Received: 8 June 2022 | Accepted: 10 December 2022

DOI: 10.1002/pan3.10429

PEOPLE AND NATURE | BRITISH ECOLOGICAL SOCIETY

RESEARCH ARTICLE

Drawing on local knowledge and attitudes for the conservation of critically endangered rhino rays in Goa, India

Trisha Gupta[1] | EJ Milner-Gulland[1] | Andrew Dias[2] | Divya Karnad[2,3]

[1]Department of Zoology, Interdisciplinary Centre for Conservation Science, University of Oxford, Oxford, UK

[2]Department of Environmental Studies, Ashoka University, Sonipat, India

[3]Foundation for Ecological Research, Advocacy and Learning, Morattandi, India

Correspondence
Trisha Gupta
Email: trisha.gupta@biology.ox.ac.uk

Divya Karnad
Email: divya.karnad@ashoka.edu.in

Funding information
Ashoka University; Levine Family Foundation; Prince Bernhard Nature Fund

Handling Editor: Álvaro Fernández-Llamazares

Abstract

1. In the context of marine species declines in data-limited regions, local ecological knowledge (LEK) is a valuable source of information on species ecology and historical trends. LEK can also help understand how threatened species exist within a local culture, in terms of their uses and values, and reveal attitudes towards their conservation. Rhino rays (guitarfish and wedgefish) are highly threatened by overfishing with most species critically endangered, yet poorly studied in countries like India that fish them the most.
2. We drew on LEK to understand the socio-ecological status of rhino rays in Goa, on the west coast of India. We investigated their habitat use and seasonality, interaction with fisheries, socio-economic uses and relational values. We also explored attitudes of fishers towards rhino rays and their conservation. A combination of semistructured interviews and key informant interviews (88 in total) was conducted with fishers at multiple sites.
3. Local knowledge suggests that nearshore habitats around river mouths form important nursery grounds for some rhino rays, and provided insights on their seasonality and breeding. Rhino rays appeared to be targeted historically but are entirely bycaught at present, with highest catches in gillnets and in the South Goa district, during September and October. LEK indicated that taxa like sawfish (*Pristis* spp.) and wedgefish (*Rhynchobatus* spp.) have severely declined or disappeared from this region. We coded different relational values, from recreation (rhino rays are consumed and enjoyed with alcohol) to symbolic values (rhino rays are considered lucky). All key informants expressed positive attitudes towards rhino ray conservation and stated that a ban on landing these species would have little to no impact on fisher earnings.
4. The usefulness of LEK suggests it should be brought into the scientific mainstream to support development of more equitable and socially appropriate management plans. Fostering relational values can reinforce fishers' positive attitudes, thereby enhancing rhino ray conservation. Their low commercial value and potentially high post-capture survival suggest that using norm-based approaches to promote live release may be successful. Further research on rhino ray ecology

and human dimensions can support the development of appropriate conservation interventions.

KEYWORDS
elasmobranch, fisheries, guitarfish, relational values, shark, traditional ecological knowledge, wedgefish

1 | INTRODUCTION

In the context of global marine species declines and data paucity, useful information on the conservation status of species is being garnered from diverse sources. In particular, local knowledge systems provide insights that are complementary to ecological science, in terms of scope and content (Tengö et al., 2017). In coastal ecosystems, the knowledge and perspectives of fishers are valuable sources of information on historical and current trends in threatened marine species, especially in developing countries with limited scientific data (Drew, 2005; Gupta et al., 2022; Haque et al., 2021). Local ecological knowledge (LEK) of fishers refers to the body of experiential knowledge including ecological, fishing practices, fishing communities, governance and markets, and their dynamic relationships, which is developed in a social–cultural and geographical context (Cowie et al., 2020). Alongside information on species, LEK systems provide insights for how and why social–ecological systems are governed, and for developing holistic solutions to resource management problems (Hazenbosch et al., 2022; Tengö et al., 2017). LEK can help understand how threatened species exist within local culture, in terms of their uses and values, and reveal attitudes towards their conservation (Cowie et al., 2020; Grant et al., 2021). Therefore, it is important to bring LEK together with the scientific mainstream to develop more holistic and equitable management and conservation plans (Drew, 2005; Haque et al., 2021; Nirmale et al., 2004).

Rhino rays are a data-limited and highly threatened group of elasmobranchs (sharks and rays). Comprising giant guitarfish (*Glaucostegidae*) and wedgefish (*Rhinidae*), 15 of 17 rhino ray species are critically endangered (Kyne et al., 2020). Rhino rays are slow-growing, long-lived and display viviparous reproduction with long gestation periods and low fecundity (Moore, 2017). Most species are known to use nearshore bays, estuaries and lagoons as foraging, resting, mating and nursery areas (Chaikin et al., 2020; Farrugia et al., 2011; Martins et al., 2018; Whelan et al., 2017). These life-history characteristics make rhino rays highly vulnerable to overexploitation by coastal fisheries, and their populations have a limited capacity to recover (Jabado, 2018). Most species are also endemic to countries where fisheries management and marine conservation are a major challenge (Kyne et al., 2020). Hence, there is a conspicuous lack of scientific information on their biology, ecology and socio-economic value, and rhino rays remain largely unmanaged (Moore, 2017).

Marine species can be utilised by coastal communities for a variety of purposes with different instrumental and relational values. Instrumental values are the values of an entity as a means to an end, generally including monetary and economic benefits (Arias-Arévalo et al., 2017; Pascual et al., 2017). In contrast, relational values are the preferences, principles and virtues associated with relationships with nature, both interpersonal and as articulated by policies and social norms (Chan et al., 2016). In the case of rhino rays, their fins are important commodities in the international market and are the primary drivers for their capture and retention (Choy et al., 2022; Jabado, 2018). However, their meat is commonly consumed in countries like India and Bangladesh, where it can form a cheap source of protein for low-income communities (Haque et al., 2021; Nazareth et al., 2022). Skin, bones and other products have also been recorded to have ethnomedical uses in noncoastal regions of India (Singh et al., 2020). Therefore, local communities may have diverse values for rhino rays. Culturally specific values underpin a community's relationship with a species, and hence can provide a local incentive for the conservation, but also exploitation, of the species (Marsh et al., 2021). For threatened elasmobranchs, understanding the historical or contemporary uses and culturally specific values that these species have could inform the development of culturally appropriate conservation initiatives with the potential to achieve high levels of engagement and participation from local resource users (Grant et al., 2021).

Alongside values, it is important to understand attitudes of stakeholder groups towards wild species. Attitudes, which refer to an individual's evaluation of a person, concept, entity or action, can help predict human behaviour and determine participation in conservation activities (Ajzen, 1991; Solomon et al., 2012; Sponarski et al., 2014). The attitudes of fishers and the general public towards sharks present both challenges and opportunities for effective shark conservation (Ali et al., 2020; Drymon & Scyphers, 2017; Glaus et al., 2018; López de la Lama et al., 2018). Fishers also tend to perceive marine species holistically and as groups, rather than individual species (Karnad, 2022). Hence assessing attitudes of fishers towards rhino rays as a group, in the context of other threatened marine species groups, can help build a holistic understanding of how locals perceive and will respond to conservation measures.

India is among the top 3 elasmobranch fishing nations globally; 43,741 tonnes of landed elasmobranchs were recorded in 2019, of which approximately 481 tonnes were guitarfish and wedgefish (CMFRI, 2019). India is a hotspot for rhino ray species richness (Kyne et al., 2020), yet their ecology is exceptionally understudied (Gupta et al., 2022). At the time of this study, one rhino ray species (*Rhynchobatus djiddensis*) was protected under India's Wildlife

(Protection) Act (WPA). Five more species have been recently listed under protection in the WPA (*R. australiae*, *R. laevis*, *Rhina ancylostoma*, *Glaucostegus obtusus* and *G. thouin*; Parliament of India, 2022). The implementation of these policy changes will be challenging given that rhino rays are mostly bycaught in Indian fisheries, highlighting the need for practical and contextually appropriate mitigation measures. Furthermore, it is important to understand how fishing communities interact with these species and how conservation policies may impact them.

Our study draws on the ecological knowledge of fishers (LEK) to understand the socio-ecological status of rhino rays in the state of Goa, on the west coast of India; an area with known populations of rhino rays and where a range of threats is present. We aimed to understand rhino ray habitat use and seasonality, and their interactions with fisheries, to get detailed insights into their ecology and associated fishing practices at a local scale, as well as to assess the level of ecological knowledge held by fishers in Goa for these species. We further described their socio-economic uses and relational values. Finally, we explored attitudes of fishers towards rhino rays, other threatened marine species, and their conservation.

2 | METHODS

2.1 | Study site

Goa is a state on the west coast of India, with a coastline of approximately 104 km characterised by estuaries and creeks, mangrove forests, patchy reefs, submerged rocks and sandy silt substratum (Velip & Rivonker, 2015). The state comprises two districts, North and South Goa. Although Goa is one of the smallest fishing states, it hosts a diversity of fisheries ranging from purse seines to non-motorised gillnets and artisanal nets, with 2938 registered fishing vessels (Goa Department of Fisheries, 2021). There are five major fishing harbours where both mechanised and motorised vessels land their catch. In addition, gillnets and other small-scale fisheries (e.g. shore seines) operate from the 39 fishing villages present along Goa's coastline (Goa Department of Fisheries, 2021). There are approximately 10,545 fisherfolk resident in Goa (marine and inland), as well as a large population of migrant workers in the fishing industry (Department of Fisheries, 2020). Aside from fisheries, Goa is also a major tourist destination with coastal tourism forming a large part of the state's economy. A large number of fishers also work in the tourist industry (Venugopalan, 2021). Therefore, the number of active fishers is likely lower than registered.

Mackerel (*Rastrelliger kanagurta*), sardines (*Clupeidae*) and carangids (*Carangidae*) are the main captured species. However, like many other fisheries in India, the fishery in Goa is multi-species and a diversity of species is captured year-round. Rhino rays are captured by small-scale gillnets, coastal trawlers and other nearshore fisheries (Hegde et al., 2014), most likely as bycatch (Sreekanth et al., 2021), with the presence of two species (*Glaucostegus granulatus* and *Glaucostegus obtusus*) confirmed in Goa. However, at least 10 species of rhino rays (families *Glaucostegidae* and *Rhinidae*) have been recorded in Indian waters (Akhilesh et al., 2014). Based on distribution maps, it is likely that most of these species are present in Goan waters (Last et al., 2016). We selected Goa for this study as rhino rays are known to aggregate in the shallow coastal waters of a number of sites in this region (A. Jamalabad, personal communication; A. Lobo, personal communication). These sites may be serving as parturition, nursery or feeding grounds, but are poorly understood with sparse and anecdotal information. Aggregations of this type are susceptible to depletion due to fisheries, coastal development, pollution, tourism and other activities commonly occurring along Goa's coast.

