-Website-catches-2018-2022.docx).

Fig. 1. As of 2025, there are 37 beaches in KwaZulu-Natal, South Africa, with installations of shark nets (and recently also baited hooks). Seven of them are in Marine Protected Areas (MPAs), which are depicted in light blue boxes.



One of the beaches, Richards Bay (Fig. 1), has a high bycatch of humpback dolphins (*Sousa plumbea*) in the shark nets, indicating that this gear impacts Endangered dolphins as well as sharks, suggesting changes are required to mitigate mortality (Atkins et al. 2013, 2016, Braulik et al. 2023). This presented an opportunity to engage other stakeholders in the research–implementation space. Thus, a stakeholder analysis was conducted to identify those whose work intersects with various aspects of KwaZulu-Natal's bather–shark conflict; these stakeholders and their network were characterized, and their perceptions of the obstacles and opportunities to change this conflict were investigated (Atkins et al. 2023, 2024). To improve the likelihood of reducing this human–wildlife conflict, here we embed conservation science within social and decision processes.

We created a social learning platform so that diverse stakeholders in KwaZulu-Natal's bather–shark conflict could share their perspectives with one another and collaboratively design a way forward. Specifically, we investigate who would use the platform and why, how they would benefit from it, and which recommendations they might offer to reduce the bather–shark conflict following exposure to the perspectives of other stakeholders in this social-ecological system. We demonstrate the use of a social learning process by hosting a knowledge café to engage these stakeholders and encourage them to mutually develop their views of leveraging change that prevents shark mortalities without impacting bathers.

METHODS

Philosophical principles

The philosophical principles and theoretical assumptions of scientists can affect the design, execution, and interpretation of research and therefore should be reported (Moon et al. 2016). We used Moon and Blackman's (2014) guide to describe our principles. Our ontology was structural realism because we posit that one reality exists but how it is defined, measured, etc., makes it elusive. Our epistemology was constructionism because conservation is a social issue, with values and culture influencing interpretation, and therefore meaning is constructed from the interplay between subject and object. Our theoretical perspective was participatory, as we were deliberate participants in the process.

Identifying stakeholders

Stakeholders were identified in Stage One of the project (Atkins et al. 2023) using a combination of key-informant and purposive sampling (Bernard 2017), starting with the staff at the KwaZulu-Natal Sharks Board and the municipal Beach Manager at our focal beach, Richards Bay. We identified stakeholders who managed, sought to understand, and/or mitigate some aspect of the bather–shark conflict in their professional capacity. These are people who work in various parts of this social-ecological system and belong to the organizations that are most likely to initiate and/or implement any changes. We tried to sample a range of roles within each organization's hierarchy. Our final sample comprised 29 respondents whom we interviewed to investigate their perspectives of KwaZulu-Natal's bather–shark conflict (Atkins et al. 2023, 2024).

In Stage Two, we invited these 29 respondents to a stakeholder engagement—and invited another 15 stakeholders for three reasons: staff had changed, some stakeholders requested invitations for colleagues, and we became aware of other stakeholders, e.g., a social and a shark scientist, a new student, and a fine artist intrigued by the bather–shark conflict (Fig. 2). In total, we invited 44 people. The research was approved by the University of the Witwatersrand's Human Research Ethics Committee (Non-medical; Clearance Certificate H18/09/01).

