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Articulating the dynamics among stakeholders in KwaZulu-Natal's bather-shark conflict to create a productive research-implementation space

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ABSTRACT

Research-implementation gaps pervade conservation practice. However, reconceptualising these gaps as productive learning spaces for stakeholder engagement can yield solutions. The first step in this process is to identify the stakeholders to engage in this research-implementation space and understand their relationships. An important research-implementation gap arose when research showed that fishing gear, set on South Africa's east coast to protect bathers from sharks, was a threat to endangered dolphins that were caught incidentally. It became apparent that it was necessary to improve our understanding of the social aspects of the human-wildlife conflict involving bathers and sharks. In this study, we aimed to (i) identify stakeholders in this bather-shark conflict and their involvement and (ii) describe the dynamics among these stakeholders. We interviewed 29 stakeholders whose work intersects with the conflict, assessed perceptions of their influence and interest, and the structure of their communication network. We found that governance is top-down and the communication network is small with limited information flow about non-lethal alternatives to the current fishing method. Since power dynamics impact conservation initiatives, articulating the relative decision-making positions may aid future negotiations for conservation. In small networks, such as this one, improving connectivity and thus information flow can transform the system. Forming a Working Group composed of interested and affected stakeholders who contribute knowledge and diverse perspectives could make governance more inclusive and improve network connectivity. Our research simultaneously identified who to work with in this research-implementation space and began the process of learning together to improve the flow of information.

1. Introduction

Research-implementation gaps pervade conservation practice. They have been defined as a lack of progression from the scientific evaluation of valued elements of nature to the activities required to maintain or enhance those elements (Knight et al., 2008). The term "gap" has negative connotations and suggests a deficit. Reframing it as a "space for interaction" has more positive connotations and could yield new ways of considering how to connect research and implementation (Toomey et al., 2016). In this reconceptualised research-implementation space, various stakeholders should be included, ensuring inclusion of scientists, decision-makers and others holding local knowledge, values and rules (Toomey et al., 2016). In fact, it is more than just including these various stakeholders - they need to be empowered, which can be achieved by establishing social learning institutions that provide for adaptive management (Knight et al., 2006).

Once the need to work in a productive learning space between research and implementation has been highlighted, the first step is logically to identify who needs to be engaged by conducting a stakeholder analysis. Such analyses can be as simple as identifying who affects or is affected by a process, or it can extend beyond just identifying stakeholders and include a better understanding of the stakeholders. Good practice in stakeholder analyses for natural resource management recommends a careful definition of the context before identifying stakeholders (Reed et al., 2009). Defining the context involves establishing the focus and the system boundaries, and investigating the

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stakeholders involves identifying who is interested and affected and understanding the relationships between them.

Two types of relationships are of particular interest. First, the way power dynamics are managed among stakeholders can contribute to the success or failure of conflict resolution (Reed et al., 2018). Therefore, elucidating how power is distributed among stakeholders is useful to enhance the transparency and equity of decision-making. Second, information flow through the stakeholder network can affect governance and the implementation of management actions (Bodin and Crona, 2009). The structure of such networks formed among stakeholders—how sparse or dense their communication connections are, and how clustered into cohesive subgroups the stakeholders are— have important implications for how information flows and can modulate conservation decision-making processes (Bodin and Crona, 2009).

1.1. The research-implementation space in a human-wildlife conflict regarding sharks, bathers and bycatch

A research-implementation space arose in KwaZulu-Natal, South Africa, when evidence showed that shark nets, set to protect bathers from sharks, threatened the ongoing population viability of Endangered Indian Ocean humpback dolphins, *Sousa plumbea,* that are caught incidentally as bycatch (Atkins et al., 2013, 2016; Braulik et al., 2023). The managers of the shark netting programme, the KwaZulu-Natal Sharks Board (hereafter Sharks Board), were concerned about the impact of the nets on the dolphins and, in August 2016, proposed implementing changes at Richards Bay (−28.84121; 31.992159), a beach with the highest bycatch of humpback dolphin. However, implementing the changes was delayed for reasons that are not well understood. In the meanwhile, those concerned about the wider impact of the nets on dolphins realised that the problem would not be solved by approaching it as a bycatch issue focused on the dolphins, but that it was necessary to understand the larger social-ecological system (Knight et al., 2019) composed of bathers and the sharks that pose a risk to them, as well as those who are interested in the management of that risk.

In KwaZulu-Natal, between 1940 and 1962, 62 people were bitten by sharks and sustained serious injuries, 24 of whom died (Wallett, 1983; Cliff, 1991). The affected coastal community was traumatised, the vital tourism economy was negatively impacted, and the public demanded that the authorities provide protection (Davis et al., 1995). In response, local municipalities set gillnets to catch and kill sharks to reduce their numbers and hence the risk to bathers (Dudley and Cliff, 1993). These gillnets, known locally as shark nets, do not only catch the three species of sharks that are potentially dangerous to bathers, i.e. Zambezi *Carcharhinus leucas*, white *Carcharodon carcharias* and tiger *Galeocerdo cuvier* sharks (Chapman and McPhee, 2016), they also catch a variety of other large marine species incidentally: non-target sharks, cetaceans, turtles and other elasmobranchs (Cliff and Dudley, 2011).