2.2 | Interviews

We used mixed methods, applying a combination of semistructured interviews and key informant interviews. Study sites included 16 fishing villages and four major fishing harbours, randomly selected from a list of the major fishing sites in Goa (Goa Department of Fisheries, 2021; Figure 1; Appendix S1). We first conducted semistructured interviews in February–March 2021, with fishers as they are the most likely to hold LEK for rhino rays and can also provide insights into the fishing and nonfishing threats to these species. At some study sites, we used a combination of convenience sampling, where available fishers were approached at the landing centre, and snowball sampling, where interviewed fishers were asked to suggest other respondents (Newing et al., 2011). At other sites, we were introduced to the communities through respected members like religious leaders and used this to snowball and interact with a wider cross-section of the communities. Knowledge of the site and informal conversations with fishers indicated that we sampled the majority of active fishers at each site.

At the start of the semistructured interviews, respondents were shown a photo of a rhino ray and asked if they recognised this fish. If yes, the researcher (AD) would introduce himself, explain the research objectives and asked if the fisher was willing to participate in the research. Informed oral consent was obtained, rather than written consent, due to variability in literacy rates and fishers' comfort with reading and signing written documents (Appendix S2). These interviews were conducted in Hindi or Konkani and lasted 20–30 min. Respondents were asked a mix of open-ended and closed questions on rhino ray ecology (local names, habitat use, seasonality, behaviour, breeding), fisheries (gear, catch rates) and post-capture uses. We also looked into perceptions of changes in rhino ray populations, and drivers of those changes. Pilot interviews found that fishers expressed significant uncertainty in distinguishing rhino ray species, particularly giant guitarfish (*Glaucostegus* sp.). Hence our interviews looked at rhino rays collectively rather than at species level, to avoid any bias or errors in species identification. Nevertheless, any species-specific information mentioned by respondents was noted. This study received ethics clearance from the Ashoka University

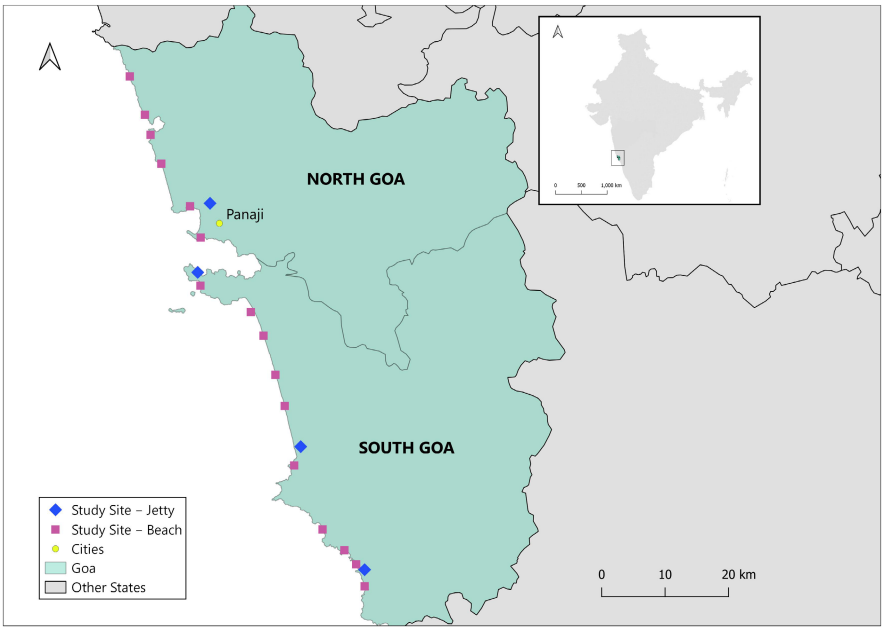

FIGURE 1 The study sites

Institutional Review Board, following the code of ethics set forth in the Belmont Report (HHS, 1979).

While we aimed to interview individual fishers, this was not always possible. Respondents were often approached when they were sorting catch, cleaning their nets or resting with other crew members. Even if a fisher was alone when approached, the interview process would often attract the attention of others in the vicinity. In these cases, group interviews were conducted, which differed from focus groups in that the individuals who formed the group were not invited intentionally, and these interviews were used to collect rather than confirm or contrast against data (Bernard, 2017). Demographic information was not collected for group interviews, and where more than one respondent contributed to a question, consensus in the answer given was confirmed before documenting it. As the aim of these interviews was to gather LEK and information on fishery characteristics, interviews conducted with small groups of collective fishers would not violate this aim (Grant et al., 2021).

Based on information obtained in the semistructured interviews, we conducted qualitative interviews in October 2021, with key informants who were selected purposively because they had great expertise on fishing and could provide views that represented the community (Newing et al., 2011; Poggie, 1972). Key informants included fisher union leaders, community leaders, elderly fishermen and traders at the same study sites. They were identified based on our prior knowledge of the site, and through conversations with fishers and other community members, and approached at their homes, landing centres or markets. These interviews took 30–60 min and were conducted in Hindi by TG and AD. They primarily consisted of open-ended questions to get a better understanding of rhino rays and their conservation (Appendix S3). Key informants were first asked questions about their knowledge of and interactions with rhino rays to triangulate and better understand information gained from the semistructured interviews. We then investigated attitudes towards the conservation of rhino rays and other threatened species like marine turtles and cetaceans. Key informants were asked to list marine species that to their knowledge are protected, and provide their opinions on the prohibition of harvest for these species. We then discussed rhino rays, asking key informants what would happen if these species were similarly protected, and their attitudes towards rhino ray conservation

2.3 | Data analysis

Interview data addressed four predecided themes: (1) Ecological characteristics (habitat, seasonality and behaviour), (2) socio-economic characteristics (fisheries, uses and values), (3) population trends and (4) conservation. Data from the semistructured interviews were used to address sections 1 to 3. Key informant interviews were used to triangulate these data and explain some of the trends obtained. Section 4 was designed based on information obtained in the semistructured interviews, and hence was addressed entirely by key informants.

The closed, quantitative data were entered into Microsoft Excel and analysed using RStudio to produce descriptive statistics. The open-ended, qualitative data were thematically analysed on NVIVO. We used a hybrid approach, with both deductive and inductive coding. For example, responses on rhino ray habitat and seasonality were deductively coded based on a priori codes. However, emerging and unexpected themes, such as feeding behaviour, were inductively coded from the responses. Statements and knowledge about rhino ray ecology were compared with information from the scientific literature. We reviewed information for the rhino ray species that possibly occur in this region in databases like Rays of the World (Last et al., 2016) and FishBase (Froese & Pauly, 2022), as well as scientific papers. This was

not intended to be a comprehensive literature review, but was done to understand how LEK and scientific knowledge complement and contradict each other (Tengö et al., 2014). We also aimed to identify and gain new insights for rhino ray populations in this region.

Different values for rhino rays were observed in interview transcripts and appeared to emerge as an important theme. Therefore, these values were captured and analysed using the relational values framework described by Chan et al. (2016, also see Arias-Arévalo et al., 2017). Coding was done by TG and checked by AD. To understand attitudes towards conservation, responses of key informant interviews were coded as positive (attitudes that favoured conservation) and negative (attitudes that did not favour conservation).

The term 'respondents' is used to refer to the semistructured interviews, whereas 'key informants' refers to the key informant interviews. The results are presented in terms of percentage of total respondents/key informants, and ranges, means and medians are presented as appropriate. We also present specific quotes from the interviews to better explain our findings.

2.4 | Positionality

All fieldwork and interviews were conducted by AD and TG. We are both Indian nationals but are not residents of Goa nor belong to any of the fishing communities with whom we worked. We are western-trained early career natural scientists, with additional training in interdisciplinary conservation science. Therefore, our lenses are shaped as well as limited by our identities and training. We mitigated our position as outsiders by building a rapport with our interviewees and reassuring them about the confidentiality of the information they provided. As a measure of the trust built, fishers voluntarily revealed some sensitive information such as illicit fishing activities. We also acknowledge that our positionality may have biased the way we collected, transcribed and interpreted the data. We have strived to represent the knowledge of the interviewed fishers as authentically as possible and remain true to the words used by the fishers themselves. However, our work does focus on specific dimensions of LEK and hence represents a partial understanding of the vast ecological knowledge held by fishers in Goa.

3 | RESULTS

We conducted a total of 66 semistructured interviews, with gillnet fishers (59%), mechanised fishers (35%) and other small-scale fishers (21%). Respondents were mostly from Goa (66%), with some migrant fishers. Just over half of these were group interviews (53%), hence we did not record demographic details such as age and years of fishing experience. Additionally, we conducted 22 key informant interviews, again focusing on gillnet and small-scale fishers (91%) with a few mechanised fishers. All key informants interviewed were locals from Goa, with an average of 28 years of fishing experience.

3.1 | Ecological characteristics

Rhino rays were recognised by nearly all the interviewed fishers (97% of respondents). Only two respondents, both migrant fishers, did not recognise rhino rays and were hence not asked further questions. The presence of rhino rays in shallow coastal waters was confirmed in all the study sites; respondents also mentioned finding these species all along Goa's coastline, as well as in the neighbouring states of Karnataka and Maharashtra where they have also fished or resided. We recorded eight different local names for rhino rays across the Goan coastline. In the South, rhino rays were most often referred to as 'Ellaro' whereas in the North, they were called 'Phadke' or 'Kharra'. There were no separate names for different species, with a few exceptions (Appendix S4).

Overall, fishers were able to provide insights into the ecology of rhino rays at a broad resolution. Responses were provided to most questions and there were only a few occasions where fishers stated that they did not know. Rhino rays were stated to inhabit sandy sea floors (86% of respondents), near or in between rocks (48%) and in the mouths of rivers and creeks along Goa's coastline (44%). They were observed in shallow nearshore waters (up to 5 m depth, 79% of respondents), but showed ontogenetic shifts with juveniles and pups occupying shallow waters and moving offshore as they grow bigger (24%). This LEK aligned with information on rhino rays in the scientific literature (Table 1).