The stakeholder engagement/social learning platform

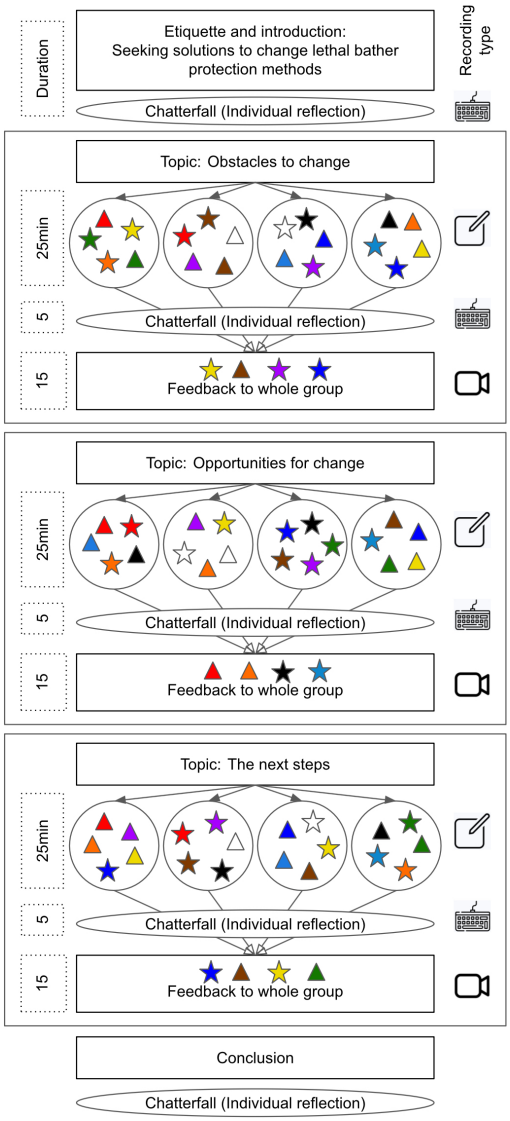
A social learning platform is defined here as an opportunity for social learning, which is "learning as a process of iterative reflection that occurs when we share our experiences, ideas and environments with others" (Armitage et al. 2008:88). This social learning platform took the form of a knowledge café in which a topic of mutual interest is discussed in several rounds in small groups, whose composition changes periodically (Steier and Brown 2015, Löhr et al. 2020). At knowledge cafés, the topic is introduced, a question or subtopic is posed, and the group splits into several smaller, break-away groups for discussion. Periodically, group membership changes and new questions or subtopics are discussed. The larger group is reconvened and insights are shared with everyone. The knowledge café format was chosen because it encourages cross-pollination of ideas, fosters collaborative learning, builds relationships, and allows participants to share information in an equitable, non-threatening manner (Fouché and Light 2011, Singh 2017). Like focus groups, it is a discursive method that facilitates dialog to gather and share knowledge, although the knowledge café allows more people to participate, with more participation among them (Löhr et al. 2020). In addition, power imbalances among participants may be diminished by the frequent changes in group membership (Löhr et al. 2020).

Fig. 2. "Conflicted" by Mandy Coppes-Martin, an example of artwork linking artists and viewers to the bather–shark conflict. This artwork offers a transdisciplinary element that broadens how the public engages with human–wildlife conflict and exemplifies how artists—like scientists, policy makers, and community members—interpret and connect with this issue, offering emotive resonance that complements empirical research (Strand et al. 2022). Reproduced here, with permission, to increase its accessibility and to highlight the value of diverse knowledge sources in transdisciplinary work.



The knowledge café took place online (using Zoom Video Communications Inc. 2016) on 1 March 2022, 09:00–13:00 h. Professional facilitators hosted the meeting and created a "thinking environment" (Kline 1999), emphasizing the principles of attention, equality, ease, and appreciation. We held discussions in three rounds (Fig. 3). Each round comprised 25 min. of discussion in four smaller groups (six to eight participants), followed by a brief opportunity for individual reflection (see "chatterfall" below), followed by 15 min. of feedback from smaller group representatives to the large group. This feedback was recorded with participants' permission.

Fig. 3. The knowledge café process and data sources. Each shape/color represents a figurative meeting participant and shows how group membership changed in rounds. Following an introduction, discussions were held in three rounds. Rounds were composed of (1) 25 min. in four small groups (notes were scribed in a shared online word processor), (2) a brief opportunity for individual reflection, which was typed in the chat facility of the teleconference platform (called Chatterfall), and (3) 15 min. of feedback by small-group representatives to the whole group (video-recorded). The composition of the small groups changed each round. A final opportunity for reflection was followed by the conclusion and thanks.



Data sources and analysis

Individual reflections were solicited by the facilitator using "chatterfall": participants were given a short time to type their perspectives into the "chat" function and then everyone simultaneously pressed "enter" to share their thoughts. Chatterfall was collected to investigate participants' motivation to use the social learning platform and perceived benefits. At the meeting's start, the facilitator asked, "Why did you say yes to being part of today's conversation? Why does being here matter to you?" At the meeting's end, the facilitator asked, "What did you appreciate the most about our time together today?" Multiple data sources were used to investigate the suggested next steps. During the last round of the knowledge café, the question was "How do we move forward? What are the next steps?" During the smaller-group discussions, participants captured notes in real time using a shared online word-processor. Following the discussion, the facilitator solicited chatterfall, asking "My top recommendation as a next step or action is..." Finally, a representative from each smaller group presented a verbal summary of their discussions. The recording (and its transcription) of these presentations constituted the main data source, supplemented by the notes and chatterfall.

The qualitative data captured in the recording, notes, and chatterfall were analyzed manually. We analyzed what was said, without trying to interpret the underlying meaning (Graneheim and Lundman 2004). One of us (SA) coded the data, reviewing the process and results with others (JML and SL). We used an inductive approach, creating codes directly from the data, using different coding approaches for each question to best reflect the nature of the responses, as described in Saldaña (2013). For question 2 (motivation), we first used process coding, which captures participants' actions and intentions using gerunds, to identify the essence of the responses and then used pattern coding to identify similarly coded data and group them into broader categories. For question 3 (benefits), we first used in vivo coding, which uses participants' own words as codes to preserve their voices and expressions, followed by pattern coding to group codes into shared themes. For question 4 (next steps), a single coding cycle sufficed. We themed the discussions, capturing the meaning as an extended thematic statement, i.e., the participants' discussion points, which were communicated in multiple sentences, were contracted and expressed as an action. Code lists are in Append. 1. We did not report any quantitative metrics because ideas expressed by a single participant were considered as valuable as those expressed by many.