This situation, where sharks have harmed humans and humans have reacted by harming sharks (and other marine wildlife), can be framed as a human-wildlife conflict (Nyhus, 2016). In addition to the direct impacts, there are indirect effects, such as impacts on tourism economy, ecological health of the marine ecosystem where the fishing gear is deployed, and conflicts between people about conservation (IUCN, 2023). The Sharks Board have strived to reduce the negative ecological impact of the nets, most recently by replacing many shark nets with baited hooks (called drumlines) which are far more selective and have a reduced bycatch of cetaceans, turtles and some non-target elasmobranch species (Cliff and Dudley, 2011). Many of the species that are caught are on the IUCN's Red List of Threatened Species: 24 of 30 species with published catch data are Vulnerable, Endangered, or Critically Endangered (Supplementary Material Table 1). Therefore, it is necessary to find a solution that protects bathers without killing sharks and other animals.

This bather-shark conflict is complex and balancing the risks to humans and to marine wildlife does involve trade-offs. No one person or organisation currently has a solution for the conflict in KwaZulu-Natal as the harsh and turbid sea conditions make it difficult to use methods other than the fishing gear which is placed beyond the surf zone (Dudley, 1997; McPhee et al., 2021). However, collectively, stakeholders may be able to find potential solutions. Therefore, we aimed to ascertain who to collaborate with in creating a productive learning space linking conservation research and implementation in the bather-shark conflict. Here, we identified who is involved in the bather-shark conflict, defined the nature of their involvement and endeavoured to understand the dynamics among the stakeholders, in terms of decision-making power and the flow of information. We conducted individual interviews and surveyed the perceptions of key informants to investigate stakeholders' interest in, and influence over, which methods are used to protect bathers, and the structure of the stakeholder network.

2. Methods

2.1. Philosophical principles and system boundaries

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., 2019). We used Moon and Blackman's (2014) guide to understand these social science principles. Our research ontology was structural realism in which we posit one reality exists but how it is defined and measured makes it elusive. Our epistemology was constructionism because values and culture influence people's interpretation and understanding of conservation issues, which suggests that meaning is constructed from the interplay between the subject and the object. Our theoretical perspective was social constructivism, i.e. we suggest that meaning is in humans' construction of reality.

The point of departure for a stakeholder analysis is to define the context and clearly identify the issue under investigation to establish the boundaries of the social and ecological phenomena (Reed et al., 2009). In this study, the issue under investigation was the system that manages the interactions between humans and sharks at beaches in KwaZulu-Natal, South Africa, that involve the risk of injury or death to humans or sharks. Central to the issue is the current use of lethal methods (i.e. shark nets and baited hooks) to mitigate the risk to bathers which threatens biodiversity, ecosystem health and animal welfare. Therefore, our focus was on modifying the system to reduce the impact on sharks and other marine megafauna without increasing the risk to people. Because our ultimate goal was to bring about the implementation of conservation actions, we intentionally focused on stakeholders who are most likely to be engaged in the bather-shark system professionally, i.e. those whose work intersects with either the drivers of the conflict (e.g. tourism and bather protection) or with the consequences of the conflict (e.g. conservation of sharks and marine biodiversity). We focused on one location, Richards Bay, because shark nets deployed here for over four decades have had a particularly high bycatch of humpback dolphins and non-target sharks (Dudley and Cliff, 2010; Atkins et al., 2013).

2.2. Stakeholders and their stakes

Stakeholders were identified using a combination of key informant and purposive sampling (Bernard, 2013). We began with the staff at the Sharks Board and the Richards Bay municipal Beach Manager. We asked them and subsequent respondents how their work related to the bather-shark conflict. We also asked who else they knew whose work was linked to this conflict. We identified stakeholders who managed, sought to understand and/or mitigate some aspect of the bather-shark conflict in their professional capacity. These people work in various parts of this social-ecological system and are employed by organisations that are most likely to initiate and/or implement changes. We aimed to sample a range of roles within each organisation and at different levels

within the organisations' hierarchies. While not exhaustive, we believe that our sampling strategy covered many, if not most of the stakeholders that are most closely involved in KwaZulu-Natal.

We conducted all interviews between March 2019 and April 2021. We invited 40 stakeholders, representing a range of organisations, to participate in individually conducted, semi-structured interviews. Of these, 33 consented, and seven declined or did not respond to the request. We conducted 30 interviews in-person and three virtually. Potential respondents were provided with information as per the ethical procedure required of the University of the Witwatersrand's Human Research Ethics Committee (Non-medical) (Clearance Certificate Protocol H18/09/01). Four interviewees did not meet the criterion of a close, recent link with the bather-shark conflict, and although the interviews were completed, their data were not included in the analysis. The final sample comprised 29 respondents.