August and September, right after the monsoon season, were identified as months of highest sightings nearshore (61%, Figure 2). On the contrary, the summer months of April and May were stated to have little or no presence of rhino rays in nearshore waters (24%). Respondents believed that rhino rays bred nearshore, particularly around the river mouths (30%), during the monsoon (24%), or just after the rains (9%). Such insights into seasonal habitat use and movements has not been reported in literature for this region and hence adds new information to the scientific knowledge base (Table 1).

Some respondents also mentioned unique behavioural observations for rhino rays (Table 1), although sample sizes for these were low. Certain species-specific insights were also noted: the bowmouth guitarfish (*Rhina ancylostoma*) was only found in deeper waters and not observed nearshore. Some respondents suggested that the sharpnose guitarfish (*G. granulatus*) was less common than the widenose guitarfish (*G. obtusus*). The former was found in deeper waters and was generally found alone while *G. obtusus* was found in groups.

3.2 | Social and economic relationships between fishers and rhino rays

3.2.1 | Fisheries

Rhino rays are caught as bycatch; no respondent stated that they targeted these species. However, one key informant from South Goa

TABLE 1 Fishers' local ecological knowledge (LEK) of rhino rays, along with an example quote from the interviews and references from the scientific literature, if present. The green colour indicates that the local knowledge aligns with scientific literature at a broad resolution; blue indicates that this information is not reported in scientific literature (to our knowledge) but is consistent with biological characteristics of rhino rays or literature for species not found in this region; orange indicates information given as personal interpretations by fishers, which does not align with scientific literature or biological characteristics.

LEK from fishers (% of respondents)	Aligns with scientific literature? (reference)	Example quote
Habitat use		
Rhino rays inhabit sandy sea floors (86%), near or in-between rocks (48%)	Yes (Last et al., 2016)	*They prefer sandy waters so they can bury themselves under the sand. They also like to be near rocks and caves sometimes*
Found in the mouths of rivers and creeks (44%) The following rivers and backwaters in Goa were specifically mentioned (sample size >1): Betul, Talpona, Agonda, Chapora, Zuari and Mandovi	Yes (Froese & Pauly, 2022; Last et al., 2016) Use of brackish and freshwater habitats is poorly studied for most species, however	*Sometimes you even find them going 1–2 km upriver in certain rivers and going back out to sea. This happens during the rainy season, as the water level is higher*
Rhino rays are found in shallow, nearshore waters (up to 5 m depth, 79% of respondents). They are also found in offshore waters, up to 110 m depth and 80 km offshore (29%)	Yes (Last et al., 2016)	*You can find them in ankle deep water as well as deep water, 50–60 km from shore. They are bottom dwelling fish*
Ontogenetic shifts in rhino rays, with juveniles and pups occupying shallow waters and moving offshore as they grow bigger (24%)	Yes (Last et al., 2016)	*The bigger ones are mostly in the deep side. The babies come to the shallows to feed, so we see them more*
Seasonality		
Maximum sightings of rhino rays nearshore are in the months of August and September, right after the monsoon season (61%)	No Consistent with trends reported by Nazareth et al. (2022) in the Andaman Islands, East coast of India	*The festival of Ganesh Chaturthi, during the rains, is the season for these fish. That and after the rains is the best time to come spot them*
Little or no presence of rhino rays in nearshore waters in the summer months of April and May (24%)	No	*In summer, the water becomes too hot for these fish. They go to deeper, cooler waters*
Breeding takes place during the monsoon (24%), or just after the rains (9%)	No Consistent with literature for rhino ray species not found in this region (Chaikin et al., 2020; Last et al., 2016)	*The rainy season, July and August, is the time their populations increase*
Other behavioural observations		
Rhino rays come to the shallow waters on the shoreline, or upriver, to feed on fish and crabs (23%)	Yes (Last et al., 2016; Sreekanth et al., 2021)	*They come to the very edge of the shoreline because they eat the small white crabs that run on the shore. To catch the crabs, they have to take a risk and come to the edge of the shoreline where the waves break*
Rhino rays are found in pairs or groups of up to five individuals, especially juveniles (12%)	No Consistent with literature for rhino ray species not found in this region (Chaikin et al., 2020)	*These fish travel in pairs. They travel together to feed and rest. It could be possible that they could be from the same mother. As they get bigger they split up*
Rhino rays are sometimes predated on by crows and other birds in the shallow nearshore waters (3%)	No Predation of rhino rays by birds does not appear to be previously published and needs further examination	*Sometimes you find the small ones near the river mouth but they go back quickly into deeper water because birds trouble them. Crows and fish-eating birds like pond herons can pick up the lighter ones and eat them*
Rhino rays come to the water surface to 'breathe' (6%)	No Does not align with published biological characteristics, needs further investigation.	*They are bottom dwelling fish. They sometimes come to the surface upside down, take a gulp of air and go back down*

mentioned that rhino rays used to be targeted several decades earlier (*In August to October, lots of rhino rays used to come in the nets, especially big ones. Fishermen used a special net, 400 mm, for rhino rays. This was about 40 years ago. My father used to fish them*). Previous targeting of rhino rays was also mentioned in some informal interviews with other fishers in South Goa. In contrast, more than a third of respondents

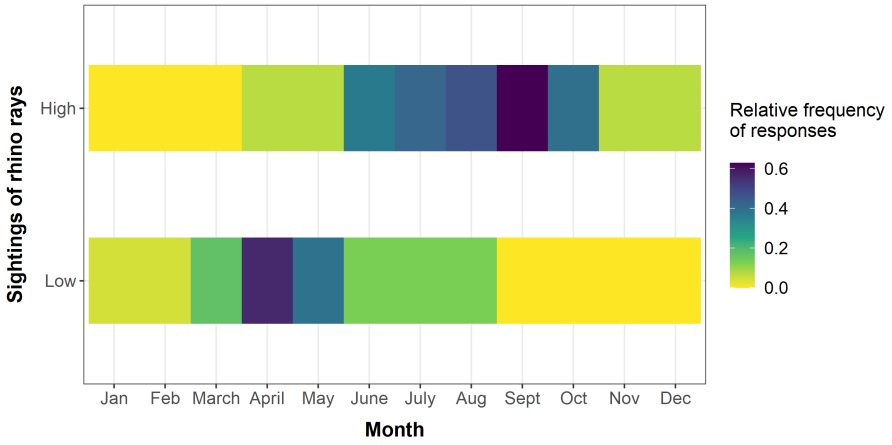

FIGURE 2 Seasonality of rhino ray sightings, expressed as relative frequency for each month. Relative frequency was calculated as the number of responses for high (top) and low or no (bottom) sightings of rhino rays for each month, divided by total number of responses for this question (Tanna et al., 2021).

(38%) listed sharks as one of their target species, especially in South Goa (67% of respondents from the south). Key informants explained that sharks were seasonally targeted by many gillnet fishers in Goa.

Most respondents said that rhino rays were captured in bottom-set gillnets for crabs (61%), followed by trawl nets (26%) and shore seines (21%). The bowmouth guitarfish (*R. ancylostoma*) was stated to be caught only in trawl nets whereas the other species were captured across all gear. Rhino rays of less than 2 feet (61 cm) in length were captured most frequently (73% of respondents), which were likely to be juveniles or even pups. Nearly half (44%) said they also caught medium-sized individuals of 2–4 feet (61–122 cm). Very few respondents caught large rhino rays bigger than 4 feet (122 cm, 8%). The smallest sizes were seen in shore seines, where 82% of shore seine fishers caught individuals less than 2 feet. The size distribution in trawl nets was larger, with all sizes of rhino rays captured. Reported bycatch rates were highly variable, ranging from 1 rhino ray per year to 15 per month. On the whole, bycatch rates were higher in the south, with four rhino rays caught per month being the most common response (18% of respondents in the south), whereas in the north less than once a month was the most common response (21%). Some respondents did not provide a bycatch rate, stating that it was too variable.

The months of September (59% of all respondents) and October (47%), right after the monsoon, were stated to have the highest rhino ray bycatch. This corresponded to information provided about their seasonality and months of highest occurrence (Figure 2). Gillnet fishers in particular stated that in post-monsoon they could catch multiple rhino rays each time they cast their net (*After the rains, they come inland a lot more. We can catch close to 5–10 per week, sometimes more.*).

3.2.2 | Post-capture uses

Post-capture, rhino rays were sold commercially at local markets (71% of respondents), taken home for consumption (58%) or discarded (dead or alive, 65%). Most respondents had multiple uses, depending on size and number of rhino rays caught, the quantity and quality of the remaining fish catch, market price and other factors. On average, rhino rays were sold for Rs. 66 ($0.87) per kilo, with sale price ranging from Rs. 13 to Rs. 150 ($0.17–$1.98) per kilo. In comparison, Indian mackerel (*R. kanagurta*), one of the most popular and common species in this region, is generally sold for between Rs. 150 and 200 ($1.98–$2.62) per kilo. Most respondents stated that they believed that the rhino rays they sold were used locally for consumption, with some stating that they were also traded to other parts of India, particularly the state of Kerala.

Post-capture use of rhino rays varied with district (Figure 3). In the north, most respondents (91% of respondents in the north) discarded them, followed by selling them in the market (70%) and consuming at home (58%). Size appeared to be the deciding factor, as only large-sized (i.e. adult) rhino rays were sold or consumed. No respondent sold or consumed juveniles, which were all discarded as they were considered to have less meat or be very 'bony' and not favoured for consumption (45%), and because of their lack of market value (27%). This contrasts with fishers in South Goa, who primarily sold rhino rays in markets (73% of respondents in the south, Figure 3) followed by consumption (58%). Most of these respondents stated that they sold or consumed all sizes, including juveniles. Only a few respondents discarded rhino rays (39%); this was done largely due to their lack of market value (27%) and if they had too many (9%).

According to key informants, these observed differences can be attributed to tourism. Tourism is highly developed in North Goa, hence fisher behaviour may be adapted to catching and selling species that are popular among tourists. In the South, with less commercial tourism, fishing behaviour was more based on tradition and on local market demands. Therefore, fishers in South Goa exhibited higher capture and retention rates of rhino rays.

