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Contribution to the Special 'Global status of wedgefish and guitarfish'

Fisher insights into rhino ray status, utilisation, and conservation at five major fishing harbours in India

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ABSTRACT: Rhino rays (order Rhinopristiformes) are among the most threatened marine species. India is one of the world's top shark and ray fishing nations and harbours a high diversity of these species, but research on them has been limited. This study provides insights on rhino ray status, utilisation, and conservation across 5 large fishing harbours in India (Porbandar, Mumbai, Chennai, Ganjam, and Digha) by describing fishers' ecological knowledge of fisheries interactions, patterns of catches and utilisation, and perceptions and attitudes towards rhino ray conservation. Interviews (n = 161) revealed that rhino rays are considered bycatch (99.3% of respondents), with catch declines of up to 95% in the last decade (85%, n = 137) and unsustainable fishing noted as the leading cause of declines. Primary use was for local consumption (71%, n = 114), mostly as fresh meat. Large-bodied individuals (>1 m total length [TL]) could reportedly be sold for the fin trade or locally consumed. Small-bodied individuals (<1 m TL) were reportedly discarded at sea, consumed, or considered trash fish. Knowledge of products, prices, and trends in utilisation was mostly anecdotal, and it was evident that respondents' concern for rhino ray conservation was very low. The lack of ecological knowledge was assessed to be due to population declines. Overall, 78% of respondents (n = 126) had higher use-oriented attitudes towards rhino rays than conservation-oriented attitudes. Hence, conservation actions need to be complemented with policies to protect rhino ray species and critical habitats. Our findings demonstrate the urgency of immediate conservation actions for and recording ecological knowledge of these species.

KEY WORDS: Conservation · Fishers' ecological knowledge · Fisheries · Bycatch · Guitarfish · Wedgefish · Rhinopristiformes

1. INTRODUCTION

Rhino rays, a group of 68 species comprising sawfishes (Pristidae), wedgefishes (Rhinidae), giant guitarfishes (Glaucostegidae), guitarfishes (Rhinobatidae), and banjo rays (Trygonorrhinidae), are amongst the most imperilled marine taxa globally (Dulvy et al. 2021, Kyne & Jabado 2021). According to the IUCN Red List of Threatened Species, over 70% of species assessed are considered threatened (Critically Endangered, Endangered, or Vulnerable) (Kyne et al. 2020a, Kyne & Jabado 2021). Throughout their distribution, fisheries (target and bycatch) and habitat degradation are the primary threats to rhino rays (Moore 2017, Jabado et al. 2018). Life-history characteristics including slow growth, long life span, long

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gestation period, and low fecundity make rhino rays highly susceptible to overexploitation (Last et al. 2016, Jabado 2018). Once depleted, some populations are likely to have a limited capacity to recover since some species have a low intrinsic rate of population increase (D'Alberto et al. 2022). Targeted fishing, or retention when incidentally caught in a wide range of gear, is primarily driven by demand for their fins in international markets, demand for their high-quality meat in local markets, as well as a developing market for their skins and snouts (Moore 2017, Newell 2017, Haque et al. 2021, Choy et al. 2022). Furthermore, rhino rays are primarily found at depths of less than 100 m and are distributed in areas overlapping some of the highest fishing pressure in the world, namely coastal shallow areas, estuaries, and lagoons (Whelan et al. 2017, Chaikin et al. 2020, Gupta et al. 2023). Species richness and endemicity are highest in the tropics, where geographical ranges overlap with growing and intense fisheries, most characterised by many management challenges including illegal, unreported, and unmanaged (IUU) fishing (Kyne et al. 2020b, Kyne & Jabado 2021). As such, there is an urgent need to improve available information on their life-history traits, habitat use and requirements, and socio-economic value to allow for informed policy-making related to fisheries and trade.

India is among the top 3 chondrichthyan (shark, ray, and chimaera; hereafter referred to as 'shark') fishing nations globally (Okes & Sant 2019). Fisheries contribute significantly to the Indian economy, and large proportions of coastal communities are dependent on this sector for their livelihood. Official statistics indicate that over 270 000 licensed vessels (motorised, non-motorised, and mechanised vessels) operate from mainland India (Department of Fisheries 2020). Such a large fleet, chiefly known for IUU fishing, has limited the ability to monitor and enforce regulations, resulting in catch declines (Ganapathiraju 2012, Karnad et al. 2014, Bhatt 2020). Reported shark and ray catches have drastically declined in the past few decades from ~33 500 t in 1961 to ~25 900 t in 2020 (Akhilesh et al. 2023). Although there are some targeted shark (e.g. in Tamil Nadu) and ray fisheries (e.g. Andaman and Nicobar Islands: Tyabji et al. 2022; state of Goa: Gupta et al. 2023), these species are generally incidentally captured in all fishing gears and retained for the international trade in their products, local meat consumption, or other uses (e.g. liver oil) (Hanfee 1997, Kizhakudan et al. 2015, Jabado & Spaet 2017, Karnad et al. 2020). With an increasing dependence on fisheries, including sharks and rays, as a source of protein across coastal communities, there are concerns about the continuing impact on marine species. Research and conservation focused on rhino rays in India are of great importance, since these species are known to be highly threatened globally, particularly in the western Indian Ocean region (Jabado 2018, Jabado et al. 2018, Kyne & Jabado 2021).

India is a hotspot for rhino ray species richness, with reports on the occurrence of 15 species from 4 families (Last et al. 2016, Kizhakudan et al. 2018). This includes 3 species of sawfish and 4 species from each family of wedgefish, giant guitarfish, and guitarfish. Of these, only the whitespotted wedgefish *Rhynchobatus djiddensis* is protected under India's Wildlife (Protection) Act (WLPA) since 1972. This is despite the species being reported from India but having never been confirmed to occur here (Tyabji et al. 2020). Across the country, research on rhino rays has been mostly limited to opportunistic data collection, often reported as aggregated landings. In much of the historical literature, rhino rays (order Rhinopristiformes) were often referred to as 'skates' (e.g. Hanfee 1997), making it difficult to separate between data relevant to this species group or actual 'skates' of the order Rajiformes. Furthermore, recent literature has lumped together species into 1 category (e.g. guitarfishes), which has not allowed the species-level impacts of fisheries to be determined (e.g. Mohanraj et al. 2009). Yet, rhino rays have been identified as bycatch in trawl and other net fisheries, with fishing clearly contributing to population declines (e.g. Mohanraj et al. 2009, Raje & Zacharia 2009, Bhagyalekshmi & Kumar 2021). For example, an analysis of aggregated rhino ray catch and landings data provides evidence of population declines of up to 86% on the east coast (2002–2006) and 63% on the west coast of India (1990–2004) (Mohanraj et al. 2009, Raje & Zacharia 2009). In addition to the difficulty in identifying historical catch trends, biological information (i.e. length–weight ratios, diet, occurrence) is only available for a few species, based on opportunistic landings or fish market data from major harbours (e.g. Purushottama et al. 2020, Bhagyalekshmi & Kumar 2021, Kishore Kumar et al. 2021, Mary et al. 2021). This lack of data and ecological knowledge has made it difficult to understand utilisation patterns for rhino rays in India. To overcome this, information has increasingly been gathered through local ecological knowledge of fishers or coastal communities across peninsular India and its Union Terri-

tories (Nazareth et al. 2022, Tyabji et al. 2022, Gupta et al. 2023). Considering the scale of Indian fisheries, and the interwoven cultural heritage and diversity amongst coastal communities, understanding the local uses and values, along with population status and conservation needs, is the first critical step to enable the formulation of nationally and regionally appropriate conservation actions.

Fishers' ecological knowledge has allowed for conservation-oriented data to be produced, such as the identification of critical areas for rhino rays, assessments of overlaps between rhino ray distributions and fisheries, as well as reconstruction of population trends (Giovos et al. 2018, Colloca et al. 2020, Karnad 2022, Nazareth et al. 2022). Fishers' knowledge has also supported the development of baseline distribution information and the identification of potential reproductive areas for the giant guitarfish *Glaucostegus typus* (Nazareth et al. 2022). For species that have heavily declined across their range, this type of knowledge has proven to be a valuable source of information, since it is often no longer viable to collect conventional fisheries-dependent data (Thornton & Maciejewski Scheer 2012). Overall, an understanding of how local fishing communities interact with species, what their uses and values of species are, their perception of conservation, and their willingness to change their fishing and consumptive behaviour, can be gained through interviews (e.g. Moore et al. 2010, Jabado et al. 2015, Tyabji et al. 2022). Such information is needed to determine how various conservation measures might impact fishers and their livelihoods and provide an opportunity for holistic and equitable approaches to management (Haque et al. 2021).