RESULTS

Who attended?

Forty-four people from 22 organizations were invited, and 29 people from 17 organizations attended. Table 1 shows the organizations, their stakes in the conflict, and their attendance. Attendees represented (1) the KwaZulu-Natal Sharks Board, which manages the bather protection operation; (2) three levels of government—local, provincial and national; (3) Ezemvelo KwaZulu-Natal Wildlife (provincial conservation entity); (4) three non-governmental organizations (NGOs); (5) academics; (6) others. Invited organizations that did not attend included the

Table 1. The organizations invited to attend the knowledge café, the type and stakes of the organizations, and the number of attendees relative to the number of invitees. *One invitee, who could not attend, sent a representative in their stead. KwaZulu-Natal (KZN); South Africa (SA).

Stakeholder organization	Type of organization	Stakes	Attended/invited
KZN Sharks Board (KZNSB)	Provincial entity	Mandated to provide environmentally sensitive bather protection in KZN.	2/3*
KZN Dept. Economic Development, Tourism and Environmental Affairs	Provincial government	KZNSB's "controlling department." Grants two-thirds of the KZNSB's costs annually.	3/4*
Ezemvelo KZN Wildlife	Provincial entity	Conserves nature in KZN.	5/6
Tourism KZN	Provincial entity	Promotes tourism in KZN.	0/1
uMhlathuze Municipality	Local government	Mandated to provide beach amenities. Pay KZNSB for their service.	1/6
Dept. Forestry, Fisheries and Environment	National government	Issues operating and research permits to KZNSB. Administers the Shark Biodiversity Management Plan. Provides scientific information.	3/5*
South African National Biodiversity Institute	National government entity	Explores, reveals, celebrates, and champions biodiversity.	0/1
Various: SA Association for Marine Biological Research; WildTrust; Wildlife and Environment Society of SA; Endangered Wildlife Trust	Non-governmental organizations	Conserve biodiversity (and sustainable tourism in some cases).	5/6
Various: Universities of Stellenbosch, Pretoria, North West, South Africa, Oceanographic Research Institute, Oceans Research	Academia	Study species that are caught in the bather protection program and/or public perceptions of managing the risk of shark bites	6/7
Other: Shark Spotters, SharkSafe Barrier Pty. Ltd, City of Cape Town Coastal Manager; independent Fine Artist; independent Communications Specialist	Various	Various, e.g., provide/have developed/use non-lethal methods of bather protection; creates artworks on the human–wildlife conflict; volunteered to help create resources to increase awareness	4/5
Total			29/44

South African National Biodiversity Institute, Tourism KwaZulu-Natal, one NGO, and the City of Cape Town, which reduces shark risks non lethally. Invitees who were interviewed in Stage One but did not attend this meeting were more senior government representatives, e.g., departmental directors and heads (although some sent representatives). Only one of six invitees from the municipality attended, although it was a senior representative (acting Deputy Municipal Manager). Where reasons for not attending were offered, they included: reluctance to engage in potentially controversial discussions; higher priorities; ill health; technical difficulties with the online program.

What motivated them to attend?

Sixteen respondents offered five types of motivation for attending: (1) the drive to explore options to manage the human–wildlife conflict; (2) the need for change in managing the human–wildlife conflict; (3) the desire to make a difference; (4) an interest in the subject, which varied from general curiosity to a broad interest in human–wildlife interactions to a deep, long-lived interest in KwaZulu-Natal's bather–shark conflict; and (5) the desire to defend wildlife (quotes in Append. 1).

How did they benefit?

Eighteen respondents saw benefit in various aspects of the meeting. They particularly appreciated the people: how many people are invested in seeking solutions, being connected to like-minded people, and the extent of their combined knowledge. Some appreciated hearing diverse views. Others appreciated the willingness within the group—to work together, to learn, and for change. Some appreciated the discussions, which were described as constructive and level headed. Others appreciated the opportunity to contribute. Additional aspects included: the identification of actionable opportunities; the progress made; the passion; and the knowledge gained (quotes in Append. 1).

What are the potential next steps?

Participants proposed ten potential steps to accelerate change to conserve sharks without compromising bathers in KwaZulu-Natal (Table 2). These ten suggestions were grouped into three themes: collaborate, reuse existing knowledge and structures, and weigh up the costs and benefits (Fig. 4). Note that these suggestions are not prescriptive or binding but are actions that various organizations might undertake together in various combinations. Not everyone necessarily agreed with every suggestion, but these are the collective ideas of the participants, whose combined experience is considerable. There was no discussion regarding sequence. At the meeting's conclusion, 14 attendees from 12 organizations volunteered to initiate a working group to begin taking these next steps. Most were natural scientists, and there were representatives from the provincial and national governments.