3.2.3 | Values

In addition to instrumental (monetary) and subsistence uses, we coded 22 responses expressing relational values for rhino rays. These ranged from recreation (rhino rays are consumed and enjoyed with alcohol) to symbolic values (rhino rays were considered lucky) and others (Table 2). Some respondents also expressed negative values for rhino rays, considering them to be a bad omen, and not suitable for consumption.

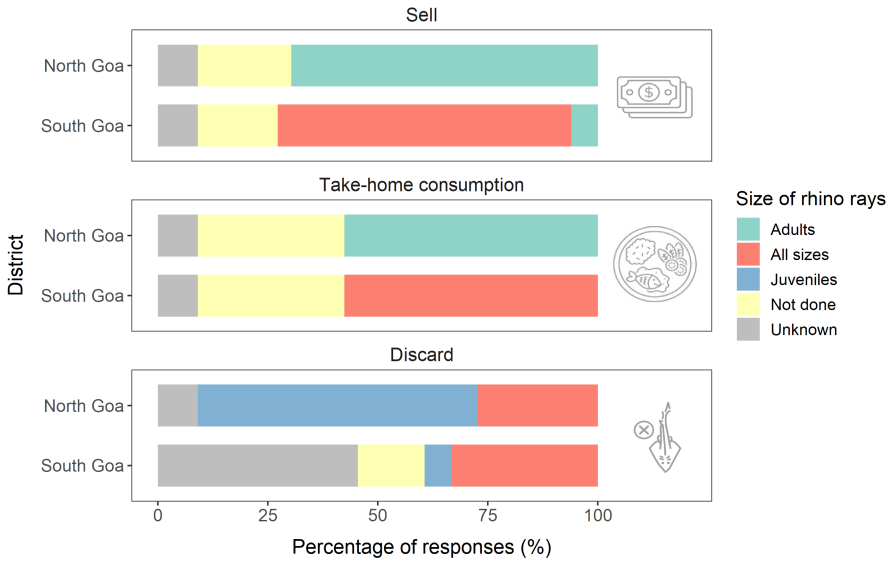

FIGURE 3 Post-capture uses of rhino rays in each district of Goa. The colours indicate the size of rhino ray individuals for each use. Graphics courtesy of The Noun Project (2014)

TABLE 2 Values for rhino rays expressed by fishers in Goa, through the semistructured interviews, categorised following the values framework described by Chan et al. (2016), and adapted by Arias-Arévalo et al. (2017).

Type of value	Articulated value	No. of responses (% of total)	Example quotes
Instrumental The value of an entity as a means to an end	Monetary benefits (guitarfish are sold for profit, albeit for a low value)	47 (71%)	*Whatever is caught and can be sold, is sold in the market*
Relational The importance attributed to meaningful relations and responsibilities between humans and between humans and nature	Subsistence (used for take-home consumption)	38 (58%)	*We eat any size of guitarfish. Even if we have caught small guitarfish of 1 foot size, sometimes we take that home and make curry and eat it*
	Recreation (consumed along with alcohol)	9 (14%)	*It has got a very sweet tasting flesh. After a rough day's work, it goes well with our evening drink*
	Nonfishing experiences (e.g. childhood memories, observations of them playing in the water, etc.)	6 (9%)	*When I was a child, we would try to spot these fish as competition to see who would make a better fisherman*
	Symbolic value (Rhino rays are considered to be lucky because of their rarity)	4 (6%)	*It's a super rare fish, but you can see it on the shore. If you see it on the shore, means your stars are lined and you are very lucky*
	Social cohesion (large guitarfish catch is shared with the community)	3 (4%)	*If the guitarfish is big and too much for our household, we cut and share it with our neighbours*
	Negative (considered to be a bad omen or not fit for consumption)	3 (4%)	*I tried this fish once and it upset my stomach. I tried feeding the leftover meat to my cat and the cat also rejected it. After this, I never dared to consume it again, I throw it back into the water*
Intrinsic The value of nature, ecosystems or life as ends in themselves, irrespective of their utility to humans	Not expressed	—	—

It should be noted that although most respondents sold rhino rays in markets, these species were generally considered to be low-value catch and did not fetch high profits (*We sell it, but there is not much value for this fish. Only locals eat it.*). Similarly, while more than half of the respondents consumed rhino rays, consumption was infrequent (1–2 times a month, on average) and hence it is unlikely that these species form a staple food source.

3.3 | Population trends

Most respondents (53%) believed that there had been no change in rhino ray populations since they started fishing. Some perceived a decrease (18%) or increase (18%) in rhino ray populations. These patterns were not confirmed by key informants, most of whom perceived decreasing populations (58%

of 16 key informants who answered this question). We did not find any clear patterns in responses between North and South Goa.

We prompted key informants to provide the reasoning behind their own perceptions, as well as the possible reasons for other respondents' perceptions (Figure 4). Key informants who perceived decreasing trends stated that they had observed a reduction in the number and/or size of rhino rays caught in their nets compared to when they first started fishing, and could provide concrete examples for this (*Earlier we used to get a lot more, especially large ones. When we would catch lots of rhino rays, they would be dried and stored to be consumed later. Now we don't get that many, so we don't dry them anymore*). Some also mentioned the disappearance of particular species, such as white spotted wedgefish (*Rhynchobatus* spp.) and sawfish (*Pristis* spp.).

The reasoning provided for why populations might be perceived as increasing was that fishers noted higher catches of rhino rays in their nets, or increasingly observed them in the nearshore waters (*We keep getting them in our nets, we get them every day. Their populations are increasing*). Reasoning behind perceptions of 'no change' were that these species were low in number to begin with and were not targeted for fishing (*This fish was always low in number, right from the start. They haven't changed because no one catches them much*). For both these potential reasons, however, key informants were unable to provide concrete examples or evidence.

Capture of rhino rays by mechanised fishing vessels, and general overfishing, were cited as possible drivers for the decline in rhino ray populations by a few key informants and respondents. Nonfishing activities as such pollution and tourism (including dolphin watching tours and water sports) were also suggested as potential drivers of declines. These activities were believed to cause declines in nearshore fish populations generally, or drive fish offshore and away from the coast.

3.4 | Conservation

3.4.1 | Knowledge of and attitudes towards protected marine species

At the time of the study, 10 elasmobranch species, all marine mammals and marine turtles were protected under Schedule I of the WPA in India, their harvest prohibited (Kizhakudan et al., 2015). Most key informants listed dolphins (91%) and turtles (82%) as protected marine species; a few mentioned 'big sharks' (18%) and stingrays (9%) as well.

While these bans were generally complied with, some key informants (50%) admitted that protected species were still occasionally captured by themselves or other fishers in their community, and sometimes consumed or sold. Many (59% of informants who answered this question) held negative attitudes towards the protection and ban on catching these species, particularly dolphins, stating that they 'stole' fish from their nets and caused a lot of damage (Figure 5). This was particularly the case in North Goa. However, some positive attitudes towards protecting these species were also expressed (41%), particularly for turtles as they were considered holy by Hindu communities. These positive attitudes were expressed mainly in South Goa.

No compensation, monetary or other, was provided to fishers for the damage caused to their net when releasing a protected species. Some key informants (62% of informants who answered this question) believed that such compensation was not needed, whereas others (38%) stated that the government should provide them with some compensation for their damaged nets and mentioned that this would also incentivise fishers to release protected species (Figure 5).

3.4.2 | Attitudes towards rhino ray conservation

We then asked key informants what they would feel if rhino rays were similarly protected. All key informants held positive

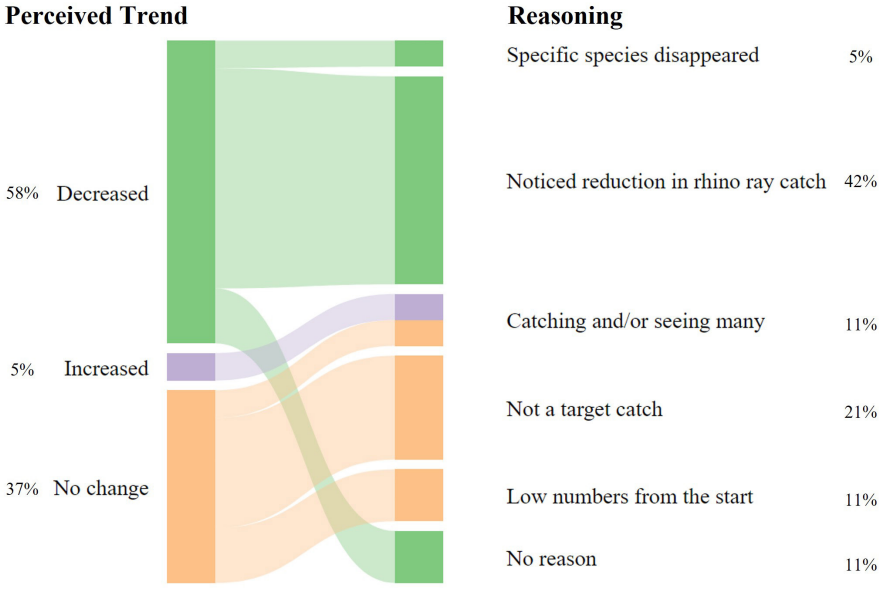

FIGURE 4 Perceived population trends of rhino rays by key informants, and the rationale or reasoning behind each perception