Here, we present an examination of fishers' knowledge of rhino rays across 5 major fishing harbours (i.e. those with the largest contributions to shark and ray landings in the country). Specifically, we (1) examined interactions between fisheries and rhino rays, (2) sought fishers' knowledge about patterns of rhino ray catches, and (3) examined post-capture utilisation, perceptions of declines, and attitudes towards rhino ray conservation.

2. MATERIALS AND METHODS

2.1. Study area

India has a coastline of 8118 km with an exclusive economic zone of 2.02 million km^2 split between 9 coastal states (Department of Fisheries 2020). Overall, the Indian marine fishery sector is characterised by 3 types of vessels: (1) an estimated 25 689 non-motorised (small fishing boats/canoes propelled by paddles manually; often use cast nets and shore seines); (2) 97 659 motorised vessels (medium sized fishing boats that use 9–12 HP outboard/inboard motors where motor is used only for propulsion; often use gillnets); and (3) 42 985 mechanised boats (large fishing vessels with inboard motors used for propulsion; can mechanically operate all their fishing gear and often use trawls and purse seines) (CMFRI-FSI-DoF 2020). We selected one fishing harbour in 5 different coastal states: Porbandar in Gujarat; Mumbai (Sassoon Docks) in Maharashtra; Chennai in Tamil Nadu; Ganjam in Odisha; and Digha in West Bengal (Fig. 1). These sites were selected based on at least 2 of the following criteria: (1) reported high levels of landings of sharks and rays; (2) negligible information on shark and ray fisheries despite ongoing fishing operations; and (3) little to no research previously reported from the area on fishery interactions with rhino rays despite consistent landings over time (Kizhakudan et al. 2015). In India, existing fisheries statistics are reported at the state level (e.g. vessel numbers, landings of commercial species, including sharks and rays); however, information is often limited at the site level.

At the state level, the west coast state of Gujarat has the largest fleet of mechanised trawl vessels in India (CMFRI 2016). The Porbandar fishing harbour in Gujarat (Fig. 1) provides livelihoods to 9% of the total fishing population of the state and also acts as an auction hub for the sale of fish from other parts of the state. Maharashtra, on the west coast, has the third largest mechanised fishing fleet in the country. Fisheries in Mumbai (Maharashtra) are dominated by mechanised fishing boats, where trawlers (76%) and purse-seiners (12%) contribute to the majority of the catch (CMFRI 2010).

Tamil Nadu, on the east coast, has the highest contributions to the total shark and ray landings in India (Table 1). Fisheries in Chennai (Tamil Nadu) consist not only of trawl and purse seine vessels (30% of vessels) but also of small-scale vessels using gillnets (70% of vessels) (Fig. 1). Odisha and West Bengal, also on the east coast, rank lower in their contribution to total fish landings in India, compared to the west coast states. In both states, multi-day mechanised trawlers dominate fisheries. The fisheries of Ganjam (Odisha) operate from 20 landing sites with mainly small, motorised gear (775) and non-motorised (1130) vessels, using

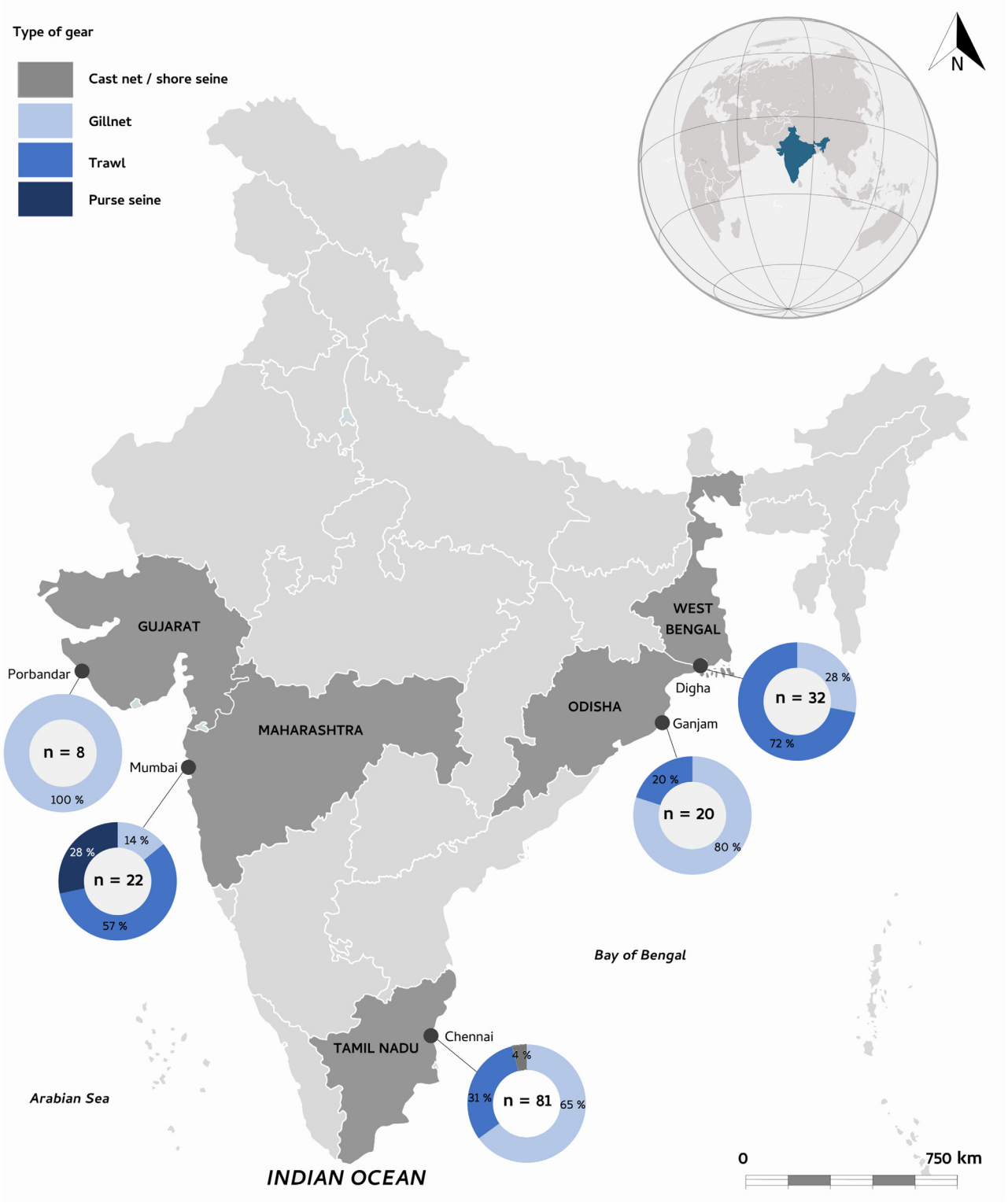

Fig. 1. Study sites (black dots) in the 5 major coastal harbours in India, with details of the number of individuals interviewed at each site (n) and primary fishing gear reportedly used. The states in which each site is located are indicated in dark grey

nearshore gillnets (CMFRI 2010). Digha (West Bengal) is one of the landing sites in the district of Purba Medinipur, and at this site, 83% of fishers operate mechanised trawlers (CMFRI 2010).