DISCUSSION

A variety of stakeholders whose work intersected with the controversial bather–shark conflict, representing a diversity of institutions, were invited to a knowledge café. The aim was to create a social learning platform to improve our mutual understanding and consider improving the conservation status for sharks while still protecting people in KwaZulu-Natal. Two-thirds of the invitees attended, representing 77% of the invited organizations, indicating high levels of interest. Exchanges among stakeholders were constructive, and participants remained open minded—they welcomed the opportunity to engage others and to hear diverse views. They admired the willingness of the community to work together and were more forward focused than retrospective. Broadly, they proposed collaborating, using what exists, and weighing up costs/benefits (Fig. 4). Ultimately, half the participants volunteered to form a working group.

Table 2. During discussions at a knowledge café, potential actions to accelerate change were suggested by diverse stakeholders, whose work intersects with KwaZulu-Natal's bather–shark conflict. Discussions were themed, capturing the meaning expressed in multiple sentences as a single extended thematic statement. Quotes illustrate some aspects of the discussions.

Extended thematic statement	Case-specific description	Example quote(s)
Initiate a working group	Initiate a formal working group to support future engagement	"There's got to be some sort of expert panel or some working group that enables people to have a look at what is not only available in the province, but in the country, but also globally." [G4]
Communicate with decision makers	Work more closely with decision makers to improve our shared understanding of the conflict	"We need to target the key decision makers and support them. They need a clear understanding of the reality of shark nets—risk and impact." [G2]
Identify a champion	Identify government officials who support the cause and will bring attention to it	"[A participant] brought up a point about how it's worked in Cape Town and initially how the non-lethal beach safety was driven by a sort of champion within the municipality. [The participant] was just saying that Cape Town had one municipality—KZN is divided up into multiple municipalities so it's a bit different. But the important point there was that they had a municipal representative that was a champion for implementing non-lethal solutions. So, we were discussing how that might be translated into finding a champion from a body that has vested interests, either Sharks Board, beach managers, municipalities." [G2]
Collate and share existing information	Collate information that already exists within the country and beyond and make it accessible to decision makers	"There actually is enough information out there that's available, not only from government, but from scientists in general. And maybe the challenge that was evident is that the information is sitting in a place where it's not necessarily available to everyone and has not necessarily filtered down to policy." [G4] "We also looked at what's happening on an international perspective and what can we learn from there? South Africa is not unique in our "problem" regarding this human–wildlife conflict. We don't have to reinvent the wheel. There is global knowledge. There's a need to try and facilitate some sort of coordination of that information." [G2]
Leverage existing legislation	Make use of existing legislation, specifically Marine Protected Area legislation, to accelerate change	"And it was an interesting discussion in our group about the removal of nets in MPAs and the fact that, if we do that, especially the MPAs in the north, we can probably halve the catch without having a massive impact on the number of installations. That's something that we should really start pushing for." [G2]
Tap into existing programs	Use existing platforms like the Blue Flag Beach certification program	"And then also great input from [a participant] just about how, from the Blue Flag Beach management point of view, their organization is also very willing to collect information at their beaches about the beach users' perceptions etc. So, speaking to both the management and the research question at specific beaches." [G1]
Align with government frameworks	Align the work with existing government policies and strategies, e.g., the Shark Biodiversity Management Plan	"Research needs to speak to policy and strategies of government." [G4] "Do we hang on to the Shark Biodiversity [Management] Plan or do we hang it with something else, a tourism plan? How do we make it into the national program?" [G3]
Conduct site-specific cost:benefit analyses	Critically analyze beach-specific circumstances, factoring in tangible and intangible aspects of social and ecological factors	"So, we discussed sort of a cost:benefit analysis at each installation. Do the users actually want it? Does the municipality support it? Is it worth the money? Does it, you know, ensure beach safety? So again, it's being paid for... what's the cost:benefit at each installation? So, getting down to the detail. But then we also spoke about engaging with Sharks Board, looking at seasonal catches, looking at which sharks are caught when." [G1]
Assess the feasibility of multiple alternatives	Assess and prioritize multiple potential alternative strategies to be tested in KwaZulu-Natal	"We must be able to look at a variety of options. We need a structured research project looking at alternatives, their pros and cons." [G3]
Consider funding options	Explore different funding models	"How are we going to fund where we're heading to?" [G3]

We made a start to transdisciplinary learning

Although not specifically designed so, the social learning platform was actually a transdisciplinary learning platform as the stakeholders came from diverse institutions (e.g., governmental, non-governmental, academic) and had backgrounds across scientific and societal bodies of knowledge, including science, policy, and practice (Lang et al. 2012). These stakeholders started reconciling multiple perspectives, co-evolving their understanding of this social-ecological issue, and co-producing knowledge to create systemic change—all key transdisciplinary learning activities (Roux et al. 2017). We tapped into the knowledge (explicit and tacit) of stakeholders who understand different parts of this human–wildlife system to co-produce knowledge, which is defined as "the collaborative process of bringing a plurality of knowledge sources and types together to address a defined problem and build a systems-oriented understanding of that problem" (Armitage et al. 2011:996).