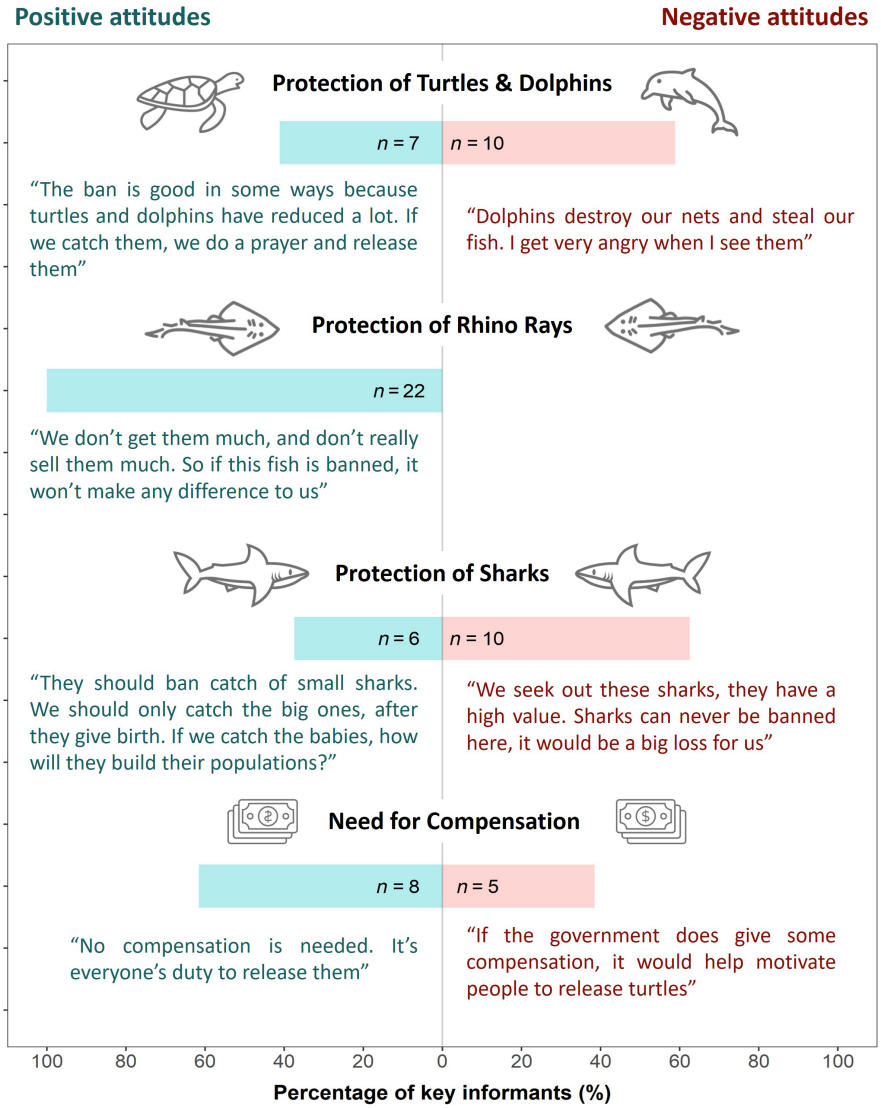

FIGURE 5 Attitudes of key informants on the protection, and hence fishing ban, of dolphins and turtles, on the hypothetical protection of rhino rays and sharks, and on the need for monetary incentives as compensation for a species being protected. Attitudes are classified as positive if they are more favourable towards conservation, and negative if they do not favour conservation. Number of responses for each attitude is indicated in the bar, and percentage in the *x*-axis. Not all key informants discussed and provided responses to all these questions, hence percentage here is calculated based on total number of responses for each section. Quotes from the interviews are provided as an example for each attitude. Graphics courtesy of The Noun Project (2014).

attitudes about this, stating that a ban on these species would have little to no impact on fisher earnings (Figure 5). Key informants mentioned that avoiding capture of these species would be challenging, though, as they co-occur with target species such as crabs and are hence bycaught. However, many suggested that live onboard release would be possible, and stated that rhino rays were usually alive in their nets and would survive if released immediately. One key informant mentioned the need to enforce any ban at the level of the market, as de-valuing the species would encourage fishers to release them. Another stated that fishers would be more willing to release rhino rays if they better understood the role these species play in the ecosystem.

In contrast, negative attitudes were expressed about any potential restriction on shark fishing (63% of informants who answered this question). Sharks were considered high-value catch and were seasonally targeted; many key informants believed that a ban on shark fishing would affect their earnings and that they would be unlikely to comply (Figure 5).

4 | DISCUSSION

4.1 | Fisheries and threats to rhino rays

Targeted fishing of rhino rays has been recorded in many parts of the world for their high-value fins used in shark fin soup (e.g. Indonesia, D'Alberto et al., 2022; Lebanon, Lteif et al., 2016; Bangladesh, Haque et al., 2021; United Arab Emirates, Jabado, 2018). Our interviews revealed the targeted capture of large-bodied rhino rays by gillnet fishers in Goa in the past, for their fins as well as meat. This is no longer practiced, as rhino rays appear to be entirely bycaught and their catch dominated by juveniles. Furthermore, we did not find any evidence of trade in fins at present and these species are used only for local or regional consumption. Disappearance of this targeted fishery and shift in the socio-economic valuation by fishers may reflect a decline of rhino rays in this region. However, fin trade may still represent a future threat on the horizon, as there is a growing market for small, low-value fins in Southeast Asia for inexpensive shark fin soup (Cardeñosa et al., 2020). Regular monitoring is needed to ensure that this trade

does not develop in coastal fisheries such as in Goa, as it may incentivise the exploitation of juvenile rhino rays. Our study also revealed that a seasonal targeted fishery does exist for sharks in this region. Further research is needed to understand the drivers of this fishery.

Goa has undergone rapid development and change in recent decades, and marine biodiversity may be facing a range of threats from different sources, not just fisheries (Bhagat, 2022). Tourism is highly developed in the north, but relatively less so in the south, and may therefore explain the differences in interactions with rhino rays between these two districts. Tourism may shape fisher behaviour in the north, incentivising trade in more popular and commercial species, and causing a decline in traditional fishing and consumption practices (de Madariaga & del Hoyo, 2019). This may have a positive outcome for threatened rhino rays that are now discarded more often and can support the implementation of conservation measures. However, tourist demand patterns can also be responsible for driving overexploitation and trade of threatened wildlife (Arias et al., 2020; Garcia Rodrigues & Villasante, 2016). Respondents suggested that tourism activities like dolphin watching, water sports and beach shacks can have negative impacts on nearshore fish populations. For the biodiverse coastline of Goa where livelihoods are highly dependent on tourism and fishing (Venugopalan, 2021), it is crucial that impacts of tourism and coastal development on marine ecosystems are better understood.

4.2 | Importance and limitations of LEK

Our study adds to the growing body of evidence acknowledging the importance of fishers' LEK in characterising fisheries, evaluating species abundance, population trends, assessing threat and extinction probability and supporting effective fisheries management decision making (Beaudreau & Levin, 2014; Drew, 2005; Farr et al., 2018; Haque et al., 2020; Nazareth et al., 2022). Despite the elevated extinction risk they face, rhino rays have been poorly researched and there remain conspicuous gaps in our knowledge of their ecology and fisheries, particularly in developing countries like India that fish them the most (Kyne et al., 2020). LEK can help address some of these gaps in Goa, contributing to our understanding of the habitats used by rhino rays and the seasons they use them in. Insights from fishers confirmed our hypothesis that nearshore habitats in Goa around river mouths and estuaries form important nursery grounds, particularly for species like *G. obtusus*. Given their slow growth rates and low fecundity, juvenile survivorship is one of the most crucial features for sustaining elasmobranch populations, highlighting the importance of nursery grounds (Heupel et al., 2019; Martins et al., 2018). LEK helped identify prospective nursery sites in Goa, which need further assessment and long-term research.

A concerning finding that emerged from fisher's LEK is the possible disappearance of white spotted wedgefish (*Rhynchobatus* spp.) and sawfish (*Pristis* spp.). While there is considerable evidence for the decline of sawfish in south Asian waters (Fordham et al., 2018; Haque, Leeney, et al., 2020; Tanna et al., 2021), little information exists for guitarfish and wedgefish. Elasmobranch landings are often not recorded at the species level in many parts of India, making it challenging to assess long-term trends for threatened species like rhino rays. In such contexts, LEK can be the sole source of information to monitor populations of threatened species (Valerio-Vargas & Espinoza, 2019). Substantial declines in *Rhynchobatus* spp. have been reported by fishers in Bangladesh (Haque et al., 2021). Although some *Rhynchobatus* species have been found to be relatively productive (D'Alberto et al., 2019), these findings indicate that depletion exceeds population recovery time for wedgefish in South Asia compared to other elasmobranch taxa. Wedgefish populations may especially be in crisis and need urgent action.

As a result of profound economic, cultural and environmental changes local and indigenous knowledge is being weakened and eroded globally, particularly when pertaining to ecology (Aswani et al., 2018). It is thus interesting to see the levels of LEK displayed by fishers in the present study, where most respondents could recognise rhino rays and were able to provide responses to most questions at a broad resolution, even though these species have low commercial values. In contrast, Tanna et al. (2021) found that less than half of interview respondents could identify and provide information about sawfish in Sri Lanka, indicating shifting baselines and loss of knowledge (Turvey et al., 2010). This 'societal extinction' of a species from a culture can weaken pro-environmental attitudes and even accelerate biological extinction (Jarić et al., 2022). In Goa, existence of LEK for rhino rays indicates their continuing presence in nearshore waters and suggests that these species are embedded within cultural values, which were also recorded by our study. It is important that this knowledge is preserved and strengthened to prevent societal extinction. Fishers' LEK must be brought into the scientific mainstream and incorporated into policy and management, which can be done through various participatory approaches and frameworks (Cowie et al., 2020; Tengö et al., 2014).

While discussing the use and benefits of LEK, it is equally important to acknowledge its limitations. Insights of fishers can be biased by their own practices, habits and experiences (Turvey et al., 2010, 2014). For instance, higher sightings of rhino rays in the post-monsoon months can be a result of increased fishing activity during this period. Inaccuracies can also be seen in the contrasting information obtained from respondents and key informants on population trends. This emphasises the need to work with local key informants and not only randomly selected individuals in ecological studies that incorporate local knowledge (Chalmers & Fabricius, 2007). There can also be challenges in getting precise spatial information through LEK (i.e. 'fuzziness'; Karnad, 2022), due to different conceptions of scale and space between local residents and scientists. In the present study, respondents could describe rhino ray habitats at a broad resolution but could not provide nuanced information on specific locations. Another significant limitation is the absence of species-level data for rhino rays, due to misidentification by respondents. We also acknowledge that although we aimed to sample as comprehensively as possible, our study relied on key informants and convenience sampling and that might have affected our findings.

Most of these shortcomings can be addressed through combining LEK with other sources of information. Many studies have successfully

synthesised LEK with scientific information through ecological surveys for more effective decision making in conservation and management (Lopes et al., 2019; López-Angarita et al., 2021; Mason et al., 2019).