Table 1. Details of study locations as reported by the Department of Fisheries (2020) and CMFRI (2016, 2021, 2023)

State (study location)	Contribution to marine fisheries (t)	Ranked contribution to national fish catches	Contribution to national shark and ray landings (%)	Number of fishing harbours across state	Number of mechanised vessels using various gear types in each state	Number of motorised boats (includes gill-nets, hooks and lines)	State coastline length (km)
Gujarat (Porbandar)	530 000 (14.4 %)	4	9	107	Trawl – 9905; Gillnet – 2602	12 825	1600
Maharashtra (Mumbai)	170 000 (5 %)	7	5	155	Trawl – 3408; Gillnet – 584; Purse seine[a] – 230	6788	720
Tamil Nadu (Chennai)	722 000 (20.7 %)	1	39	349	Trawl – 5893; Gillnet – 38 575; Purse seine[a] – 219	31279	1076
Odisha (Ganjam)	133 000 (3.8 %)	8	12	55	Trawl – 1390; Gillnet – 358	5678	480
West Bengal (Digha)	190 000 (5.4 %)	6	9	49	Trawl – 2004; Gillnet – 1764	6564	158

[a]Note that purse seine vessels only operate officially in 4 coastal states in India, including Maharashtra and Tamil Nadu

2.2. Interviews

A semi-structured questionnaire (see Supplement at www.int-res.com/articles/suppl/n053p049_supp.pdf), adapted from Moore et al. (2010) and Jabado et al. (2015) was used to collect information on the status of rhino rays across the 5 study sites. Ethics approval was obtained from the Ethics Committee at the United Arab Emirates University (Jabado et al. 2015). For the purpose of this study, although sawfishes (family Pristidae) and banjo rays (family Trygonorrhinidae) are considered rhino rays, sawfishes were excluded since they have mostly disappeared from the region (Yan et al. 2021), and banjo rays do not occur in the region (Last et al. 2016). Interviews consisting of both open-ended and closed questions were conducted by 4 of the authors (A.B., D.K., S.N., S.M.), each at one of the sites, between March 2019 and March 2020. Boat owners, captains, and crew were opportunistically approached outside of peak landing and trading times at fishery harbours, fish markets, and landing sites (Fig. 1). This was to ensure respondents could be approached by individual co-authors in the absence of onlookers, either when the respondents were relaxing, mending nets, or prior to the start of the auction. This ensured that they took the time to respond to questions and were not in a rush. After obtaining informed consent, assuring respondents of their anonymity, and the voluntary nature of the discussion by reading the statement on the questionnaire, interviewers informed respondents that the interview could be stopped at any moment, and they could choose not to answer questions. Respondents were interviewed individually in the relevant local language (Gujarati, Hindi, Marathi, Tamil, Odiya, Bengali). Active fishers, regardless of age or type of fishing vessel they worked on, were chosen as respondents. Responses were recorded in writing by the interviewers, translated, and then transcribed in English.

As a first step, basic demographic information (e.g. age, occupation) was collected from each respondent. Then, illustrations of each rhino ray species known to occur in India (Jabado 2019), and photographs collected during field work of their pups were shown to respondents. Illustrations were chosen to better enable respondents to point out differences between species during the interviews since pictures of animals at landing sites are often of animals that are covered in blood or have already changed colors and patterns. If respondents could not identify illustrations to the species or family level, interview questions focused solely on those species groups that they could recognize (e.g. wedgefishes, guitarfishes [including giant guitarfishes in one grouping]). Questions focused on gathering information on fishing characteristics and gear utilisation, historical and recent sightings, species diversity, local names and cultural significance, spatial and temporal patterns of occurrence, perceived changes in abundance over

time, as well as use, trade, and value of various derivative products. Although the questionnaire was semi-structured, interviews were conducted as far as possible in a conversational manner with no limits on time, to allow fishers to be comfortable and provide a chance for additional information to be provided.

2.3. Data analysis

Data were analysed using MS Excel (2021), and a Sankey plot was created using Sankeymatic (built on d3-sankey v.0.12.3) to visualise the types of fishers who held differing perceptions about reasons for the decline of rhino rays. Analysis consisted of categorizing the data for consistency, coding the data, based on emergent themes for content analysis of open-ended questions, followed by calculating percentages, and visualisation. Responses related to perceptions were coded as 'use-oriented' if any subsistence or trade use was mentioned, such as their medicinal or nutritional properties or the economic value of their fins or meat. 'Conservation-oriented' responses were classified if respondents mentioned the value of having these species alive and/or in their natural habitat. If respondents declined to answer the question, or mentioned that they did not have opinions, data were classified as 'no stated perception'. Responses related to perceived changes in catch were calculated as catch sizes in the present year as a percentage of catch sizes 10 yr ago. While we acknowledge that this is not an accurate representation of catch sizes, it provides an index of changes in catch. All percentages are reported for the sample size of 161 respondents, unless noted otherwise.

3. RESULTS

We interviewed 161 fishers in Porbandar (4.9%, n = 8), Mumbai (13%, n = 21), Chennai (50.3%, n = 81), Ganjam (11.8%, n = 19), and Digha (19.8%, n = 32) (Fig. 1). Respondent age ranged from 21 to 75 yr (mean = 43.3 ± 0.91), and they had between 1 and 60 yr (mean = 25.6 yr) of fishing experience (Fig. 2A,B). All respondents were males, since women are only involved in post-fishing marketing operations. Most (86.9%, n = 140) noted fishing as their primary occupation and coming from a family of fishers or having a father who worked at the harbour (79.5%, n = 128). Respondents held various positions on vessels, including crew members (70.8%, n = 114), captains (23.6%, n = 38), and both owners and captains (5.5%, n = 9).

3.1. Fishing characteristics

All respondents actively fished throughout the year (at least 8–10 mo), except during the various seasonal fishing bans (e.g. 15 April to 15 June each year in Ganjam), monsoon season, or various religious holidays. Overall, 85.1% (n = 137) were resident marine fishers (i.e. from the state where they were interviewed), while the remaining respondents were evenly divided between fishers who migrated to other marine fishing areas (for example fishers from the east coast who seasonally migrate to fish on the west coast) for a part of the year (7.4%, n = 12), and fishers who fished in fresh or brackish water part of the year (only respondents from Ganjam, 7.4%, n = 12). The majority of respondents (70%) used multiple gear in one fishing trip, depending on area, season, and their target species (Fig. 1). Users of large mechanised vessels (>12 m) (71.4%, n = 115) tended to spend more time at sea (averaging 28 d mo^{-1}) than users of small (<12 m) vessels (28.5%, n = 46) (averaging 15 d mo^{-1}). Median duration of fishing trips was 12.5 d mo^{-1} across all sites, with a range of 4 to 30 d (Fig. 2C).

3.2. Ecological knowledge

3.2.1. Species

Overall, 99.3% of fishers could identify rhino rays. Of the fishers who could identify them, 67.7% of respondents (n = 109) did not know how many species of rhino rays occurred in India or believed it was fewer than 4 species. Altogether, respondents identified 3 species of wedgefishes and 5 species of guitarfishes (Fig. A1 in the Appendix). To explain the differences they saw in sizes of animals captured, some fishers noted that guitarfishes were juveniles of wedgefishes. Many respondents (34%, n = 55) were able to distinguish the bowmouth guitarfish *Rhina ancylostomus* and described how they distinguished it from other species (i.e. rounded head with thorns on it) (Table 2). A few fishers (n = 4) confused *R. ancylostomus* with the whale shark *Rhincodon typus*. Only 34% (n = 55) of respondents could distinguish wedgefish from guitarfish (including giant guitarfishes). In Porbandar (2.5%, n = 4) and Ganjam (3.7%, n = 6), those respondents who could distinguish between guitarfishes and wedgefishes made the distinction based on the selling price they received for the animals (wedgefishes fetched higher prices than guitarfishes) or based on the size/height of their fins. On the other hand, respondents in