All but two of the interviews were voice-recorded and transcribed verbatim. For the two who preferred not to be recorded, detailed notes were made during the interview and then sent to the interviewees for approval and correction to ensure that their answers had been captured accurately. To describe the various organisations' involvement (stakes), we used both information gained during the interviews and the literature, such as peer-reviewed publications, legislation, annual reports and organisational websites. For example, the description of the Sharks Board's involvement was supplied by the interviewees from the Sharks Board, as well as the literature. To protect our interviewees' privacy, we only identified people by their organisations, and sometimes by their positions, not by their names.

2.3. Interest and influence

When most of the interviews had been completed (20 of the 33 interviews), we identified key informants (at least one person within each stakeholder organisation) who were likely to provide additional information. We asked these key informants about their perceptions of the influence and interest of other stakeholders. This assessment involved a brief questionnaire emailed to 13 key informants from nine organisations. We presented a list of 20 stakeholders to the key informants and asked them: "For each of the stakeholder positions presented, please rate out of 10 (1 lowest and 10 highest) your perceptions of their influence (the capacity to affect what type of methods are used to protect bathers) and their interest (in a variety of methods of bather protection)". These 20 stakeholders were identified by their position within organisations rather than by their name, e.g. Head of Research, KwaZulu-Natal Sharks Board; Beach Manager, uMhlathuze municipality; Director, Department of Forestry, Fisheries and the Environment: Ocean Conservation strategies. All 13 key informants were on this list, plus seven other stakeholders that we had interviewed at that stage. We received replies from eight interviewees, representing seven organisations. Using the key informants' ratings, we calculated mean and standard deviation (SD) of the score for the influence and interest of each organisation. These results were plotted on a graph that was then divided into 4 equal-sized quadrants and labelled Key Players (high influence, high interest), Context Setters (high influence, low interest), Subjects (low influence, high interest), and Crowds (low influence, low interest), following the approach described by Reed et al. (2009).

2.4. Stakeholder network

We defined a communication network among the interviewed stakeholders as a set of nodes representing the stakeholders linked by edges denoting professional contacts and interactions through which information is communicated (Aggarwal, 2011). To define the network edges, we asked the same key informants (described in section 2.3 above) to report the frequency with which they communicated with the other stakeholders. Specifically, we asked, "For each of the stakeholder positions presented: 1) How often do you communicate with this stakeholder? 2) How often do you communicate about the use of non-lethal methods to protect bathers?" They could choose categorical measures of frequency (daily, weekly, monthly, annually, never, other), which were then converted to numeric measures: "daily" was converted to 365, "weekly" to 52, "monthly" to 12, "annually" to 1, "never" to 0; "other" included reports of "quarterly", "biannually", "occasionally" and "as needed" which were converted to 4, to 2, 0.5, and NA respectively. Using each of these self-reported frequencies of communication, we constructed two directed, weighted networks in which nodes representing individual stakeholders were linked by edges whose direction indicated who cited whom, and the thicknesses were proportional to the cited frequency of communication between them.

To investigate the structural properties of the networks, as well as the role of individuals and organisations on the flow of information in the networks, we used four network metrics: connectance, modularity, cohesiveness and centrality (detailed in Newman, 2018). First, to estimate the density of the communication networks, we calculated their connectance as the proportion of realised edges (communication links between stakeholders), relative to the maximum number of edges possible. High connectance indicates highly connected networks, through which information can potentially flow quickly and more directly than in sparse networks (e.g. Cantor and Whitehead, 2013). Second, to estimate levels of network clustering and subgroup interconnectivity, we calculated network modularity (Q) and tested statistical significance with a null model approach. Modularity informs us about the existence of densely connected subgroups (Newman, 2006); in this case, subsets of stakeholders that communicate more with each other than with the rest of the network. We used a swapping algorithm to generate an ensemble of 1000 permuted networks of the same size of the originals by shuffling edges among nodes (Gotelli and Entsminger, 2001), and calculated modularity to all of them to create a theoretical distribution of Q-values to which we compared the observed modularity. Modularity was considered significant if it fell outside of the 95% confidence interval (CI) of this distribution. Third, to measure the degree of cohesiveness of the networks, we calculated closeness centralisation, a summary of centrality by closeness (Freeman, 1979) for the whole network. Closeness centrality is the reciprocal of the sum of the length of the shortest paths between the node (stakeholder) and all other nodes in the network, and it informs us how 'close' individuals are in the network via their connections, and who are best placed to influence the flow of information through the entire network. We also calculated the node-based closeness centrality for each stakeholder in both communication networks. Finally, we calculated betweenness centrality, another metric of social centrality (Freeman, 1979), to consider the number of shortest paths (here, shortest chains of communication) that pass through a given stakeholder. Stakeholders that are peripheral in the communication network have zero betweenness, while individuals who connect otherwise discrete subgroups have particularly high betweenness, and so have a particularly high influence on the spread of the information. All network analyses were performed in R (R Core Team, 2014) using the package igraph (Csardi and Nepusz, 2006).