Considering the proposed next steps

Collaborate: mobilize diverse expertise and leadership

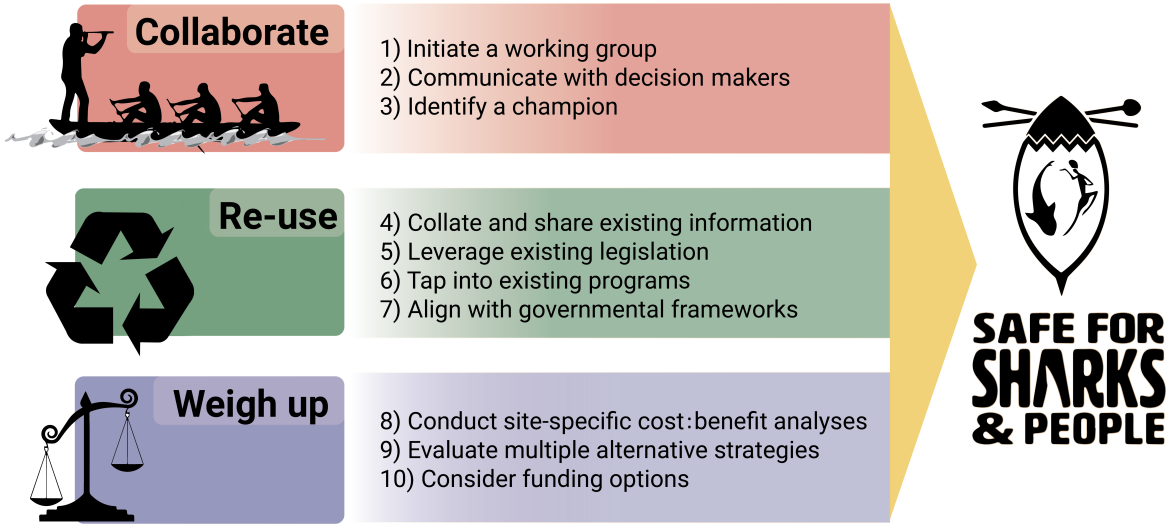
1. Initiate a working group

Participants suggested initiating an expert panel or working group to support reducing the ecological impact of KwaZulu-Natal's bather–shark conflict. Because such conflicts will not be solved by fact-based, expert-driven approaches alone (Simpfendorfer et al. 2021, Toomey 2023), and groups selected for their diversity can outperform groups of the best problem solvers (Hong and Page 2004), this working group should be transdisciplinary and purposefully incorporate the multiple perspectives—a strategy that helps to achieve adaptability and inclusivity, key principles of transformative ocean governance (Strand et al. 2022).

2. Communicate with decision makers

Throughout the knowledge café, communication with the public was discussed frequently. However, regarding the next steps,

Fig. 4. The proposed actions to promote change and reduce the bather–shark conflict in KwaZulu-Natal fell into three broad themes: Collaborate (mobilize diverse expertise and leadership); Re-use (utilize existing knowledge and structures); and Weigh up (consider costs and benefits).



communication with decision makers was prioritized. The human–shark conflict is complex, and decision makers must trade off social, political, economic, and ecological risks (Game et al. 2014, Hamman et al. 2016). Perceptions of risks influence decision making, and the risk of shark bites is invariably overestimated (Reynolds 2011, Crossley et al. 2014). Politically, biodiversity conservation is rarely prioritized, especially in countries with deep inequality and rising socio-economic needs (Kinzig and McShane 2015, Rose et al. 2018). Therefore, effective engagement with decision makers will require constructive engagement with differing values, perceptions, and politics; and reciprocal knowledge sharing is imperative going forward (Roux et al. 2006, Toomey et al. 2017, Infield et al. 2018).

3. Identify a champion

A participant noted that, in Cape Town, the policy of using only non-lethal bather protection was driven by a "champion" within the municipality. This champion convened a multidisciplinary specialist workshop to rationally assess shark-bite mitigation, shark conservation, recreational trends, emergency responses, governance, and communication (Nel and Peschak 2006). Generally, participatory processes are more likely to be accepted and implemented when initiated by government bodies, and champions in local government can positively affect the mainstreaming of environmental issues (Pasquini et al. 2015, De Vente et al. 2016). In our case, champions should be sought within the Sharks Board, among the municipalities, and/or provincial departments.

