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Marine species conservation awareness and community perceptions among tribal fishers of Car Nicobar, India

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Abstract

Understanding the perceptions, attitudes, and awareness levels of tribal fishers who interact daily with fragile marine ecosystems is vital, as these communities depend heavily on these resources for their livelihood and food security. Nicobarese fishers (n=195) from Car Nicobar Island in the Bay of Bengal were interviewed to assess their knowledge, awareness, and attitudes towards marine conservation, including perceptions of species protection, enforcement, community participation; threats to marine biodiversity and the sustainability of marine fauna. Awareness of conservation regulations was moderate, with 81% of respondents familiar with Wildlife (Protection) Act, 1972, and 72% supporting protected status for marine species, citing rarity and their restricted distribution as key reasons. However, institutional mechanisms were weak, 74% of respondents reported lack of tribal-level management plans, while 97% indicated that no formal legal framework for marine conservation existed within tribal councils. Nearly all respondents (97%) reported encountering rare marine species encountering during fishing activities, but their responses varied, with 44% releasing such speices back into the wild, and 27% consuming them. Perception scores reflected strong support for species conservation (4.02±0.68) and enforcement measures (3.97±0.62), although confidence in existing management practices and community consensus was only moderate. Generalised Linear Model (GLM) analysis revealed that age, fishing experience, and especially education were significant predictors of conservation awareness ($p<0.05$), whereas village-level variations were not significant. The findings emphasised a strong conservation commitment among Car Nicobar's fishing communities, but also revealed weak institutional frameworks and community mechanisms. To better align conservation knowledge with sustainable marine resource management, it is crucial to strengthen environmental education, establish conservation regulations through tribal councils, and launch targeted awareness campaigns.

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Introduction

Coastal systems are diverse, dynamic, and complex socio-ecological systems (Jentoft and Chuenpagdee, 2009), which support the livelihoods and food security of numerous coastal fisherfolk in Asia, many of whom possess rich traditional ecological knowledge (Kurien, 1998). In this context, coastal communities should take a leading role in the sustainable management of marine resources (Veitayaki, 2008; Berkes and Nayak, 2018; Evans *et al.,* 2023; Seaside Sustainability, 2023; Yanda *et al.,* 2023), as these resources are crucial for their livelihoods and employment. Effective management is crucial for ensuring sustainable fish harvests (Jentoft, 1989). Marine resources are managed through a mix of cultural and administrative processes that are influenced by human livelihoods (Jentoft *et al.,* 1998; Levine *et al.,* 2015; Relano *et al.,* 2022). It is crucial to understand stakeholders' knowledge and contributions to marine spatial planning from governance and social perspectives (Jefferson *et al.,* 2015; Morf *et al.,* 2019). Their understanding of potential threats to marine ecosystems and management approaches that could promote conservation is also critical (Fonner *et al.,* 2020).

Classical fisheries economics indicates that common-property fisheries can be susceptible to overexploitation when access is inadequately regulated, and individual harvesting choices are misaligned with collective management rules (Gordon, 1954). However, studies also demonstrate that common-property systems should not be equated with unregulated open access; instead, strong local institutions, well-defined rules, monitoring, graduated sanctions, and conflict-resolution mechanisms can facilitate collective action in common-pool resource systems (Ostrom, 1990). This is especially important within the concept of Blue Economy, as ocean-based development needs to balance economic benefits with ecological sustainability and social equity. For indigenous and small-scale fishing communities, Blue Economy strategies are only effective when their customary rights, local knowledge, and participation in decision-making are acknowledged. At the global policy level, the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (VGSSF) provide a human-rights–based framework that empowers small-scale fishing communities to align conservation with livelihood security (FAO, 2015). In practice, locally tailored approaches such as co-management, locally managed marine areas (LMMAs), and participatory enforcement have been shown to improve ecological outcomes when grounded in local values and knowledge (Hamelin *et al.,* 2024).