3. Results

3.1. Stakeholders and their stakes

Various organisations have stakes in the bather-shark conflict (Table 1). The KwaZulu-Natal Sharks Board is mandated to protect bathers from the risk of shark bites while minimising environmental impact (KwaZulu-Natal Sharks Board Act, No. 05 of 2008). The objectives of this Board are to undertake, initiate, control and approve measures for safeguarding bathers against shark attack in the province and perform the powers, duties and functions that pertain to this objective (KwaZulu-Natal Sharks Board Act, No. 05 of 2008). It is a provincial public entity and falls under the Department of Economic Development, Tourism and Environmental Affairs (EDTEA). Almost two thirds of the

Table 1
The stakeholders in the KZN bather-shark conflict, the organisations involved, their stakes and the number of representatives interviewed and the number of key informants that responded to our survey regarding their perceptions of influence and interest, and communication frequency. KZN = KwaZulu-Natal; KZNSB = KZN Sharks Board; SA = South Africa.

Stakeholder organisation	Type of organisation	Stakes	Interviews analysed/ invited	Key informant responses received/ solicited
KZN Sharks Board	Provincial entity	Mandated to provide environmentally-sensitive bather protection in KZN.	3/6	2/3
KZN Dept. Economic Development, Tourism & Environmental Affairs	Provincial government	KZNSB's "controlling department". Grants 2/3 of the KZNSB's costs annually.	4/5	1/2
Ezemvelo KZN Wildlife	Provincial entity	Conserves nature in KZN.	4/5	1/2
Tourism KZN	Provincial entity	Promotes tourism in KZN.	1/1	
uMhlathuze Municipality	Local government	Mandated to provide beach amenities. Pay KZNSB for their service.	3/5	0/1
City of Cape Town (note: not in KZN but Western Cape)	Local government	Mandated to provide beach amenities. Has a bather protection policy that is not lethal to sharks. Received guidance from KZNSB.	1/1	
Dept. Forestry, Fisheries & Environment: Oceans Conservation Strategies	National government	Issues an operating permit to KZNSB. Administers the Shark Biodiversity Management Plan.	2/2	1/1
Dept. Forestry, Fisheries & Environment: Biodiversity & Coastal Research	National government	Provides scientific information to other dept, e.g. Oceans Conservation Strategies, and research permits to KZNSB.	3/3	0/1
Dept. Forestry, Fisheries & Environment: Fisheries	National government	Researches shark catches in South Africa.	0/1	
South African National Biodiversity Institute	National entity	Explores, reveals, celebrates and champions biodiversity.	0/2	
Various: SA Association for Marine Biological Research; WildTrust; Wildlife & Environment Society of SA; Endangered Wildlife Trust	Non-governmental organisations	Conserve biodiversity (and sustainable tourism in some cases).	4/5	2/2
SouSA Consortium	Consortium of researchers	Studies the conservation biology of endangered humpback dolphins in SA.	1/1	
Nelson Mandela University	Academic	Studies dolphins caught in shark nets.	1/1	
SharkSpotters	Non-profit organisation	Reduces interactions and conflict between bathers and sharks using non-lethal methods.	1/1	1/1
SharkSafe Barrier	Pty Ltd	Has developed non-lethal bather protection equipment.	1/1	
Total			29/40	8/13

Sharks Board's income is granted by the provincial government (KwaZulu-Natal Sharks Board Annual Reports, 2015–2022). The Member of the Executive Council (MEC) who oversees the activities of EDTEA, is ultimately accountable as the executive authority. The MEC appoints a Board of Directors which appoints a Chief Executive Officer responsible for the administrative and financial management of the Board, and for the appointment and management of staff (KwaZulu-Natal Sharks Board Act, No. 05 of 2008). In 2022, there were 143 staff members (KwaZulu-Natal Sharks Board Annual Report, 2022). The main activities of the organisation include: 1) providing bather protection; 2) conducting research into the biology of sharks and other animals caught and developing alternative methods of protecting bathers; and 3) conducting public education and outreach programmes on sharks, safe bathing and the activities of the Sharks Board (KwaZulu-Natal Sharks Board Annual Report, 2022).

Another primary stakeholder is the local government (local municipalities). Providing beach amenities is a mandated function of the local government (Integrated Coastal Management Act, No. 24 of 2008). In KwaZulu-Natal, the coastal municipalities contract and pay the Sharks Board to provide bather protection from sharks. There are five coastal municipalities, and their combined fees constitute about one third of the Sharks Board's annual income (KwaZulu-Natal Sharks Board Annual Reports, 2015–2022). Originally, in the 1950s, 60s and early 70s, the municipalities were responsible for maintaining the shark nets deployed at their beaches, but in 1974, the task was assigned to the Natal Anti-Shark Measures Board, now the KwaZulu-Natal Sharks Board (Dudley and Cliff, 1993; Powell, 2017).