Re-use: utilize existing knowledge and structures

4. Collate and share existing information

The discussion suggested that much useful, empirical data already exist to support decision making but are not readily available. Therefore, participants suggested collating existing local, national, and international research and making it accessible to decision makers. A question of primary importance is: what are the differences between KwaZulu-Natal and other South African provinces that do not use lethal methods? When applying any of these national and international lessons, the unique, local context must be considered—a point raised by the participants (Step 7. Conduct beach-specific cost:benefit analyses) and within the human–wildlife conflict literature (Madden 2004).

5. Leverage existing legislation

Concern was expressed about lethal shark control inside Marine Protected Areas (MPAs). These areas are already valued for their high biodiversity, making a good starting point to elicit change. Currently, seven installations of shark nets and baited hooks are inside MPAs: Zinkwazi and Blythedale in uThukela MPA; Karridene, Umgababa, and Scottburgh in Aliwal Shoal MPA; and San Lameer and Trafalgar Beach in Trafalgar MPA (Fig. 1; CoastKZN https://maps.coastkzn.co.za/CoastKZN). A participant highlighted the high shark catch rate at Zinkwazi (Dudley and Cliff 2010); changes there would maximize the conservation return. Trafalgar is also a Blue Flag Beach, which yields additional opportunities (see step 6).

6. Tap into existing programs

The Blue Flag Beaches Program is an international certification system awarded to beaches with high environmental, educational, safety, and accessibility standards (Lucrezi et al. 2015). The Blue Flag implementation agent in South Africa, Wildlife and Environment Society of South Africa (WESSA), who participated in the knowledge café, offered the Blue Flag platform to conduct research, test innovations, and communicate with mutual stakeholders. Suggestions included: (1) investigate beach users' perceptions of human–shark interactions; (2) pilot changes at Blue Flag beaches and run concurrent social media campaigns to monitor people's reactions; (3) engage beach managers at Blue Flag workshops; and (4) use Blue Flag's progressive environmental management requirements to incentivize municipal decision making to test and/or adopt alternative strategies.

7. Align with governmental frameworks

This governance recommendation demonstrates the value of scientists and non-scientists learning together when trying to leverage change. Many types of conservation actions are fundamentally policy processes and require support/actions by government actors (Game et al. 2015). Explicitly linking the process of seeking solutions to existing government structures, policies, and/or strategies increases the salience and relevance to the government, likely facilitating their participation in the process and uptake of any recommendations. Participants noted the Shark Biodiversity Management Plan, which includes objectives of reducing shark catches and finding non-lethal methods to protect bathers. Aligning with provincial and municipal frameworks may also be prudent.

Weigh up: consider costs and benefits

8. Conduct site-specific cost:benefit analyses

According to the municipality representative, the financial cost of bather protection is high, yet no one has analyzed the costs vs. benefits. Each beach has unique ecological, physical, and social characteristics. Transdisciplinary teams that include beach managers (and MPA managers) should assess the economic and environmental costs vs. economic and social benefits of using lethal fishing gear. Beach-specific assessments could include the presence and behavior of target sharks, bathers, tourists, and bycatch, and local environmental conditions. Beach-specific assessments should also include the attitudes of bathers to human–shark interactions (e.g., Lucrezi and Gennari 2021, Sheridan et al. 2021), and those of lifeguards and local communities because intangible costs and benefits impact wildlife tolerance (Kansky et al. 2016). Niella et al. (2021) included some of these elements when assessing how changes to shark control may impact sharks and humans.

9. Evaluate multiple alternative strategies

Alternative methods to detect and deter sharks exist, although none is a silver bullet (McPhee et al. 2021). For example, the electrical shark repellent cable, a physiological shark deterrent, has been developed by the Sharks Board and described as "a non-lethal solution to the use of nets and drums, which are designed to catch and kill sharks" (KwaZulu-Natal Sharks Board 2021:54). Other alternatives include Shark Spotters (Engelbrecht et al. 2017) and technologies like the SharkSafe Barrier® (O'Connell et al. 2014) and drones (Colefax et al. 2020). However, all KwaZulu-Natal's shark-managed beaches are exposed to high-energy surf and have turbid waters (Dudley 1997), characteristics that make it difficult—logistically and financially—to use these alternatives. A new, innovative method is the SMART drumline, which enables a quick response to catches and relocation of target sharks (Guyomard et al. 2019, Butcher et al. 2023). Use of this expensive method reflects an increasing reluctance to harm marine megafauna. To date, none of these methods have been tested in KwaZulu-Natal. To identify options worth trying, transdisciplinary teams could assess the feasibility of each alternative against beach-specific circumstances, using processes like the participatory multi-criteria decision analysis (Marino et al. 2021). Multi-pronged approaches are generally recommended for human–wildlife conflicts (Madden 2004) and specifically for the bather–shark conflict (Huveneers et al. 2024). Non-technical strategies like education and community engagement were included as alternative strategies to reduce this conflict (Kock et al. 2012, Marchini et al. 2021, Simpfendorfer et al. 2021, Consorte-McCrea et al. 2022).