4.3 | Harnessing values and attitudes for conservation

There has been considerable research on the relationship between human values, attitudes and behaviours. Values can underpin and influence the manifestation of pro-environmental attitudes and behaviours, and therefore can be leveraged for conservation (Ihemezie et al., 2021). In the present study, we identified diverse values for rhino rays, from subsistence to recreation and social cohesion. As we coded values that were naturally expressed during interviews without direct questioning, our sample size is small. Nevertheless, it offers insights into the different relationships that fishers can have with low-value bycatch species like rhino rays. Moreover, key informants exhibited positive attitudes towards rhino ray conservation. According to the Theory of Planned Behaviour, a favourable attitude towards a behaviour is linked to a stronger intention to perform the behaviour (Ajzen, 1991). This suggests that fishers in Goa have a higher likelihood of participating in conservation interventions for rhino rays. Fostering pro-environmental values (e.g. symbolic values, where rhino rays are considered lucky) can reinforce these positive attitudes and support the implementation of interventions for sustainable fishing and conservation (Ihemezie et al., 2021; Skubel et al., 2019). For example, sacred values for turtles have strengthened their conservation in many communities in India (Phillott & Chandrachud, 2021; Tripathy & Choudhury, 2007). In our study, we also found positive attitudes towards and compliance with marine turtle conservation.

4.4 | Live release measures for rhino rays

With more rhino ray species recently listed under protection in India's WPA, it is necessary to develop practical, on-the-ground measures to mitigate their capture, particularly in the case of bycatch (Booth et al., 2019). In the context of fisheries in Goa, the release of live rhino rays, on board or from the shore, may be the most feasible solution. While avoidance of capture would be ideal to conserve threatened bycatch species (Milner-Gulland et al., 2018), it would be challenging here due to the relatively low selectivity of gear and shared habitats with target species. Release can be an effective and low-cost conservation measure in tropical, mixed species fisheries, especially when measures like spatial closures or gear modifications are not feasible (Gupta et al., 2020; Wosnick et al., 2022). Although poorly studied, some studies have noted moderate to high survival rates post-capture for different rhino ray species (Fennessy, 1994; Prado et al., 2021; Stobutzki et al., 2002); high survival has also been observed by fishers in our study site.

Monetary incentives (such as payments for ecosystem services) or disincentives (like fines or sanctions) may be effective in implementing conservation interventions but may also have unintended consequences (Booth et al., 2021; Muradian et al., 2013; Travers et al., 2016). On the other hand, social norms, culture and institutional arrangements can also shape individual behaviour, and can be an entry point for conservation (Booth et al., 2021; Ostrom, 1990). Given the low commercial values of rhino rays, positive attitudes towards their conservation and possible relational values, voluntary release measures implemented through norms-based approaches might be successful. For example, a pay-to-release programme for guitarfish turned into voluntary releases by the local community in Brazil (Wosnick et al., 2020). Our study identified the fishing gear, regions and seasons in Goa that should be targeted for a release intervention. Prior to designing and implementing this, however, further research on attitudes, behaviour, social norms and other human dimensions is necessary (McDonald et al., 2020; Veríssimo, 2013), alongside ecological studies of capture and survival rates.

AUTHOR CONTRIBUTIONS

This study was conceptualised by Trisha Gupta, Divya Karnad and EJ Milner-Gulland. Data were collected by Andrew Dias and Trisha Gupta, and analysed by Trisha Gupta. All authors discussed the results and contributed to writing and editing the manuscript.

ACKNOWLEDGEMENTS

TG is supported by the Levine Family Foundation. DK and AD were supported by a 2020–2021 Faculty Research Grant from Ashoka University, and a 2021 grant from the Prince Bernhard Nature Fund. We thank the fishing communities of Goa for their participation in this study. We also thank Dr Aaron Lobo for his guidance on this research and Dr Sreekanth for his assistance in fieldwork, and acknowledge the Fisheries and Forest Departments of Goa and WWF-Goa for their support. We are grateful to Sonia and Ashish Gupta and to the Pedro Arupe Institute for assisting with accommodation in Goa. Finally, we thank the reviewers and associate editor for their valuable and helpful comments which have substantially improved our manuscript.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

All data used in this manuscript, except the interview transcripts as we do not have the required consent to archive these, are either presented in the main text through figures and tables or available on the data dryad repository at https://doi.org/10.5061/dryad.vt4b8gtwq.

ORCID

Trisha Gupta https://orcid.org/0000-0002-2329-6540
EJ Milner-Gulland https://orcid.org/0000-0003-0324-2710
Divya Karnad https://orcid.org/0000-0002-4967-5362

REFERENCES

Ajzen, I. (1991). The theory of planned behaviour. *Organizational Behavior and Human Decision Processes*, *50*, 179–211.

Akhilesh, K. V., Bineesh, K. K., Gopalakrishnan, A., Jena, J. K., Basheer, V. S., & Pillai, N. G. K. (2014). Checklist of chondrichthyans in Indian waters. *Journal of the Marine Biological Association of India*, *56*(1), 109–120. https://doi.org/10.6024/jmbai.2014.56.1.01750s-17

Ali, L., Grey, E., Singh, D., Mohammed, A., Tripathi, V., Gobin, J., & Ramnarine, I. (2020). An evaluation of the public's knowledge, attitudes and practices (KAP) in Trinidad and Tobago regarding sharks and shark consumption. *PLoS One*, *15*(6), e0234499. https://doi.org/10.1371/journal.pone.0234499

Arias, M., Hinsley, A., & Milner-Gulland, E. J. (2020). Characteristics of, and uncertainties about, illegal jaguar trade in Belize and Guatemala. *Biological Conservation*, *250*(August), 108765. https://doi.org/10.1016/j.biocon.2020.108765

Arias-Arévalo, P., Martín-López, B., & Gómez-Baggethun, E. (2017). Exploring intrinsic, instrumental, and relational values for sustainable management of social-ecological systems. *Ecology and Society*, *22*(4). https://doi.org/10.5751/ES-09812-220443

Aswani, S., Lemahieu, A., & Sauer, W. H. H. (2018). Global trends of local ecological knowledge and future implications. *PLoS One*, *13*(4), 1–19. https://doi.org/10.1371/journal.pone.0195440

Beaudreau, A. H., & Levin, P. S. (2014). Advancing the use of local ecological knowledge for assessing data-poor species in coastal ecosystems. *Ecological Applications*, *24*(2), 244–256. https://doi.org/10.1890/13-0817.1

Bernard, H. R. (2017). *Research methods in anthropology: Qualitative and quantitative approaches*. Rowman & Littlefield.

Bhagat, M. (2022, June 3). *Rowing towards a sustainable future of marine conservation in Goa*. Outlook India. https://www.outlookindia.com/travel/rowing-towards-a-sustainable-future-of-marine-conservation-in-goa-news-200165

Booth, H., Ramdlan, M. S., Hafizh, A., Wongsopatty, K., Mourato, S., Pienkowski, T., Adrinato, L., & Milner-Gulland, E. (2021, November 14). *Designing locally-appropriate conservation incentives for small-scale fishers*. https://doi.org/10.31219/osf.io/bxzfs

Booth, H., Squires, D., & Milner-Gulland, E. J. (2019). The neglected complexities of shark fisheries, and priorities for holistic risk- based management. *Ocean & Coastal Management*, *182*, 104994. https://doi.org/10.1016/j.ocecoaman.2019.104994

Cardeñosa, D., Shea, K. H., Zhang, H., Feldheim, K., Fischer, G. A., & Chapman, D. D. (2020). Small fins, large trade: A snapshot of the species composition of low-value shark fins in the Hong Kong markets. *Animal Conservation*, *23*(2), 203–211.

Chaikin, S., Belmaker, J., & Barash, A. (2020). Coastal breeding aggregations of threatened stingrays and guitarfish in the Levant. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *30*(6), 1160–1171. https://doi.org/10.1002/aqc.3305

Chalmers, N., & Fabricius, C. (2007). Expert and generalist local knowledge about land-cover change on South Africa's Wild Coast: Can local ecological knowledge add value to science? *Ecology and Society*, *12*(1). https://doi.org/10.5751/es-01977-120110

Chan, K. M. A., Balvanera, P., Benessaiah, K., Chapman, M., Díaz, S., Gómez-Baggethun, E., Gould, R., Hannahs, N., Jax, K., Klain, S., Luck, G. W., Martín-López, B., Muraca, B., Norton, B., Ott, K., Pascual, U., Satterfield, T., Tadaki, M., Taggart, J., & Turner, N. (2016). Why protect nature? Rethinking values and the environment. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(6), 1462–1465. https://doi.org/10.1073/pnas.1525002113

Choy, C. P. P., Jabado, R. W., Clark-Shen, N., Huang, D., Choo, M. Y., & Rao, M. (2022). Unraveling the trade in wedgefishes and giant guitarfishes in Singapore. *Marine Policy*, *136*, 104914.

CMFRI. 2019. *Annual Report 2019* (p. 364). Kochi: Central Marine Fisheries Research Institute.

Cowie, W., Al Dhaheri, S., Al Hashmi, A., Solis-Rivera, V., Baigun, C., Chang, K., Cooney, R., Kamaka'ala, S., Lindeman, K., Louwa, C., Roe, D., Walker-Painemilla, K., Al Baharna, R., Al Ameri, M., Al Hameli, S., Al Jaberi, K., Alzahlawi, N., Binkulaib, R., & Al Kharusi, Y. (2020). *IUCN guidelines for gathering of fishers' knowledge for policy development and applied use*. https://doi.org/10.2305/iucn.ch.2020.11.en

D'Alberto, B. M., Carlson, J. K., Pardo, S. A., & Simpfendorfer, C. A. (2019). Population productivity of shovelnose rays: Inferring the potential for recovery. *PLoS One*, *14*(11), 1–24. https://doi.org/10.1371/journal.pone.0225183

D'Alberto, B. M., White, W. T., Chin, A., & Simpfendorfer, C. A. (2022). Untangling the Indonesian tangle net fishery: Describing a data-poor fishery targeting large, threatened rays (Superorder Batoidea). *Aquatic Conservation: Marine and Freshwater Ecosystems*, *32*(2), 366–384.

de Madariaga, C. J., & del Hoyo, J. J. G. (2019). Enhancing of the cultural fishing heritage and the development of tourism: A case study in Isla Cristina (Spain). *Ocean and Coastal Management*, *168*, 1–11.

Department of Fisheries. (2020). *Handbook on fisheries statistics*, *2020*. Ministry of Fisheries, Animal Husbandry & Dairying, Government of India.