The national government is another stakeholder because the South African National Environmental Management: Biodiversity Act, No. 10 of 2004 provides for the management and conservation of biological diversity and governance in biodiversity management and conservation. Related to this, the Threatened or Protected Species regulations (2017) regulate specific restricted activities involving specimens of listed threatened or protected marine species. The Sharks Board's use of gill-nets and baited hooks involves restricted activities: catching, releasing and being in possession of several species that are listed in these regulations. Therefore, the Sharks Board applies to the national Department of Forestry, Fisheries and the Environment's (DFFE) Ocean Conservation Strategies annually for a permit for the operation. In addition, this branch administers the national Shark Biodiversity Management Plan (2015) which includes KwaZulu-Natal's bather protection issue. Another branch within the DFFE - Biodiversity and Coastal Research - contributes information to the permitting process and the Shark Biodiversity Management Plan, and they also issue research permits to the Sharks Board. Because the Sharks Board's operation constitutes a fishery, a third DFFE branch, Fisheries Management, analyses some of the Sharks Board's catch data (da Silva et al., 2015; Wintner and Kerwath, 2017; Department of Forestry, Fisheries and the Environment, 2022).

Other government entities are also stakeholders. The provincial Ezemvelo KZN Wildlife (KwaZulu-Natal Nature Conservation Act, No. 9

of 1997) and the national South African National Biodiversity Institute (National Environmental Management Biodiversity Act, No. 109 of 2004) are both involved in conservation of biodiversity. Tourism KZN is tasked with promoting tourism in KwaZulu-Natal and dealing with activities that could have an impact on tourism (KwaZulu-Natal Tourism Amendment Act, No. 2 of 2002). In addition, various non-government organisations are involved because of research projects to understand and mitigate the bycatch issue, raising awareness about the bather protection programme or sustainable tourism programmes. The list of non-government organisations identified is not exhaustive but it is representative of those with strong connections to the bather-shark conflict in KwaZulu-Natal. Several academics conduct research on catches in the fishing gear (e.g. Plön et al., 2012, 2020) and humpback dolphin conservation in South Africa (SouSA Consortium: Vermeulen et al., 2018; Plön et al., 2021).

Further afield in the Western Cape Province, a series of shark bites, some fatal, threatened coastal tourism in the 2000s. The City of Cape Town (local government), in consultation with various stakeholders, including the Sharks Board, considered various approaches to bather protection, and opted to use non-lethal methods rather than shark nets (Nel and Peschak, 2006). They use the Shark Spotters, a Public-Benefit organisation that deploys trained observers that watch for sharks and warn bathers of their presence (Engelbrecht et al., 2017). There is also a South African proprietary company, the SharkSafe Barrier Pty Ltd, which has developed a non-lethal method of protecting bathers (O'Connell et al., 2014).

3.2. Influence and interest

The brief questionnaires that were sent to the key informants (Table 1) yielded individual ratings of the perceived influence and interest of many of the stakeholders. When these were averaged by organisation, it showed that the mean (SD) influence and interest of the organisations varied (Fig. 1). The Sharks Board, national and provincial government were perceived as Key Players, with high influence and high interest in the type of methods used for bather protection. The local government was perceived as a Context Setter with high influence but less interest. The provincial conservation and tourism entities and the NGOs were perceived as Subjects with high interest but low influence. No one within the stakeholder community was perceived as lacking both influence and interest.

There was variability in perceptions (i.e. large standard deviations in Fig. 1). For instance, although perceptions of the influence of the Sharks Board were quite consistent, perceptions of their interest in alternative methods were more variable. There was also large variability in perceptions of the provincial government's interest. Generally, there was greater variability in perceptions of interest than influence.

3.3. Stakeholder communication network properties

The weighted, directed network of the reported frequency of general communication among the stakeholders (Fig. 2a) was a benchmark against which to consider the weighted directed network of communication about non-lethal alternatives specifically (Fig. 2b). In terms of the density of the communication network, there were 63 communication links (edges) among 19 of the 20 interviewees resulting in a low network connectance (C = 0.184), i.e. about 20% of the possible communication links

between stakeholders were realised generally. By contrast, there were only 24 communication links specifically about non-lethal alternative methods of protecting bathers and these occurred among only 12 interviewed stakeholders. Relative to the maximal number of edges in the general (benchmark) communication network containing all interviewed stakeholders, the connectance of the network of communication about non-lethal alternatives is much lower (C = 0.07). These findings suggest that the overall communication is relatively low, especially regarding non-lethal alternatives methods of protecting bathers.