Island ecosystems largely depend on marine fisheries, yet community-led conservation efforts often remain unnoticed. This is especially true for islands like the Andaman and Nicobar Islands, where marine fisheries are vital to local economies (George *et al.,* 2011; Advani *et al.,* 2013; Kirubasankar *et al.,* 2013, 2021), despite their ecosystems being vulnerable (Roy and Krishnan, 2005; Yuvaraj *et al.,* 2015; Kiruba-Sankar *et al.,* 2019). Even the remote Nicobar Islands face numerous underreported threats that jeopardise their long-term sustainability (Patankar *et al.,* 2016; Roy *et al.,* 2017a, b; Kiruba-Sankar *et al.,* 2023a). Studies on Nicobarese communities highlight rich traditional fishing practices and gear, emphasising the value of Traditional Ecological Knowledge (TEK) as a management resource rather than an obstacle (Ravikumar *et al.,* 2015; 2016; Kiruba-Sankar *et al.,* 2023b). Combining TEK with ecosystem-based management highlights the necessity of involving local communities in decision-making, integrating scientific, administrative, and indigenous knowledge (Stori *et al.,* 2019).

Understanding the awareness levels of tribal fishers who interact daily with fragile marine ecosystems is vital, as they depend on these ecosystems for their livelihoods and food security. Marine resources are crucial for providing nutrition and food security to Nicobar Island communities and integrating tribal knowledge into management can enhance resilience against climate change, overfishing, and habitat loss. Therefore, this study evaluated the awareness, attitudes, and perceptions of Nicobarese tribal fishers regarding marine resources, particularly their understanding of the status and sustainability of these resources. The results aim to support the active engagement of tribal communities in species conservation, foster community-led stewardship, and ensure the long-term sustainability of Car Nicobar's fragile ecosystems.

Materials and methods

Study area and stakeholder surveys

The study was conducted on Car Nicobar Island, the administrative headquarters of the Nicobar District, and the survey spanned 14 villages (n=195) representing the major fishing communities (Fig. 1) during 2022-23. A questionnaire was prepared to assess respondents'

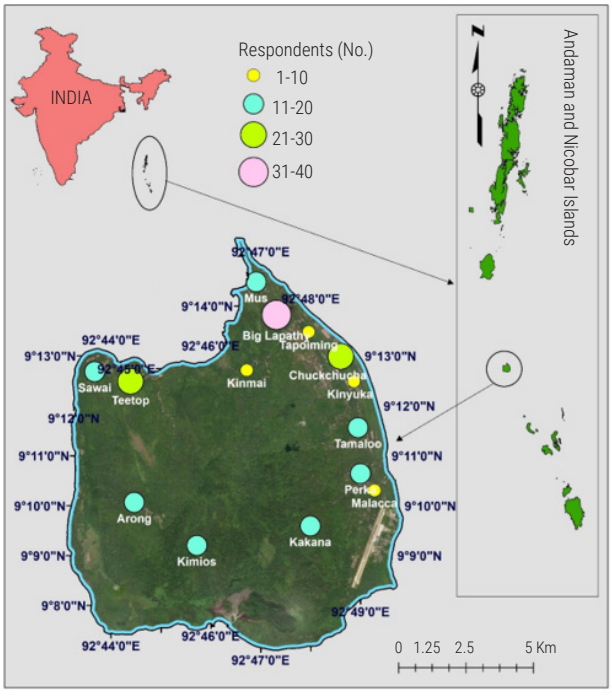

Fig. 1. Map of the study area survey locations and the distribution of respondents

socio-demographic characteristics; to understand the level of knowledge, personal practices, and community participation in conservation, as well as gaps in awareness or legal frameworks; and to gauge the degree of agreement among respondents on statements about the need for protection, enforcement, community consensus, threats, and sustainability, using Likert scale questions (1 to 5). These questions were asked to measure the strength of attitudes and collective opinion towards conservation, going beyond simple awareness to assess levels of support and perceived challenges. A higher mean score indicated stronger agreement with conservation statements, and results were interpreted in the context of community support for management interventions.

Statistical analysis

Descriptive statistics, including mean and standard deviation, were computed. The assumptions of ANOVA were checked using the Shapiro–Wilk test for normality and Levene's test for homogeneity of variances. One-way ANOVA was used to test for differences in perceptions among groups, and Tukey's HSD *post hoc* test was used if significant differences were found. Results include the F-statistic and p-values, with significance defined at $p<0.05$.