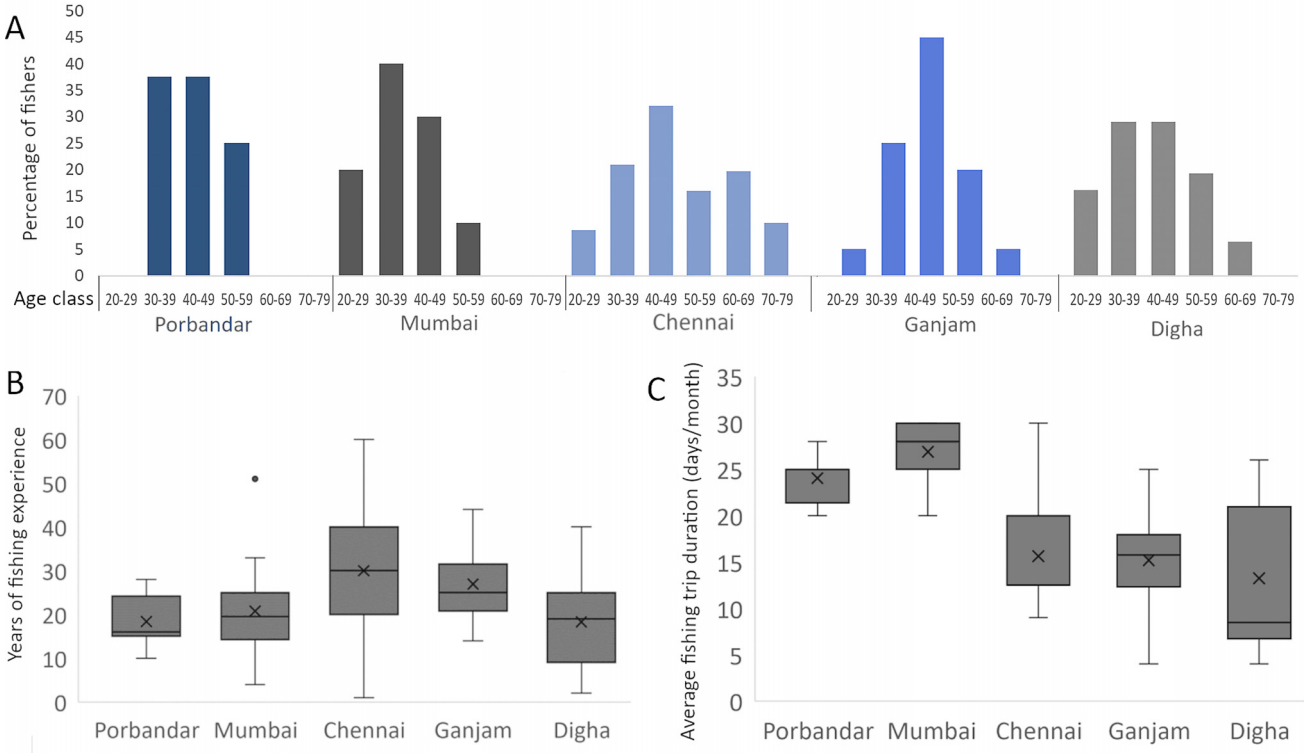

Fig. 2. (A) Age distribution of respondents across study sites. (B) Years of fishing experience. (C) Fishing trip duration, reported as the number of days per month. In (B) and (C), boxes represent the interquartile range (IQR). The line in each box represents the median, and the upper and lower whiskers represent 1.5 × IQR. The crosses indicate means and the solid point in (B) indicates an outlier

Mumbai (9.3%, n = 15) and Chennai (14.2%, n = 23) distinguished between the groups based on the size of the whole animal and price (where they considered wedgefish to be generally larger and therefore could fetch a higher price). Respondents in Mumbai (5.5%, n = 9) and Digha (4.3%, n = 7) also distinguished between the groups based on the colour and patterns on the skin, noting that wedgefishes were darker than guitarfishes.

3.2.2. Encounter characteristics and fishing areas

Across sites, 76% of respondents (n = 124) were not aware of any seasonality in wedgefish catches. Over a quarter of respondents (26%, n = 42) reported that wedgefish were so seldom caught that it was difficult to identify a pattern in catches. Of these, 89% (n = 37) of respondents used trawls. Most respondents (63%, n = 101) could not define specific locations where wedgefishes could be caught, while 36% (n = 58) said they could be found offshore in 'deep' water.

Sixty percent of respondent (n = 97) reported no seasonality in guitarfish catches, whereas 40% (n = 64) said that guitarfish were mainly caught between June and August, with 83% of these respondents being small-scale fishers from Chennai (Fig. 3). The remaining respondents noted that guitarfish were not commercially important enough for them to notice a seasonal pattern, and they considered them as bycatch. Guitarfish were reportedly captured in nearshore areas and near river mouths (54%, n = 87).

Almost half of fishers across all sites (42%, n = 68) were unable to answer questions about seeing live pups at sea or in their catch because they found it difficult to distinguish between wedgefish and guitarfish species and confused adults of one species with pups of another. The remaining respondents were able to distinguish between pups and adults, when provided with photographs, and the distinction was verified with follow-up questions. Among the respondents, 29 (18%) reported encountering wedgefish pups. Of these, 68% (n = 20) reported seeing wedgefish pups nearshore, particularly near river mouths and entangled in their nearshore nets, and 23 respondents reported encountering guitarfish pups in the past year (2018–2019), at river mouths. Only 9.3% (n = 15) of respondents noted that pups could be encountered in the period during and just after

Table 2. Local names associated with rhino rays (where available, the equivalent English meaning is provided in parentheses) in each state according to fisher interviews. 'n' indicates the number of respondents who provided the name

Rhino ray group	Porbandar	Mumbai	Chennai	Ganjam	Digha
Guitarfish or wedgefish (rhino rays in general)	*Dos/Dosla* (n = 3) *Saapa* (n = 1) *Bhatiya magru* (n = 1) (Bhatiya refers to rocky patches; flat shark caught near rocky areas)	*Lanjha* (n = 16) *Pakat* (general term for rays, n = 1)	*Padanga* (n = 19)	*Magar* (Shark) (n = 1)	*Phal* (n = 25) *Mogor* (n = 3) *Kumeer* (n = 1) *Hangor* (sharks) (n = 3)
Wedgefish (Rhinidae)	*Buthar* (n = 2)	*Suneri* (n = 2)	*Uluvai* (n = 20) (wedgefish) *Pullipadanga* (n = 4) (whitespotted wedgefish)	*Daruchi* (n = 1) *Sukulu-ulva* (n = 9) (name used by the Telugu-speaking Noliya community meaning rayshark)	*Tikka Phal* (n = 7) (spotted/white-spotted wedgefish) *Belle Phal* (n = 1) (bottlenose wedgefish)
Bowmouth guitarfish (*Rhina ancylostomus*)	*Kavra magra* (n = 2)	*Bhairat* (specifically for bowmouth, not to be mistaken with *Bhairi maasa* used for whale sharks) (n = 9)	*Kalluluvai* (n = 23) (rock wedgefish, sometimes used as a general name for wedgefishes) *Thimilai* (n = 12) (electric ray) *Sorra/Sura* (n = 4) (shark)	*Phulbuksorah* (n = 8) (specifically for bowmouth guitarfish; sorrah means shark)	*Kalo Phal* (black guitarfish/ bowmouth guitarfish) (n = 1) *Chumbo* (n = 1) (bowmouth guitarfish) *Tikka* (whitespotted wedgefish) (n = 9)
Guitarfish (Glaucostegidae and Rhinobatidae)		*Kharya* (n = 1), *Saundal/shingaat* (n = 2)	*Padanga* (n = 81) (specifically for guitarfish)	*Shutter* (n = 1)	*Bali Phal* (n = 2) (sand guitarfish) *Shaada Phal* (n = 4) (plain guitarfish) *Chacha* (n = 1) (guitarfish)

the monsoon season, with the remaining fishers not able to specify a particular season in which they saw live pups in the water or caught them in nets.

3.3. Catch trends

Only one respondent in Mumbai noted that rhino rays were targeted. All other respondents (99.3%) stated that rhino rays were incidentally captured during fishing operations in all types of fishing gears. Perceived declines in catches of rhino rays were noted by 85% of respondents (n = 137) who reported catch size declines ranging from 40 to 95% in the last 10 yr. The reported catch size declines were considered to provide a reasonable index of change over time, because respondents also provided matching information regarding changes in the utilisation and trade of these species.