In the general (benchmark) network, modularity (i.e. levels of clustering into subgroups) was high and significant (Q = 0.542, 95%CI = 0.132–0.279). This suggested a reliable division (Q > 0.3; Newman, 2006) of the network of general communication into seven clusters. In contrast, the communication network about non-lethal alternatives did not have reliable divisions, as the modularity was low and nonsignificant (Q = 0.132, 95%CI = 0.125–0.353). In terms of the degree of cohesiveness of the network, the network-level closeness centralisation (Cc) of the benchmark communication network (Cc = 0.51) was a small

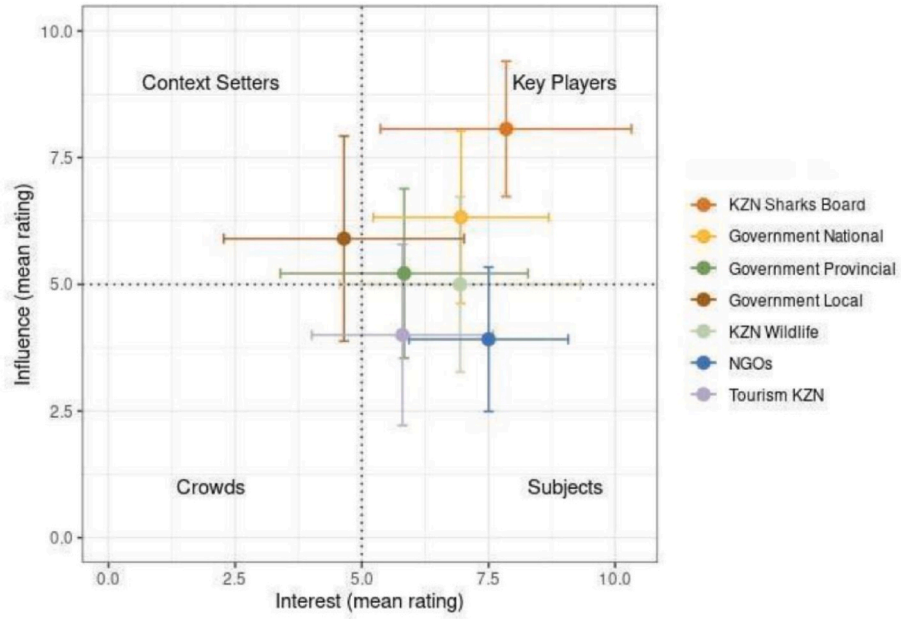


Fig. 1. The perceived influence and interest of the stakeholder organisations. Average (± standard deviation) scores of key informants' perceptions positioned the stakeholder organisations in terms of their influence on the type of methods used to protect bathers and their interest in the variety of alternative methods available for bather protection.