Drew, J. A. (2005). Use of traditional ecological knowledge in marine conservation. *Conservation Biology*, *19*(4), 1286–1293. https://doi.org/10.1111/j.1523-1739.2005.00158.x

Drymon, J. M., & Scyphers, S. B. (2017). Attitudes and perceptions influence recreational angler support for shark conservation and fisheries sustainability. *Marine Policy*, *81*(March), 153–159. https://doi.org/10.1016/j.marpol.2017.03.001

Farr, E. R., Stoll, J. S., & Beitl, C. M. (2018). Effects of fisheries management on local ecological knowledge. *Ecology and Society*, *23*(3). https://doi.org/10.5751/ES-10344-230315

Farrugia, T. J., Espinoza, M., & Lowe, C. G. (2011). Abundance, habitat use and movement patterns of the shovelnose guitarfish (Rhinobatos productus) in a restored southern California estuary. *Marine and Freshwater Research*, *62*(6), 648–657. https://doi.org/10.1071/MF10173

Fennessy, S. T. (1994). Incidental capture of elasmobranchs by commercial prawn trawlers on the Tugela Bank, Natal, South Africa. *South African Journal of Marine Science*, *14*(1), 287–296. https://doi.org/10.2989/025776194784287094

Fordham, S. V., Jabado, R., Kyne, P., Charvet, P., & Dulvy, N. K. (2018). *Saving sawfish: Progress and priorities*. IUCN Shark Specialist Group (Issue May). https://doi.org/10.13140/RG.2.2.24708.58246

Froese, R., & Pauly, D. (Eds.). (2022). *FishBase*. World Wide Web Electronic Publication. www.fishbase.org

Garcia Rodrigues, J., & Villasante, S. (2016). Disentangling seafood value chains: Tourism and the local market driving small-scale fisheries. *Marine Policy*, *74*, 33–42. https://doi.org/10.1016/j.marpol.2016.09.006

Glaus, K. B. J., Adrian-kalchhauser, I., Piovano, S., Appleyard, S. A., Brunnschweiler, J. M., & Rico, C. (2018). Fishing for profit or food? Socio-economic drivers and fishers' attitudes towards sharks in Fiji. *Marine Policy*, *100*, 249–257. https://doi.org/10.1016/j.marpol.2018.11.037

Goa Department of Fisheries. (2021). *Goa fish trails* (Vol. *IV*). Department of Fisheries, Government of Goa.

Grant, M. I., White, W. T., Amepou, Y., Baje, L., Diedrich, A., Ibana, D., Jogo, D. J., Jogo, S., Kyne, P. M., Li, O., Mana, R., Mapmani, N., Nagul, A., Roeger, D., Simpfendorfer, C. A., & Chin, A. (2021). Local knowledge surveys with small-scale fishers indicate challenges to sawfish conservation in southern Papua New Guinea. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *31*, 2883–2900. https://doi.org/10.1002/aqc.3678

Gupta, T., Booth, H., Arlidge, W., Rao, C., Manoharakrishnan, M., Namboothri, N., Shanker, K., & Milner-Gulland, E. J. (2020). Mitigation of elasmobranch bycatch in trawlers: A case study in Indian fisheries. *Frontiers in Marine Science*, *7*(July), 571. https://doi.org/10.3389/FMARS.2020.00571

Gupta, T., Karnad, D., Kottillil, S., Kottillil, S., & Gulland, E. J. M. (2022). Shark and ray research in India has low relevance to their conservation. *Ocean & Coastal Management*, *217*, 106004. https://doi.org/10.1016/j.ocecoaman.2021.106004

Haque, A. B., D'Costa, N. G., Washim, M., Baroi, A. R., Hossain, N., Hafiz, M., Rahman, S., & Biswas, K. F. (2020). Fishing and trade of devil rays (*Mobula* spp.) in the bay of Bengal, Bangladesh: Insights from fishers' knowledge. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *31*(6), 1392–1409. https://doi.org/10.1002/aqc.3495

Haque, A. B., Leeney, R. H., & Biswas, A. R. (2020). Publish, then perish? Five years on, sawfishes are still at risk in Bangladesh. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *30*(12), 2370–2383. https://doi.org/10.1002/aqc.3403

Haque, A. B., Washim, M., Gloria, N., Costa, D., Robert, A., Hossain, N., Nanjiba, R., Jahedul, S., & Ahsan, N. (2021). Socio-ecological approach on the fishing and trade of rhino rays (Elasmobranchii: Rhinopristiformes) for their biological conservation in the bay of Bengal, Bangladesh. *Ocean and Coastal Management*, *210*, 105690. https://doi.org/10.1016/j.ocecoaman.2021.105690

Hazenbosch, M., Sui, S., Isua, B., Milner-Gulland, E. J., Morris, R. J., & Beauchamp, E. (2022). The times are changing: Understanding past, current and future resource use in rural Papua New Guinea using participatory photography. *World Development*, *151*, 105759. https://doi.org/10.1016/j.worlddev.2021.105759

Hegde, M. R., Padate, V. P., & Rivonker, C. U. (2014). Biological aspects and catch trends of elasmobranchs in the inshore waters of Goa, west coast of India. *International Journal of Marine Science*, *4*(45), 1–12. https://doi.org/10.5376/ijms.2014.04.0045

Heupel, M. R., Kanno, S., Martins, A. P. B., & Simpfendorfer, C. A. (2019). Advances in understanding theroles and benefits of nursery areas for elasmobranch populations. *Marine and Freshwater Research*, *70*(7), 897–907. https://doi.org/10.1071/MF18081

Ihemezie, E. J., Nawrath, M., Strauß, L., Stringer, L. C., & Dallimer, M. (2021). The influence of human values on attitudes and behaviours towards forest conservation. *Journal of Environmental Management*, *292*(May), 112857. https://doi.org/10.1016/j.jenvman.2021.112857

Jabado, R. W. (2018). The fate of the most threatened order of elasmobranchs: Shark-like batoids (Rhinopristiformes) in the Arabian Sea and adjacent waters. *Fisheries Research*, *204*(March), 448–457. https://doi.org/10.1016/j.fishres.2018.03.022

Jarić, I., Roll, U., Bonaiuto, M., Brook, B. W., Courchamp, F., Firth, J. A., Gaston, K. J., Heger, T., Jeschke, J. M., Ladle, R. J., Meinard, Y., Roberts, D. L., Sherren, K., Soga, M., Soriano-Redondo, A., Veríssimo, D., & Correia, R. A. (2022). Societal extinction of species. *Trends in Ecology & Evolution.*, *37*, 411–419.

Karnad, D. (2022). Incorporating local ecological knowledge aids participatory mapping for marine conservation and customary fishing management. *Marine Policy*, *135*, 104841. https://doi.org/10.1016/j.marpol.2021.104841

Kizhakudan, S. J., Zacharia, P. U., Thomas, S., Vivekanandan, E., & Menon, M. (2015). *Guidance on national plan of action for sharks in India* (p. 104). http://eprints.cmfri.org.in/10403/1/NPOA_SHARKS.pdf

Kyne, P. M., Jabado, R. W., Rigby, C. L., Dharmadi, Gore, M. A., Pollock, C. M., Herman, K. B., Cheok, J., Ebert, D. A., Simpfendorfer, C. A., & Dulvy, N. K. (2020). The thin edge of the wedge: Extremely high extinction risk in wedgefishes and giant guitarfishes. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *30*, 1337–1361. https://doi.org/10.1002/aqc.3331

Last, P., White, W., de Carvalho, M., Séret, B., Stehmann, M., & Naylor, G. (2016). *Rays of the world*. CSIRO Publishing.

Lopes, D. C., Catry, P., Henriques, M., Martin, R. O., Monteiro, H., Cardoso, P., Tchantchalam, Q., Pires, A. J., & Regalla, A. (2019). Combining local knowledge and field surveys to determine status and threats to Timneh Parrots Psittacus timneh in Guinea-Bissau. *Bird Conservation International*, *29*(3), 400–412. https://doi.org/10.1017/S0959270918000321

López de la Lama, R., De la Puente, S., & Riveros, J. C. (2018). Attitudes and misconceptions towards sharks and shark meat consumption along the Peruvian coast. *PLoS One*, *13*(8), 1–16. https://doi.org/10.1371/journal.pone.0202971

López-Angarita, J., Villate-Moreno, M., Díaz, J. M., Cubillos-M, J. C., & Tilley, A. (2021). Identifying nearshore nursery habitats for sharks and rays in the Eastern Tropical Pacific from fishers' knowledge and landings. *Ocean & Coastal Management*, *213*(August), 105825. https://doi.org/10.1016/j.ocecoaman.2021.105825

Lteif, M., Mouawad, R., Khalaf, G., Lenfant, P., & Verdoit-Jarraya, M. (2016). Population biology of an endangered species: The common guitarfish Rhinobatos rhinobatos in L ebanese marine waters of the eastern Mediterranean Sea. *Journal of Fish Biology*, *88*, 1441–1459. https://doi.org/10.1111/jfb.12921

Marsh, S. M. E., Hoffmann, M., Burgess, N. D., Brooks, T. M., Challender, D. W. S., Cremona, P. J., Hilton-Taylor, C., de Micheaux, F. L., Lichtenstein, G., Roe, D., & Böhm, M. (2021). Prevalence of sustainable and unsustainable use of wild species inferred from the IUCN Red List of Threatened Species. *Conservation Biology*, *36*, e13844. https://doi.org/10.1111/cobi.13844

Martins, A. P. B., Heupel, M. R., Chin, A., & Simpfendorfer, C. A. (2018). Batoid nurseries: Definition, use and importance. *Marine Ecology Progress Series*, *595*, 253–267. https://doi.org/10.3354/meps12545

Mason, J. G., Alfaro-Shigueto, J., Mangel, J. C., Brodie, S., Bograd, S. J., Crowder, L. B., & Hazen, E. L. (2019). Convergence of fishers' knowledge with a species distribution model in a Peruvian shark fishery. *Conservation Science and Practice*, *1*(4), e13. https://doi.org/10.1111/csp2.13

McDonald, G., Wilson, M., Veríssimo, D., Twohey, R., Clemence, M., Apistar, D., Box, S., Butler, P., Cadiz, F. C., Campbell, S. J., Cox, C., Effron, M., Gaines, S., Jakub, R., Mancao, R. H., Rojas, P. T., Tirona, R. S., & Vianna, G. (2020). Catalyzing sustainable fisheries management though behavior change interventions. *Conservation Biology*, *34*(5), 1176–1189. https://doi.org/10.1111/cobi.13475

Milner-Gulland, E. J., Garcia, S., Arlidge, W., Bull, J., Charles, A., Dagorn, L., Fordham, S., Graff Zivin, J., Hall, M., Shrader, J., Vestergaard, N., Wilcox, C., & Squires, D. (2018). Translating the terrestrial mitigation hierarchy to marine megafauna by-catch. *Fish and Fisheries*, *19*(3), 547–561. https://doi.org/10.1111/faf.12273

Moore, A. B. M. (2017). Are guitarfishes the next sawfishes? Extinction risk and an urgent call for conservation action. *Endangered Species Research*, *34*(August), 75–88. https://doi.org/10.3354/esr00830

Muradian, R., Arsel, M., Pellegrini, L., Adaman, F., Aguilar, B., Agarwal, B., Corbera, E., de Blas, D. E., Farley, J., Froger, G., Garcia-Frapolli, E., Gómez-Baggethun, E., Gowdy, J., Kosoy, N., Le Coq, J. F., Leroy, P., May, P., Méral, P., Mibielli, P., … Urama, K. (2013). Payments for ecosystem services and the fatal attraction of win-win solutions. *Conservation Letters*, *6*(4), 274–279.