Since most fishers were unable to distinguish between wedgefishes and guitarfishes, they were unable to provide group or species-specific details about perceived catch change. Those that could (34%, n = 55) said 'our forefathers used to catch these but not anymore', 'they are almost extinct, very few in numbers', or 'these are very rare fish to catch, one boat in 100 will get them.' Furthermore, 25% (n = 41) noted that these species were very infrequently seen. Only one respondent thought that wedgefishes had become more abundant in recent years. Overall, for all rhino rays, 46% of respondents (n = 74) could not provide a reason for declines. Of those who perceived declines, only 66 respondents (40.9%) provided reasons (Fig. 4). The majority of respondents who perceived declines (62%, n = 41) believed declines were caused by unsustainable fishing practices, including overfishing (with an increase in the number of fishers and fishing vessels), destructive fishing techniques/gears, and targeting of critical habitats such as nursery areas (Fig. 4). Nine respondents (5%) felt that overcapitalisation of fisheries other than their own were responsible for decline. For instance, both the purse seine and

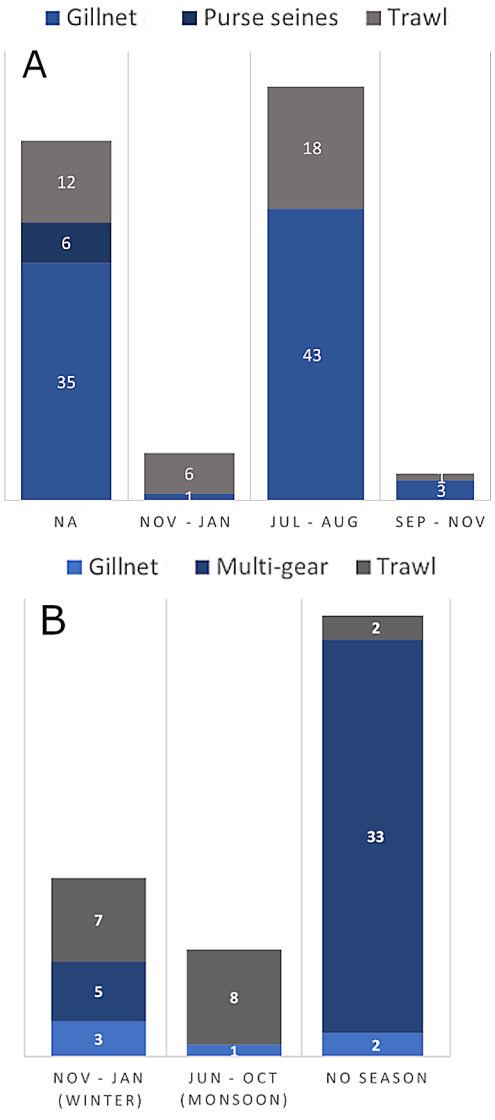

Fig. 3. Perceived seasonality of (A) wedgefish and (B) guitarfish catches. Most respondents did not perceive any seasonality, as depicted by the number whose responses were coded as 'no seasonality' and shown in (A) as NA

gillnet users indicated the increase in trawl vessels for the decline in rhino rays.

3.4. Utilisation

All respondents confirmed that currently, the majority of rhino rays were retained for sale at all sites, particularly at sizes visually estimated to be >1 m total length (TL) (Fig. 5). One fisher noted that 'the numbers have reduced a lot. Thirty years ago, we used to see many of these being caught but since they had no commercial value, we used to discard them.' Another stated, 'when they were caught, we cut the fins and the rest was thrown back at sea as it had no commercial value'. Overall, rhino rays were consumed locally (71%, n = 114), either by the respondents themselves or sold within fisher communities. A few fishers (2%, n = 3) noted that wedgefishes were preferred to guitarfishes because the meat was tastier. Many respondents (38%, n = 61), all from the east coast of India, noted that guitarfishes were not dried and only consumed fresh, as there would not be enough meat left after drying.

Juveniles of all species of rhino rays were more likely to be discarded than adults, especially in Chennai. On the other hand, at the fishing harbours (e.g. Porbandar), all animals were retained regardless of size, and the remains (e.g. heads/snouts) after processing them were sold for fish meal. One respondent noted, 'we used to get almost no price at all for guitarfishes, now we get at least a price'. However, small individuals were also likely to be consumed fresh directly onboard (4.9%, n = 8 respondents) and it was difficult to ascertain the proportion of animals retained vs. discarded. Several respondents noted that either the whole fish (if small, and especially guitarfishes that are considered to have less meat on the body), parts of larger fish, or those already spoiled at the time of landing (noting that small individuals usually die and are damaged when fishers are sorting other commercially important species onboard), were considered trash fish, which are discarded or sold for low value processing, such as the production of animal feed pellets.

Only respondents from Chennai (50.3%, n = 81) reported that rhino ray meat had medicinal value especially to treat joint and bone ailments. Because of this, they were likely to retain large-bodied individuals, and there was a considerable local market for the meat. A further 11 fishers (7% of all respondents) noted that there was a market for domestic meat trade from Chennai. However, they were not able to provide additional details.

The majority of the fishers (42%, n = 67) were not aware of the price of first sale of a whole wedgefish, because they were crew members and not involved in the sale of the catch. Of those who mentioned prices, some (5%, n = 8) noted that the cost of wedgefish <1 m in TL length ranged from USD 0.12 to 7.30 (price for whole animal). Others (5.5%, n = 9) responded that wedgefish >1 m TL length and weighing more than 20–30 kg cost between USD 121.8 and 609, with larger animals fetching higher prices per kg. However, animals were usually sold whole, by

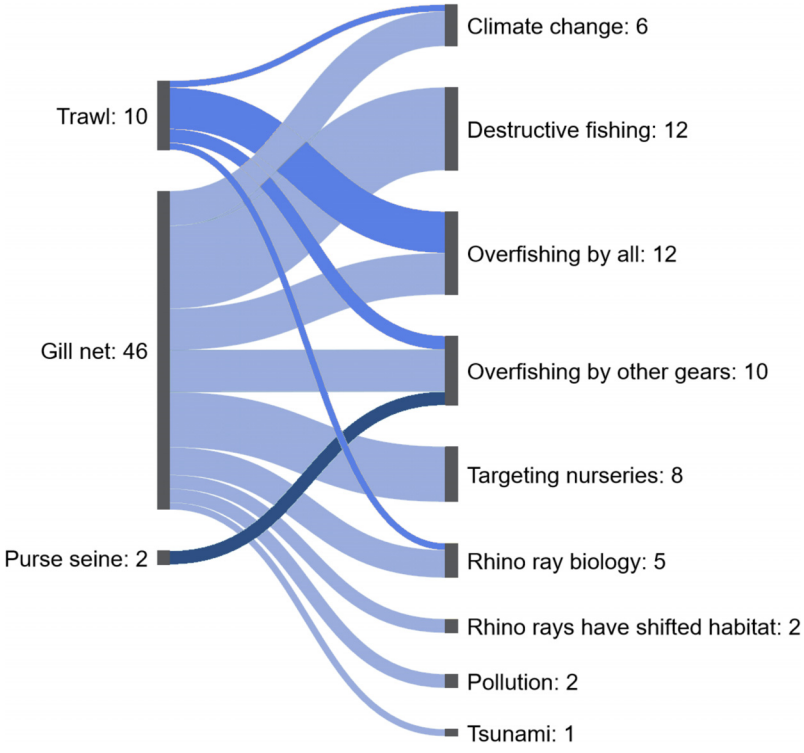

Fig. 4. Reasons for decline in rhino ray (guitarfishes and wedgefishes) catches provided by fishers (n = 66, 40.9% of respondents) according to the type of primary fishing gear used. The number of respondents using each gear type is listed on the left and the number of respondents who provided each reason for decline are listed on the right. The code 'overfishing by other gears' was used when respondents discussed overfishing by users of gear other than the ones used by themselves. Destructive fishing was used as a code whenever respondents referred to techniques such as dynamite fishing or fishing that destroyed ecosystems

piece, and fishers were not aware of the prices for fins and assumed that fin prices varied widely from USD 1 to 61 per kg. Knowledge about the price of fins was mostly anecdotal, as fishers sell the fish whole and traders cut off the fins to sell separately. Despite this, 9% (n = 14) of fishers noted that the overall price of whole wedgefishes depended on the size of their fins, and 22.9% (n = 37) of fishers noted that guitarfish fins were of no importance and were not sold because they are too small.