10. Consider funding options

The bather-protection program costs are borne by the provincial and local government (KwaZulu-Natal Sharks Board's Annual Reports). The funding for the steps proposed here should be sourced elsewhere. Suggestions included international conservation benefactors and/or the tourism industry. Madden (2004) recommends tying funding to the conflict, rather than a place or species, and encourages support for multidisciplinary, multi-pronged programs.

Usually, when human–wildlife conflicts are driven by wildlife impacts (rather than, e.g., resource use, environmental change, etc.), recommendations and responses involve technical interventions, not stakeholder interventions (Baynham-Herd et al. 2018). For example, in the shark-bite hotspot in New South Wales, the government commissioned a study to test and develop technological alternatives to lethal fishing gear (McPhee et al. 2021, Huveneers et al. 2024), although they followed up with a study of community perceptions (Martin et al. 2022). In another hotspot, Cape Town, South Africa, the local and national government organized an expert workshop to examine mitigation options (Nel and Peschak 2006). At that social learning platform, experts presented 15 papers on various aspects of the bather–shark system; recommendations resulted in the formalization of the Shark Spotter program.

Transdisciplinary social learning platforms like ours have recently been used to reduce conflicts with large carnivores, i.e., conducted with multi-stakeholder groups including government, NGOs, academics, and interest groups (Marchini et al. 2021, Salvatori et al. 2021). The recommendations resulting from these platforms, and ours, can be applied to human–wildlife conflicts elsewhere. However, to improve the chances of implementation of conservation action, it is the participatory process—the interactions among stakeholders—that is most valuable and likely to result in balanced, feasible human-safety and biodiversity-conservation goals. We recommend transdisciplinary learning platforms engaging stakeholders who drive and implement changes, as useful tools in conservationists' toolboxes to manage human–wildlife conflict more sustainably.

Limitations and future directions

During the preceding stage of the research, when we interviewed the same stakeholders individually, some differentiated between their personal views and their public/organizational views. On a public platform like this knowledge café, they likely shared only their public perspectives. Also, this study was designed with the research–implementation space in mind and focused on stakeholders whose work intersects with the bather–shark conflict, but the perspectives of bathers, fishers, and local businesses are also important. Future research should include them and follow König et al.'s (2021) methods, and establish similar dialogs internationally to conduct a cross-case analysis comparing strategies used in other human–wildlife conflict hotspots.

CONCLUSION

As scientists, we approached this research–implementation space by embedding ourselves within society and positioning our science to overlap with local knowledge and decision making (Toomey et al. 2017). We connected stakeholders and exposed them to the variety of perspectives that we had become aware of while studying KwaZulu-Natal's bather–shark conflict. The stakeholders used our social learning platform to explore options to reduce the conflict and to contribute to the change that is required. They valued the opportunity to hear the diversity of views and to connect with others who were invested in seeking solutions to protect both sharks and people. Perhaps this shifted perceptions of the social norm, which is more likely to yield optimal conservation decision making than simply providing facts (Toomey 2023).

Strengthening the social connections among the stakeholders in this social-ecological system may change the flow of information and ideas—a powerful lever to change a system (Abson et al. 2016). We hope that by improving the transdisciplinary links between various types of knowledge, socio-political conditions, and governance at multiple scales (van Kerkhoff and Lebel 2015), we have developed an effective strategy while garnering support for its implementation to improve the situation for sharks without compromising people's well-being.

The proposed next steps constitute possible actions and interactions that this community of organizations should consider, providing a foundational framework for collaborative efforts to address pressing social-ecological challenges. The diverse, transdisciplinary recommendations reflect the complexity of the problem, satisfying Ostrom's (2007) sage call to move beyond panaceas. These recommendations could be adopted in other human–wildlife conflicts because collaborations among those who are most interested and most influential will always be useful. Using existing resources before creating new ones is a sensible strategy for resource-poor countries where human–wildlife conflicts are on the rise (Seoraj-Pillai and Pillay 2016). Assessing the characteristics of each unique, local context and a variety of alternative solutions is a good way to recognize the pluralism that is inherent in every conflict.

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Data Availability:

The data and code that support the findings of this study are available on request from the corresponding author, [SA]. None of the data and code are publicly available because they contain information that could compromise the privacy of research participants. Ethical approval for this research study was granted by University of the Witwatersrand Human Research Ethics Committee (Non-medical): Ethics clearance certificate H180901.