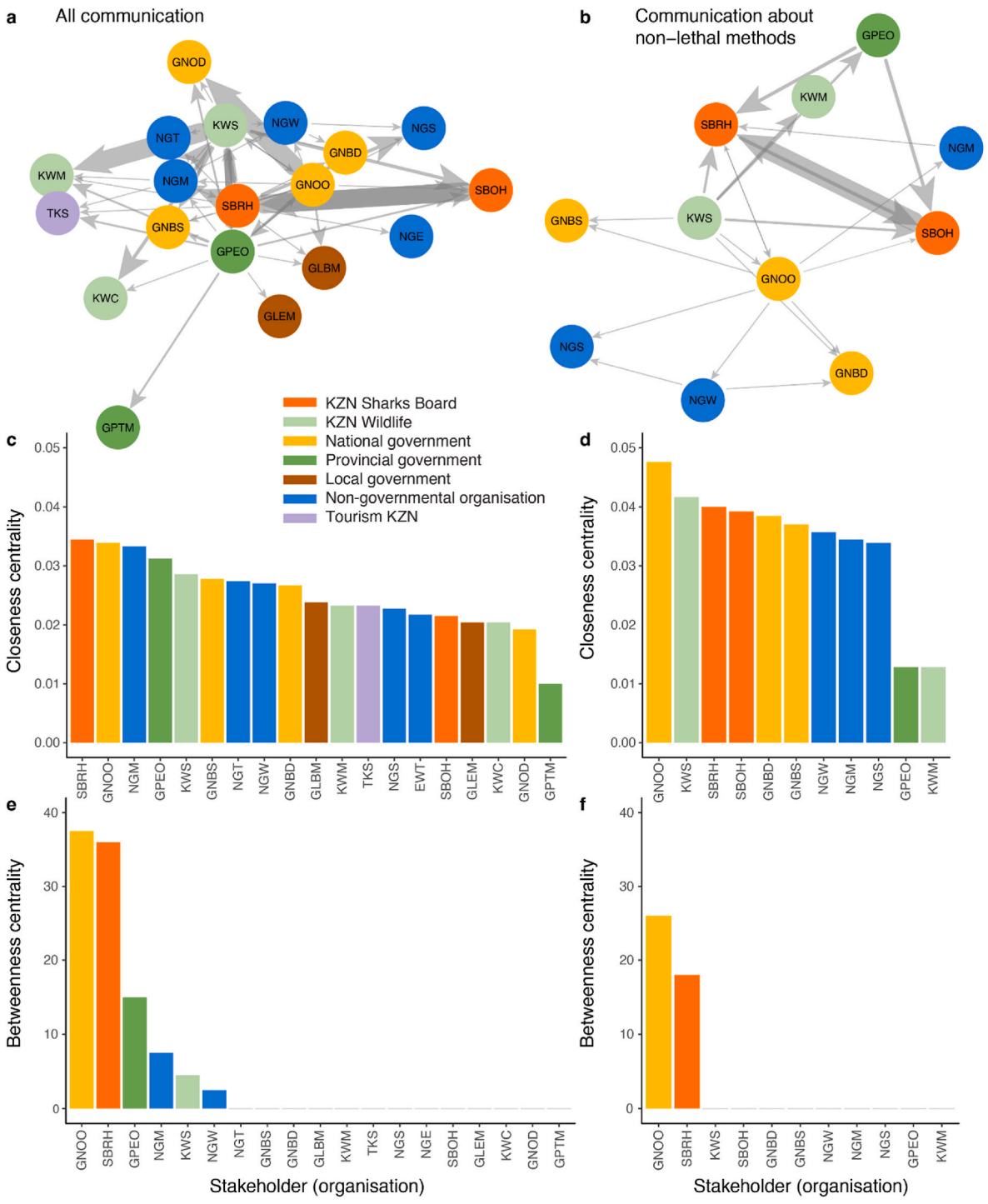


Fig. 2. Communication networks among stakeholders in the KwaZulu-Natal (KZN) bather-shark conflict. Networks depicting communication flows among the interviewees as reported by key informants: (a) general communication and (b) communication that is specifically about non-lethal alternatives to bather protection fishing gear in KZN, South Africa. The thickness of the network edges indicates the relative frequency of communication. Stakeholders are anonymised and categorised by their organisation type (details in Supplementary Table S2). The closeness scores of individuals within (c) the general network and (d) the sub-network that communicates about non-lethal methods of bather protection indicate which individuals influence the flow of information through the network. Betweenness centrality of individual stakeholders in (e) the general network and (f) the sub-network that communicates about non-lethal methods of bather protection indicate which individuals connect otherwise discrete subgroups.

fraction of the theoretical maximum of the most centralised network with the same number of nodes, which would be 8.74 (Fig. 2c). For the network of communication regarding non-lethal alternatives, the centralisation was 0.54, i.e. it is slightly more organised around a few nodes, particularly DFFE Ocean Conservation Strategies Control Environment Officer, followed by Sharks Board Head of Research and Ezemvelo KZN Wildlife Marine Scientist (Fig. 2d).

Regarding the network positions influencing the communication flow, we found that those from the Sharks Board and the National Government had a disproportionately high betweenness centrality both in the benchmark communication network (Fig. 2e) and were the only central positions in the communication network about non-lethal

alternatives (Fig. 2f). All other stakeholders and organisations can be considered at the periphery of the communication network regarding non-lethal alternatives, with little to no participation in the communication flow, as they had zero betweenness centrality (Fig. 2f).

4. Discussion

We aimed to begin the process of enabling a productive learning space between conservation research and implementation. We conducted interviews that revealed unprecedented detail about the stakeholders in the bather-shark conflict in KwaZulu-Natal, South Africa. By characterising the key stakeholders and the dynamics between them, our analyses showed that the most influential and interested stakeholder was the Sharks Board, a provincial public entity that is legislated to protect bathers in KwaZulu-Natal from the risk of shark bites and to conduct research and education pertaining to this issue. They provide this bather protection service to the local municipalities which were perceived as influential but lacking interest. The programme is heavily subsidised by the provincial government and perceptions of their influence and interest were variable but generally rated as high. The national government, which issues a permit to handle protected species, was perceived as the second-most influential and interested stakeholder organisation. The great interest of most of the conservation organisations (provincial and NGOs) was recognised, as was their lack of influence. Few stakeholders communicated regularly about alternative methods of bather protection, and among these, the Sharks Board and the national government occupied a central role in the communication flow.

In the bather-shark conflict, our findings showed that power is unevenly distributed, and that governance is top-down. There was high interest among most of the stakeholders regarding which methods are used for bather protection. Six of the seven stakeholder organisations were perceived as interested compared to four of the seven perceived as influential. The Sharks Board and the three levels of government are perceived to hold all the power. Only the local government was perceived to lack interest and their key informant did not respond to the survey. They also did not respond officially to the Sharks Board's request to approve the replacement of some shark nets with baited hooks, triggering the research-implementation gap that prompted this study. As one of the interviewees (who was not a key informant) observed: "*In KwaZulu-Natal, the decision-making responsibility has been outsourced to the Sharks Board.*"

Our study also revealed that the stakeholders of the bather-shark conflict form a small professional network with limited communication, particularly regarding non-lethal alternatives to bather protection fishing gear. The Sharks Board and national government representatives are best placed to influence the entire communication network and have the highest influence on the spread of information. Yet, the communication is predominantly internal to the Sharks Board. Occasionally they communicate with DFFE staff regarding alternatives who sometimes communicate with others.

Assessing influence and interest individually and numerically provides new insights about variability in perceptions. Often, stakeholder identification and characterisation are conducted in a group setting such as a workshop or focus group and stakeholders are mapped qualitatively with just a single point (Sandroni et al., 2022; Reed et al., 2009). In our assessment, stakeholders were mapped by key informants who independently rated influence and interest numerically, which allowed us to assess the variability in perceptions which, in turn, yielded novel insights.