3.5. Perceptions about conservation

When asked about whether there would always be rhino rays in the sea, respondents did not know or had not thought about it (32%, n = 52), or were uncertain because they could not predict the future (21%, n = 34). Another 37% (n = 60) of respondents felt rhino rays will always continue to exist in the sea and made statements such as '...as long as there is water, these [rhino rays] will be there', 'yes because that [the ocean] is their home', 'fish will always be there, but they might change place', 'it [the ocean] is their [rhino rays] home territory and they will survive', and 'where will they [rhino rays] go? The ocean is their home'. Overall, more respondents (78%, n = 126) had use-oriented attitudes towards rhino rays than conservation-oriented attitudes (Fig. 6). Only 26% (n = 42) of respondents believed that rhino rays required any conservation or protection measures, with the remaining respondents stating that since rhino rays contributed so little to their income, it did not matter if their populations declined.

Consumption-oriented attitudes for rhino rays were most predominant in Chennai, while cultural associations with live rhino rays were predominant in Ganjam and Digha where 4% (n = 7) of respondents mentioned that encountering live rhino rays at sea was a symbol of a good catch because they indicated the presence of commercially important fish. Overall, only 10.5% (n = 17) of fishers believed that we should be concerned about the future of rhino rays and stated 'There is a problem because we are not catching enough'. Seven respondents (4%) noted that there should be fishing regulations in place to protect rhino rays, with one fisher stating, 'this is our livelihood. Something needs to be done to protect these fish. If a ban helps, then it should be done.' Other respondents opposing regulations (80.7%, n = 130), from the larger harbours of Porbandar, Mumbai, and Chennai, noted 'we will lose out on money for each time we could catch them. We as fishers can't afford that', 'if it is caught accidentally, nothing can be done about that', 'I can't say yes because this is my livelihood', and 'they come dead in the nets already. It doesn't make sense to lose money on dead fish. We might as well earn money from it'.

When questioned about releasing back live animals, 52% (n = 84) of respondents stated that decisions on releasing rhino rays depended on the size of the animals. Pups and small animals could be released (as many already discarded them) but larger

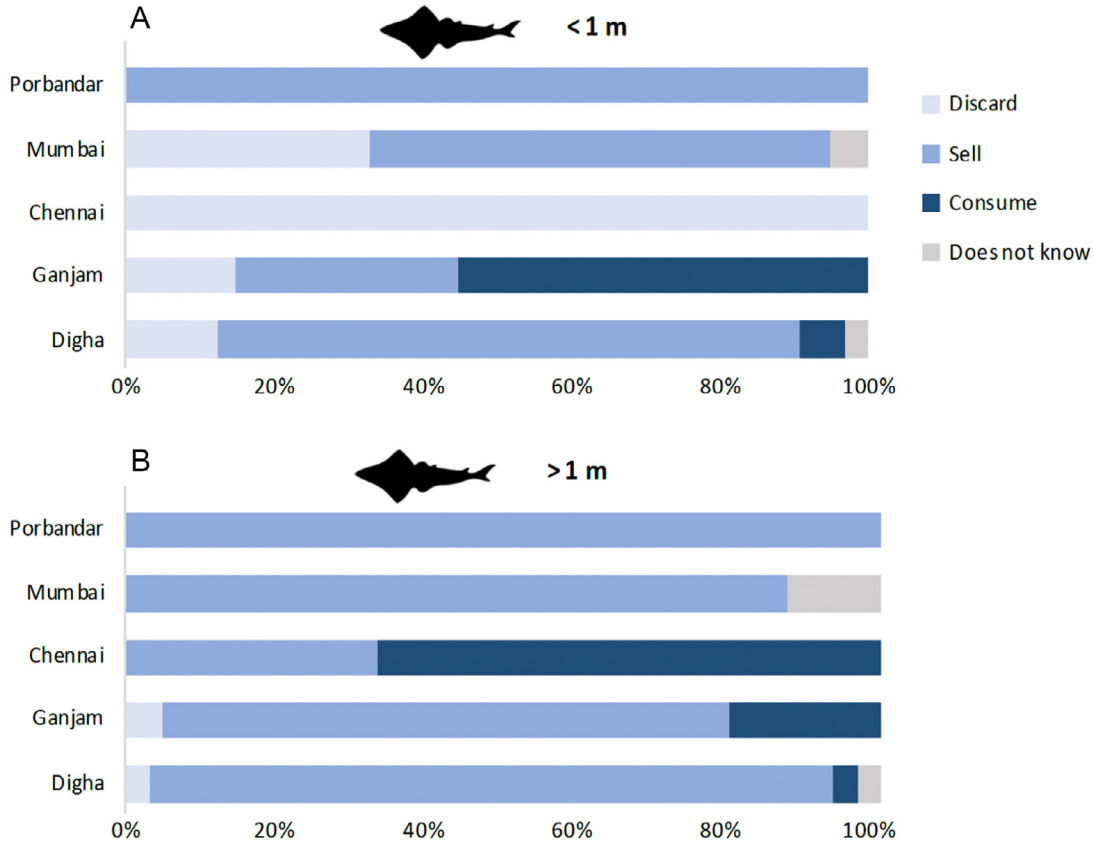

Fig. 5. Post-capture utilisation of rhino rays (guitarfishes and wedgefishes) at each study site according to the size of animals captured: (A) <1 m total length; (B) >1 m total length

animals were too valuable (26%, n = 42). Similarly, 33.5% (n = 54) noted that they would not release dead animals because they would still be able to sell them and make money. The majority of respondents could not propose gear modifications to reduce bycatch (73%, n = 117). Those that could, proposed changing mesh sizes of nets as they are too small, the ban of certain fishing techniques such as light fishing, reducing the number of boats, and banning purse seine vessels.

4. DISCUSSION

Findings from interviews at 5 major Indian fishing harbours provide insights into fisher perceptions of rhino rays in one of the largest global shark-fishing nations. Rhino rays are considered bycatch in all fisheries operating off the coast of India. They are either opportunistically retained for consumption and trade (large animals), discarded, or landed as trash fish (small sizes). Considering the threatened status of most rhino ray species, it is unsurprising that across study sites, respondents reported noticeable declines in their catches over the last decade. Of particular concern was the perception by fishers that these species could not disappear despite continued fishing, and that there was little to be done to reduce catches without affecting livelihoods. Here, we explored (1) fishers' ecological knowledge, (2) how fishing has likely impacted rhino rays, (3) utilisation patterns and their implication for the conservation of these species, and (4) the recommendations to minimise fishing interactions with rhino rays and conserve these species.

4.1. Ecological knowledge

Given the difficulty in species-level identification, most fishers were not able to tell apart wedgefishes from guitarfishes (including giant guitarfishes). This is similar to other fisher ecological knowledge studies which indicate that fishers are often only able to identify a few species with distinct characteristics, colours, or patterns (e.g. Haque et al. 2021 in

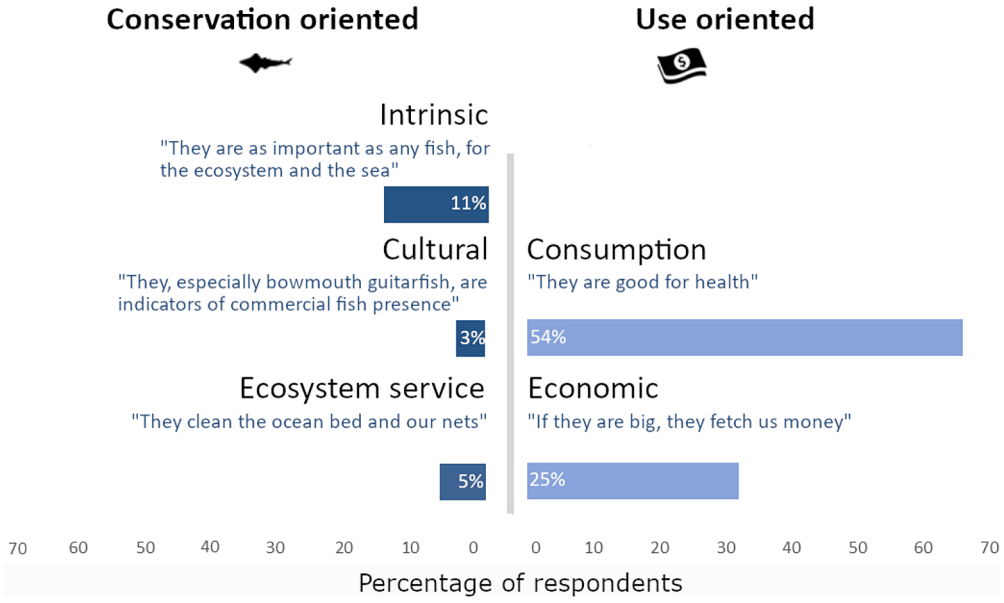

Fig. 6. Attitudes of respondents (n = 126) towards rhino rays (guitarfishes and wedgefishes). Attitudes are classified as 'conservation-oriented' if respondents value live rhino rays, or as 'use-oriented' if they value dead rhino rays. The *x*-axis indicates the number of respondents. Select quotes from the interviews are provided as examples of each attitude