National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research (HHS). (1979). *The Belmont report: Ethical principles and guidelines for the protection of human subjects of research*. U.S. Department of Health and Human Services. https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/read-the-belmont-report/index.html

Nazareth, E., D'Souza, E., Arthur, R., & Jabado, R. W. (2022). Distribution of the critically endangered Giant Guitarfish (*Glaucostegus typus*) based on local ecological knowledge in the Andaman Islands, India. *Ocean and Coastal Management*, *220*, 106075. https://doi.org/10.1016/j.ocecoaman.2022.106075

Newing, H., Eagle, C., Puri, R. K., & Watson, C. W. (2011). *Conducting research in conservation* (Vol. *775*). Routledge.

Nirmale, V. H., Sontakki, B. S., Biradar, R. S., & Metar, S. Y. (2004). Assessment of indigenous knowledge of coastal fisherfolk of Greater Mumbai and Sindhudurg districts of Maharashtra. *Indian*

Journal of Traditional Knowledge, *3*(1). http://nopr.niscair.res.in/handle/123456789/9333

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.

Parliament of India. (2022). *The wild life (protection) amendment act, 2022*. https://prsindia.org/files/bills_acts/bills_parliament/2021/Wild%20Life%20(Protection)%20Amendment%20Bill,%202021%20as%20passed%20by%20LS.pdf

Pascual, U., Balvanera, P., Díaz, S., Pataki, G., Roth, E., Stenseke, M., Watson, R. T., Başak Dessane, E., Islar, M., Kelemen, E., Maris, V., Quaas, M., Subramanian, S. M., Wittmer, H., Adlan, A., Ahn, S. E., Al-Hafedh, Y. S., Amankwah, E., Asah, S. T., … Yagi, N. (2017). Valuing nature's contributions to people: The IPBES approach. *Current Opinion in Environmental Sustainability*, *26–27*, 7–16. https://doi.org/10.1016/j.cosust.2016.12.006

Phillott, A. D., & Chandrachud, P. (2021). Fishers' ecological knowledge about sea turtles in coastal waters: A case study in Vengurla, India. *Chelonian Conservation and Biology*, *20*(2), 211–221. https://doi.org/10.2744/ccb-1455.1

Poggie, J. J. (1972). Toward quality control in key informant data. *Human Organization*, *31*(1), 23–30. http://www.jstor.org/stable/44125113

Prado, A. C., Wosnick, N., Adams, K., Leite, R. D., & Freire, C. A. (2021). Capture-induced vulnerability in male Shortnose guitarfish during their reproductive period. *Animal Conservation*, *25*, 233–243. https://doi.org/10.1111/acv.12734

Singh, A., Jabin, G., Joshi, B. D., Thakur, M., Sharma, L. K., & Chandra, K. (2020). DNA barcodes and ethnomedicinal use of Sharpnose guitarfish Glaucostegus granulatus by the locals at Keylong, Lahaul and Spiti, Himachal Pradesh. *Mitochondrial DNA Part B: Resources*, *5*(1), 113–114. https://doi.org/10.1080/23802359.2019.1698329

Skubel, R. A., Shriver-Rice, M., & Maranto, G. M. (2019). Introducing relational values as a tool for shark conservation, science, and management. *Frontiers in Marine Science*, *6*(53). https://doi.org/10.3389/fmars.2019.00053

Solomon, J., Jacobson, S. K., & Liu, I. (2012). Fishing for a solution: Can collaborative resource management reduce poverty and support conservation? *Environmental Conservation*, *39*(1), 51–61. https://doi.org/10.1017/S0376892911000403

Sponarski, C. C., Vaske, J. J., Bath, A. J., & Musiani, M. M. (2014). Salient values, social trust, and attitudes toward wolf management in South-Western Alberta, Canada. *Environmental Conservation*, *41*(4), 303–310. https://doi.org/10.1017/S0376892913000593

Sreekanth, G. B., Jaiswar, A. K., & Akhilesh, K. V. (2021). Feeding ecology of giant guitarfish, *Glaucostegus* cf. *granulatus* (Glaucostegidae: Rhinopristiformes) from Eastern Arabian Sea. *National Academy Science Letters*, *45*, 19–24. https://doi.org/10.1007/s40009-021-01078-3

Stobutzki, I. C., Miller, M. J., Heales, D. S., & Brewer, D. T. (2002). Sustainability of elasmobranchs caught as bycatch in a tropical prawn (shrimp) trawl fishery. *Fishery Bulletin*, *100*(4), 800–821. http://aquaticcommons.org/15251/1/13stobut.pdf

Tanna, A., Fernando, D., Gobiraj, R., Pathirana, B. M., Thilakaratna, S., & Jabado, R. W. (2021). *Where have all the sawfishes gone? Perspectives on declines of these critically endangered species in Sri Lanka* (Vol. *31*, pp. 2149–2163). Aquatic Conservation: Marine and Freshwater Ecosystems. https://doi.org/10.1002/aqc.3617

Tengö, M., Brondizio, E. S., Elmqvist, T., Malmer, P., & Spierenburg, M. (2014). Connecting diverse knowledge systems for enhanced ecosystem governance: The multiple evidence base approach. *Ambio*, *43*(5), 579–591.

Tengö, M., Hill, R., Malmer, P., Raymond, C. M., Spierenburg, M., Danielsen, F., Elmqvist, T., & Folke, C. (2017). Weaving knowledge systems in IPBES, CBD and beyond—Lessons learned for sustainability. *Current Opinion in Environmental Sustainability*, *26–27*, 17–25. https://doi.org/10.1016/j.cosust.2016.12.005

The Noun Project. (2014). Icons and Photos for Everything. www.thenounproject.com

Travers, H., Clements, T., & Milner-Gulland, E. J. (2016). Predicting responses to conservation interventions through scenarios: A Cambodian case study. *Biological Conservation*, *204*, 403–410. https://doi.org/10.1016/j.biocon.2016.10.040

Tripathy, B., & Choudhury, B. C. (2007). A review of sea turtle exploitation with special reference to Orissa, Andhra Pradesh and Lakshadweep Islands, India. *Indian Journal of Traditional Knowledge*, *6*(2), 285–291. http://nopr.niscair.res.in/bitstream/123456789/922/1/IJTK6%282%29%282007%29285-291.pdf

Turvey, S. T., Barrett, L. A., Yujiang, H. A. O., Lei, Z., Xinqiao, Z., Xianyan, W., Yadong, H., Kaiya, Z., Hart, T., & Ding, W. (2010). Rapidly shifting baselines in Yangtze fishing communities and local memory of extinct species. *Conservation Biology*, *24*(3), 778–787.

Turvey, S. T., Fernández-Secades, C., Nuñez-Miño, J. M., Hart, T., Martinez, P., Brocca, J. L., & Young, R. P. (2014). Is local ecological knowledge a useful conservation tool for small mammals in a Caribbean multicultural landscape? *Biological Conservation*, *169*, 189–197.

Valerio-Vargas, J. A., & Espinoza, M. (2019). A beacon of hope: Distribution and current status of the largetooth sawfish in Costa Rica. *Endangered Species Research*, *40*, 231–242. https://doi.org/10.3354/ESR00992

Velip, D. T., & Rivonker, C. U. (2015). Trends and composition of trawl bycatch and its implications on tropical fishing grounds off Goa, India. *Regional Studies in Marine Science*, *2*(November), 65–75. https://doi.org/10.1016/j.rsma.2015.08.011

Venugopalan, T. (2021). Tourism and sustainability in India—Exploring sustainability of Goa tourism from the perspective of local community. *European Journal of Business and Management Research*, *6*(3), 34–41. https://doi.org/10.24018/ejbmr.2021.6.3.852

Veríssimo, D. (2013). Influencing human behaviour: An underutilised tool for biodiversity management. *Conservation Evidence*, *10*(May), 29–31.

Whelan, R., Jabado, R. W., Clarke, C., & Muzaffar, S. B. (2017). Observations of rays and guitarfish (Batoidea) in shallow waters around Siniya Island, Umm al-Qaiwain, United Arab Emirates. *Tribulus*, *25*, 76–90.

Wosnick, N., Da Costa De Lima Wosiak, C., & Machado Filho, O. C. (2020). Pay to conserve: What we have achieved in 10 years of compensatory releases of threatened with extinction guitarfishes. *Animal Conservation*, 537–539. https://doi.org/10.1111/acv.12651

Wosnick, N., Giareta, E. P., Leite, R. D., Hyrycena, I., & Charvet, P. (2022). An overview on elasmobranch release as a bycatch mitigation strategy. *ICES Journal of Marine Science*, *2022*, fsac164. https://doi.org/10.1093/icesjms/fsac164

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1. The study sites.

Appendix S2. Semistructured survey questionnaire for fishers.

Appendix S3. Key Informant Interview Questionnaire guide.

Appendix S4. Local names of rhino rays from different parts of Goa.

How to cite this article: Gupta, T., Milner-Gulland, E., Dias, A., & Karnad, D. (2023). Drawing on local knowledge and attitudes for the conservation of critically endangered rhino rays in Goa, India. *People and Nature*, *5*, 645–659. https://doi.org/10.1002/pan3.10429