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APPENDIX 1

Code list

Supplementary table 1. Coding structure for the question of motivation: "Why did you say yes to being part of today's conversation? Why does being here matter to you?" Participants were numbered according to their organization type, as per Table 1: provincial entity (PE), provincial government (PG), national government (NG), non-governmental organizations (NGO), academia (A), other (O).

Code	Detailed description	Inclusion criteria	Exclusion criteria	Typical exemplars – a few examples of data that best represent the code	Atypical exemplars – extreme or special examples of data that still represent the code	"Close, but no" – examples that could mistakenly be assigned this particular code
Exploring	The respondents describe being keen to explore the subject to find ways to improve human-wildlife conflict management or some aspect of it.	Use of words including: seeing, observing, learning, finding out, exploring - especially relative to the bather-shark conflict generally or some specific aspect of it.		"*To see how we can change/improve on current system used for bather protection*" [PG2]	*"To learn from other people and to gain further knowledge"* [PE3]	

Desiring change	The respondents describe their perceived need to see change or resolution or conservation.	Use of the word "need" and/or some aspect of change, including resolution and conservation.	Some other statements had the word change/resolve/conserve in them but were categorized differently - in those cases, change was preceded by words allocated to other categories, e.g. "to see".	*"I believe that we need to resolve conflict between sharks and humans in a meaningful way for humans and nature to conserve sharks and marine life for current & future generations"* [NGO5]	*"I am a conservationist at heart* 💔*"* [A4]	*"To see how we can change/improve on current system used for bather protection"* [PG2]
Personal Interest	The respondents describe an interest in the subject, varying from general curiosity to a broad interest in human-wildlife interactions to a deep, long-lived interest	Use of the words me and my, suggesting something personal, and words like curiosity and interest or an allusion to a deep interest.		*"The issue of human/animal interactions is interesting to me"* [NG1]	*"This has been part of my life for nearly 40 years"* [PE1]	
Contributing	The respondents describe the desire to contribute, help, make a difference, generally or to something specific, such as policy development.	Use of words such as contribute, help, make a difference.		*"Critical policy decisions come from research work and being involved in the research is your opportunity to contribute"* [NGO6]	*"Because I care about our oceans - and people. And I believe that this process can help both."* [NGO2]	

Defending wildlife	The respondent describes the desire to defend sharks.	"Fight for"		"*I want to fight for sharks and resolve the human-shark conflict*" [A2]		

Supplementary table 2. Coding structure for the question regarding the benefit of having used the social learning platform offered in response to the unfinished statement: "What I appreciated the most about our time together today is..." Participants were numbered according to their organization type, as per Table 1: provincial entity (PE), provincial government (PG), national government (NG), non-governmental organizations (NGO), academia (A), other (O).

Category of codes	Detailed description	Inclusion criteria	Exclusion criteria	Typical exemplars – a few examples of data that best represent the code	Atypical exemplars – extreme or special examples of data that still represent the code	"Close, but no" – examples that could mistakenly be assigned this particular code
People	Respondents described appreciation of various aspects of the **people** present at the meeting, including how many people are invested in seeking solutions, being connected to like-minded people, and the extent of their combined knowledge	Use of words like meeting and engaging people, often preceded by phrases like so many, such a lot. Also "how invested" and "people with years of combined knowledge"	When the word "people" was used but related to people being protected (like the general public).	*"That so many minds are trying to find solutions to protecting people and marine wildlife, for a sustainable future!"* [NGO4] *"Listening to such a diverse group of people with years of combined knowledge."* [PE3]		*"Good to see the passion around this contentious subject of killing sharks to protect people"* [PE1]

Hearing diverse views	This was about hearing the diversity of perspectives, thoughts and ideas, views.	Use of words and phrases including: diverse, diversity, different views		*"Great to hear the diversity of perspectives, thoughts and ideas."* [NGO5]		
Willingness	Respondents appreciated the willingness within the group - to work together, to learn and for change.	Use of willing/willingness		*"That everyone is willing to work together towards a common goal"* [NGO3]		
Discussion	Quite literally about discussions.	Use of the word discussion		*"Level headed discussions with intelligent inputs. Very refreshing to attend such a meeting"* [NG1]		
Opportunity	The opportunity to make a difference or contribute.	Use of opportunity and/or contribute	When the opportunities being referred to were more about managing the conflict itself, rather than the social learning platform.	*"wonderful experience and opportunity to make a difference"* [O3]		*"some clear opportunities for change - that do not require years of research to action."* [NGO2]
Miscellaneous	Five responses that did not fit in other categories.			*"We are making steps towards protecting sharks, those marvelous creatures that deserve our care."*		

				[A2] *"I have learned a lot."* [PE3]		