Bangladesh; Tyabji et al. 2022, Gupta et al. 2023 in India). Except for the bowmouth guitarfish, which was relatively easily identified, most other species were lumped together in descriptions. This lack of knowledge about distinct species of rhino rays also confirms that wedgefishes and guitarfishes are mainly captured incidentally, with fishers paying less attention to species that have a low commercial value and that do not need to be separated prior to auctioning. Such distinctions are also less important if species are sold for processing into fish meal, as mentioned by respondents from Porbandar. Many respondents justified their lack of ecological knowledge as a lack of interest in these species due to the infrequent and low encounters (especially for wedgefishes) and the low commercial value (guitarfishes). This suggests that ecological knowledge about infrequently caught species that are rare and commercially less important could easily be lost (shifting baselines) (Pauly 1995). Additionally, generational loss in ecological knowledge has been documented elsewhere for other rhino ray species whose populations are declining (e.g. Leeney & Downing 2016, Tanna et al. 2021 for sawfishes). Research on sawfishes has indicated that important local cultural traditions were being lost due to the disappearance of species, as well as a crucial source of conservation information through local ecological knowledge that could aid efforts to revive populations of these species (Leeney & Downing 2016). Recording fishers' ecological knowledge and other forms of knowledge about species in decline is therefore a matter of the utmost urgency to prevent the loss of knowledge, and provide suggestions to motivate grassroots conservation efforts by local communities.

Declining trends in rhino ray catches were corroborated by the limited ecological knowledge respondents had about these species in general, lower knowledge about wedgefishes compared to guitarfishes, as well as general ecological information such as seasonality of catches and key habitats used by the species. Fishers who were able to provide information on the ecology of rhino rays noted that sightings and catches of small rhino rays were especially high in shallow waters and near river mouths. This seems plausible, as recent anecdotal records and opportunistic surveys in India indicate that neonates and juveniles of several species of rhino rays use coastal shallow areas (Nazareth et al. 2022, Gupta et al. 2023). Further investigations into these areas are warranted to identify critical habitats, such as nursery sites, for these species. Initiatives such as the Important Shark and Ray Areas (ISRA) to delineate areas that are critical for the long-term survival of species would support decision making by providing information on sites for consideration in area-based management approaches (Hyde et al. 2022). This is particularly important since countries like India have now committed to new targets under the United Nations Convention on Biological Diversity

Kunming–Montreal Global Biodiversity Framework to 'protect and conserve 30 percent of land and sea areas through well-connected systems of protected areas and other effective area-based conservation measures by 2030' (CBD 2022). This push to mitigate ongoing biodiversity loss and climate change while ensuring food security is an opportunity to ensure critical habitats for rhino rays are also considered in management actions over the next few years.

4.2. Fishing and catch trends

Unsustainable fishing across a range of fishing gears (trawl, gillnet, and purse seine) was noted as the main reason for the decline in rhino rays. Trends and timelines of decline reported by fishers match global trends of up to 95% population declines for these species in less than a decade (Kyne et al. 2020a). Only one respondent noted targeted fisheries for these species, while all remaining fishers stated they were incidentally caught. In other parts of the world, targeting of rhino rays has frequently been reported, including in the United Arab Emirates, Bangladesh, and Indonesia (Jabado 2018, Haque et al. 2021, D'Alberto et al. 2022). However, similar work investigating rhino ray fisheries in India using fisher ecological knowledge also indicated that targeted fisheries were no longer viable for these species in Goa (Gupta et al. 2023). This could be because most fishers noted that rhino rays were becoming increasingly difficult to capture over the last decade, especially wedgefishes.

Considering the high value of wedgefish and giant guitarfish fins in shark-fin-consuming countries, it would be surprising if rhino rays were not targeted for their fins in India, where there have been targeted shark fisheries in the past and where the trade in shark fins has been prominent (Hanfee 1997, Okes & Sant 2019)

Fins from all rhino ray species have been well documented in international trade, with fins from wedgefishes and giant guitarfishes highly prized around the world (e.g. Fields et al. 2018, Jabado 2018, Cardeñosa et al. 2020, Choy et al. 2022) and in some areas of India (Andaman and Nicobar Islands; Tyabji et al. 2022). This could be due to various reasons including the fact that in essence, fisheries in India operate as multi-gear and multi-species fisheries (Najmudeen & Sathiadhas 2008). This means that if rhino rays are present in locations where fishing operations are underway, they are likely to be caught. The demise of target fisheries in India could also be a reflection of the potential success of the 2015 'Prohibition on export of shark fins of all species of sharks' issued by the Ministry of Commerce and Industry (Government of India 2015). Traders in the Andaman and Nicobar Islands noted a steady decrease in the demand for shark fins since the introduction of this regulation and other conservation initiatives across the country (Tyabji et al. 2022).

While these regulations might have reduced demand to some degree, there are also increasing reports of illegal trade and a black market for the fin trade (Shea & To 2017). Recent evidence of stockpiling of fins, alongside seizures at ports, demonstrate that this ban has not been completely effective in stopping the trade in shark or rhino ray fins. Overall, it appears that targeted fisheries for rhino rays were historically present in at least some states in India (e.g. Goa; Gupta et al. 2023), with a few respondents noting this in this study.

While switching targets for the fin trade, from wedgefish to guitarfish, has been identified in other parts of the world (e.g. Ghana; Seidu et al. 2022), our research does not suggest that shifts have occurred at these study sites. Instead, over time, with declining catch trends, fishers may simply have altered their behaviour since the fishery is no longer viable. This has been the case in Indonesia with a decline in the vessels engaged in tangle-net fishery which targeted rhino rays (D'Alberto et al. 2022). Data from this Indonesian fishery on changes in species composition at landing sites along with a decrease in fishing vessels targeting rhino rays were a clear indication of shifting behaviour because of population declines. This might well also be the case in India, and surveys of landing sites to gather data on rhino rays at the species level are critical for monitoring changes in species composition as well as sizes and quantities landed over time. Without such information, it will be difficult to prioritise actions for the conservation of these species, especially considering the livelihood implications of any conservation measures.

4.3. Utilisation and trade

Overall, respondents had limited knowledge of rhino ray trade. Many respondents noted economic incentives to retain large-bodied individuals, especially due to the high price of their large fins, and a few noted a historical trade in wedgefishes for their fins. However, in general, respondents often were unaware of the prices of various products. It is important to note that respondents were primarily fishers,

with few boat owners, and that no traders were interviewed. Our results mirror the lack of knowledge of fishers about value chains in other national commercially important shark and ray fisheries (Karnad et al. 2020) or specialized rhino ray value chains for products such as skin in Bangladesh (Haque et al. 2021). Marine product supply chains in India are notoriously opaque, and fishers usually do not participate in trade, especially of sharks and rays (Karnad et al. 2021, Tyabji et al. 2022). Rhino rays are captured and landed by fishers before being sold directly to local processors, traders, or marketers. Furthermore, as fisheries expand in India, it appears that fishers are increasingly on the sidelines of the trade aspects. Considering that the trade in rhino ray products has been one of the drivers in their exploitation (Jabado et al. 2018), additional research into trade aspects is warranted to gain an understanding of derived products, their value, and trade routes. Recent listings of all wedgefishes (7 species), giant guitarfishes (11 species), and guitarfishes (37 species) on Appendix II of the Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES) will require improved traceability to ensure all trade is legal and sustainable. Only a few fishers mentioned exports of fins; however, it is clear that India will need to work on gathering data on rhino rays to ensure that non-detriment findings (NDF) assessments can be undertaken before trade in any derived product can be permitted (Vincent et al. 2022).