4.1. Eliciting change

Most of the communication occurs between the two most influential organisations. In small networks, changes in connectivity and improving the information flow can transform the system (Cantor et al., 2021; Meadows, 1999). In fact, according to systems thinking, changing how information flows within a system is considered a particularly "deep" leverage point, where a small shift may lead to fundamental changes in the whole system (Abson et al., 2016; Fischer and Riechers, 2019). Therefore, one way to elicit change could be to improve the flow of information about alternatives within this network.

The greatest variability in perceptions of interest was of the provincial government's interest and this may be because many of the stakeholders were not aware of their important financial role in terms of the annual grant. Stakeholders should have accurate information about the stakes and the power of the others and perhaps the provincial government is an untapped avenue to drive change. They have delegated the bather-protection responsibility to the Sharks Board yet it is worth noting that the provincial officials did not seem to be aware that the shark nets are purposefully fishing to reduce shark numbers (Atkins et al., 2023).

On the other hand, the greatest consistency was in the perceptions that conservation organisations like the NGOs struggle to influence this system, despite their great interest. Yet the management of marine biodiversity impacts everyone and the group of legitimate stakeholders is much broader than the current governance structures allow (Mikalsen and Jentoft, 2008). Interested and affected parties should be allowed to participate in this system, especially those with a stake in biodiversity conservation who generally consider not only current generations but future generations too. In a collaborative, transdisciplinary engagement that included many of the stakeholders described in this paper, one of the recommendations was to form a working group (Atkins et al., in review). The Queensland Shark Control Program, Australia, has a Scientific Working Group tasked with sharing knowledge with the Shark Control Program's officials regarding relevant information, developing research strategies and alternative methods in the state's marine parks. This Scientific Working Group is composed of stakeholders very like the ones in our study, i.e. government stakeholders, conservation-focused stakeholders and local stakeholders. Such an approach could be adapted to the South African context with the aim of preventing catches of threatened species at all beaches with nets and/or hooks, while still providing the necessary level of bather protection.

4.2. Caveats and the way forward

One caveat of our study is that the communication networks depict only a subset of the social landscape around this human-wildlife conflict. We did not ask every node in the network about their communication, and of those approached, not everyone responded. Thus, the resultant networks do not perfectly represent the complete situation. There were some positions within the stakeholder organisations whose work intersects with the bather-shark conflict that were not interviewed but which do communicate with one another. For example, the Sharks Board's boat skippers and crew communicate regularly with the municipal lifeguards. It is possible that they may discuss alternative methods of bather protection. We did not interview every stakeholder but considering that we interviewed the heads of departments and directors from the relevant organisations, and the few stakeholders that deal with any aspect of alternative methods of bather protection, it is likely that we included many of the influential and interested people that are engaged with, and thinking about, the methods used in this bather-shark conflict. Another caveat is that we measured *perceptions* of power and communication, not actual power and communication. However, these are elusive and very difficult to measure.

While our study identified "who to learn with", the next step is to identify "what to learn" and further studies should be undertaken 1) to clarify the histories, values and existing knowledge of the various stakeholders and 2) to identify concepts that promote mutual understanding and an aspirational common future (Roux et al., 2017). A small part of this has already been completed—the knowledge of the stakeholders. We found that many of them do not know that the shark nets are

fishing for sharks and they are aware of few alternatives (Atkins et al., 2023). Discussions regarding the stakeholders' perceptions of the obstacles and opportunities to change the current methods yielded a strategy that could be considered a precursor to an implementation plan (Atkins et al., in review). However, much scope remains to study the histories and the values of the stakeholders and to assess potential concepts that might inspire stakeholders to work together towards a common goal.

4.3. Conclusions

We conducted a stakeholder analysis to identify who to involve in order to turn a research-implementation gap into a productive learning space. We characterised the stakeholders in KwaZulu-Natal's bather-shark conflict and learned that power is unevenly distributed with a top-down approach to governance. Conservation practice could be improved by initiating a participatory process that will allow those who lack influence but have significant interest in the bather-shark conflict to contribute and be more involved in the conservation management. We also learned that the stakeholder network is small, with most of the communication about non-lethal alternatives occurring between the two most influential organisations. Improving the flow of information could transform the system positively. This research, which worked at the intersection between science, governance and local context, began the process of engaging stakeholders in the research-implementation space and improving the information flow. Further work should be done to explore stakeholders' histories and shared interests, as well as alternative methods of bather protection to allow sharks, other marine megafauna and people to swim safely in KwaZulu-Natal. We have articulated the power dynamics among the stakeholders by expressing them clearly and, in the process, we have begun to improve the connections and the flow of information among them, hopefully starting to strengthen the link between research and implementation in conservation.

CRediT authorship contribution statement

Shanan Atkins: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Judy Mann-Lang:** Writing – review & editing. **Geremy Cliff:** Writing – review & editing. **Neville Pillay:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. **Mauricio Cantor:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2024.107244.

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