Even as rhino rays are perceived as declining in catch, their use for local consumption appears to continue, mirroring consumption trends from other parts of the Global South (e.g. Haque et al. 2021, Seidu et al. 2022, Soares & Jabado in press). Within India, some preliminary research has suggested that domestic consumption and trade for ethno-medicinal use drives the retention of these species in fisheries (Singh et al. 2020, Gupta et al. 2023). While some fishers noted the use of rhino ray meat to treat ailments, there appears to be little cultural or traditional connection, with the exception of some fishers in Ganjam and Digha, with any species of rhino ray except for consumptive uses. This is concerning because there is little value other than economic value attached to these threatened species. A cultural value would be a conservation advantage. For instance, whale sharks have been successfully protected in India through the WLPA as well as grassroots conservation efforts involving religious leaders convincing local communities to treat whale sharks as pregnant daughters returning to their mother's home for support. Such efforts were initiated by non-governmental organisations in partnership with corporate entities and fisher communities (Bloch et al. 2016). Concerted actions have been taken, especially along the west coast of India, to ensure whale sharks can be released if incidentally captured in fisheries. This project has led to wide-scale engagement with fisher communities and the successful release of hundreds of whale sharks. On the other hand, with little cultural connections between rhino rays and coastal communities, live-release strategies might be difficult to implement, especially for adult or large rhino rays that are retained for their meat (and fins in certain cases).

Nevertheless, live release efforts similar to those for rhino rays in Brazil (Wosnick et al. 2023) could easily be replicated to conserve juveniles or small-bodied species in India. In fact, the majority of fishers noted that small animals often had little meat and were either discarded or used as trash fish. Campaigns aimed at bringing awareness of the status of these species as well as safe handling techniques could ensure reduction in landings of these species as trash fish and increased post-release survivorship. However, it is possible that the release of juveniles may not significantly impact population growth of guitarfish, especially if they follow the predicted demographic patterns of other elasmobranch species (e.g. silky shark *Carcharhinus falciformis*; Grant et al. 2020).

4.4. Conservation recommendations

Unlike previously documented interest in live release for rhino rays on the west coast of India (Gupta et al. 2020, 2023), only a minority of respondents in our study appear to feel that conservation actions are necessary for these species. This is likely because the scale of fisheries at surveyed sites in Goa is much smaller than those in this study, with the latter having the largest contributions to shark and ray fisheries in India. Furthermore, campaigns advocating the live release of adults and large-bodied individuals will be challenging due to the consumptive and economic uses, as well as gear type associated with their capture. Being a low-priced source of protein, consumption of rhino ray meat, especially by fisher communities and lower economic classes, is likely to continue unless overall fisheries declines and food security issues can be addressed (Karnad et al. 2020, Pincinato et al. 2022).

The cultural association that live rhino rays are an indicator for concentrations of commercially important species in Digha and Ganjam could be a useful

starting point for conservation-oriented communication and awareness programmes in these areas. Local communities often are not motivated to perform conservation action by arguments of scarcity, due to belief systems that vary from scientific thinking (Thornton & Maciejewski Scheer 2012). Instead, they can be motivated by local cultural beliefs, especially around symbols, such as using live rhino ray presence as a symbol of a good fish catch. The overall low interest in these species due to their low commercial value suggests that any local conservation action would need to be complemented with policies to protect rhino ray species in India. Only one species of wedgefish (*Rhynchobatus djiddensis*) was protected under the Indian Wildlife (Protection) Act (WLPA), India, at the time of this study. An additional 5 species have been protected under the new amendment (Parliament of India 2022) of the WLPA (i.e. bottlenose wedgefish, *R. australiae*, smoothnose wedgefish *R. laevis*, *Rhina ancylostomus*, widenose guitarfish *Glaucostegus obtusus*, and clubnose guitarfish *G. thouin*); however, the process by which it will be implemented is yet to be seen. The addition of rhino ray species into the new amendment of the WLPA is an important step towards effective conservation, and perhaps this will aid in rhino ray conservation in India. However, additional steps to implement protection of these species are critical if they are to make a difference. This will require major campaigns to improve engagement with fishers and other stakeholders involved in fisheries. These campaigns will need to focus on aspects of cultural beliefs, poverty alleviation and alternative livelihoods, strengthening legislation, improving capacity for implementation and enforcement, and working on area-based management initiatives. The decline in catches of rhino rays and the lack of knowledge about utilisation and trade underscore the urgency in developing and implementing effective conservation measures. Immediate actions are needed to secure the long-term survival and sustainability of rhino ray fisheries in India.

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Appendix.

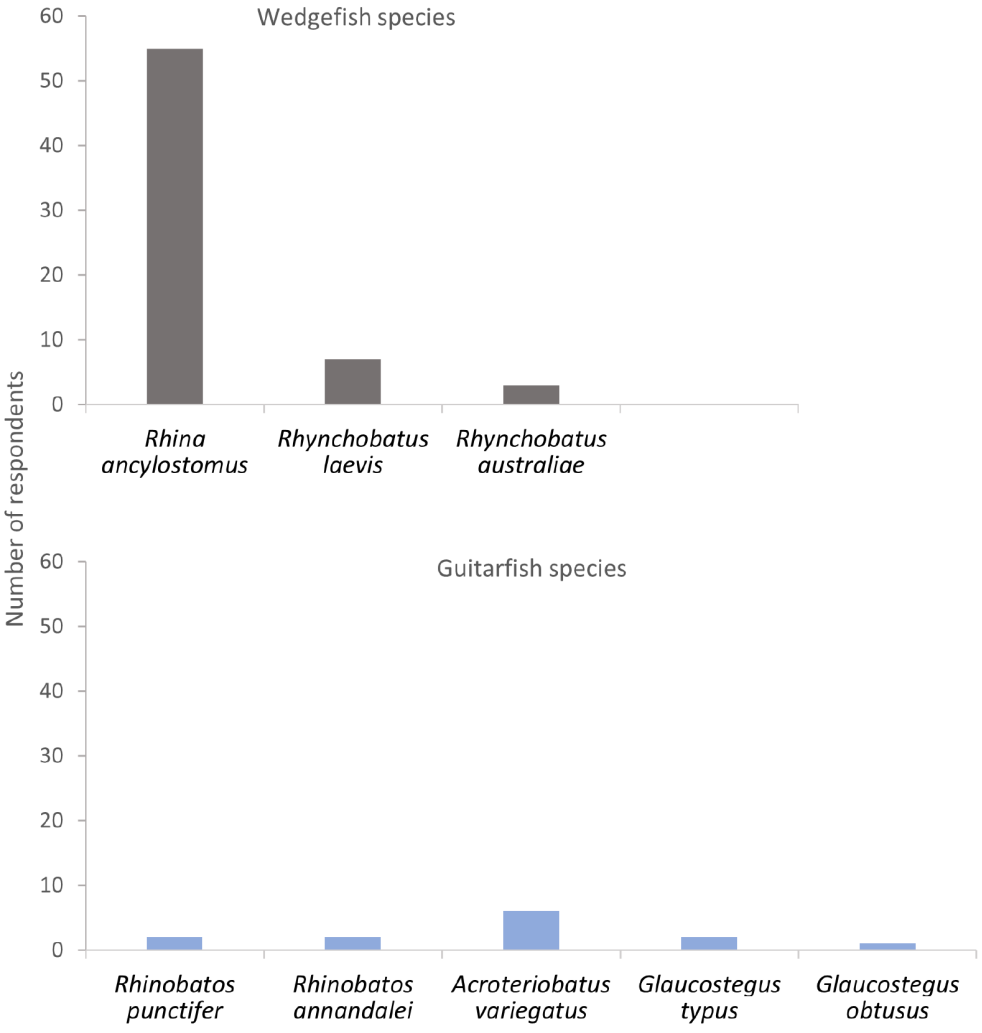

Fig. A1. Wedgefishes (grey) and guitarfishes (blue) identified by respondents. Other than the bowmouth guitarfish, most other species were identified by respondents in Porbandar and Mumbai

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