Generalised Linear Model (GLM) analysis

To identify factors influencing awareness of the marine environment, a Generalised Linear Model (GLM) was used. A binomial GLM with a logit link was employed to assess the effects of independent variables (fishing experience, age, education, and village) on awareness. The probability of awareness (Pi) was modelled as:

$$\log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 \text{Experience}_i + \beta_2 \text{Age}_i + \beta_3 \text{Education}_i + \beta_4 \text{Village}_i$$

where,

$p_i = P(Y_i = 1)$

P is the probability that the i^{th} respondent is aware of marine conservation issues. The GLM allows simultaneous testing of multiple predictors while controlling for confounding effects. Model performance was assessed using the Akaike Information Criterion (AIC), and the significance of predictors was evaluated using Wald chi-square tests at an alpha level of 0.05. Additionally, a chi-square test of independence was conducted to assess associations between categorical variables (*e.g.*, education level, village) and awareness levels. This approach was chosen because the response variable was binary (Yes/No), making it suitable for categorical comparisons. The detailed methodology for the GLM approach is described by Dobson and Barnett (2018). Data were analysed using the GLM function in RStudio (R Core Team, 2025).

Ethical considerations

Entry into the Car Nicobar Island is regulated under The Andaman and Nicobar Islands (Protection of Aboriginal Tribes) Regulation, 1956. The first author fulfilled the requirements to visit Car Nicobar Island to undertake surveys. We obtained written consent from the Chief Captain, Office of the Tribal Council, Car Nicobar, to conduct village-level personal interviews with the Nicobarese tribes as per procedure. Informed consent was obtained from the respondents before the surveys, and they were informed about the purpose, the type of questions they would encounter, and how their responses would be used, including the confidentiality of the respondents who provided the information. Considering the low literacy levels of the respondents, written consent was not obtained, whereas verbal consent was taken from the respondents before the personal interviews.

Results

Socio-demographic profile of respondents

Of the 195 respondents surveyed in Car Nicobar, all were male fishermen, aged 16 to 75 years (Table 1). Most respondents (84.1%) were Christians, while a smaller proportion (15.9%) were Muslims. Respondents were spread across several villages, with Big Lapathy (37) and Teetop (26) having the highest representation. Fishing experience varied, with most having 10 years or less (39.5%) or between 10 and 20 years (35.4%). In terms of educational attainment, more than half of the respondents had not completed the 10^{th} standard; only one respondent held a graduate degree and another a postgraduate degree. This profile

Table 1. Socio-demographic details of the respondents

Criteria	Number
Main occupation	Fishing
Village-wise respondents	
Arong	16
Big Lapathy	37
Chuckchucha	24
Kakana	14
Kinmai	4
Kinyuka	1
Kimios	12
Malacca	2
Mus	14
Perka	13
Sawai	15
Tamaloo	13
Tapoiming	4
Teetop	26
Gender	
Male	195 (100%)
Religion	
Christian	164 (84.1%)
Muslim	31 (15.9%)
Age (Years)	16-75
<=25	9
25-45	101
45-60	63
>60	22
Experience in fishing activities (Years)	
<=10	77
10-20.	69
20-30	40
30-40	5
40-50	4
Education	
Illiterates	7
Below 10^{th} Grade	108
Up to 10^{th} Grade	49
Up to 12^{th} Grade	29
Graduate	1
Post-graduate	1

reveals a predominantly traditional fishing community with limited formal education but considerable practical experience in fishing. Participation was relatively low in villages such as Kinmai, Kinyuka, Malacca, and Tapoiming, as a few approached respondents chose not to respond and were shy about the process.

Perception of stakeholders towards marine species

Most stakeholders (81%) were aware of the Wildlife (Protection) Act, 1972, and 72% recognised the importance of protecting species, with rarity (28%) and limited distribution (25%) commonly cited as reasons for conservation or protection (Table 2). Respondents also identified the Forest Department as the primary authority enforcing species protection (63%), though awareness of other agencies was limited. While 62% agreed on the necessity of marine conservation amidst increasing threats, only half reported taking personal actions, such as avoiding the fishing of rare species. Community awareness was low, with only 37% reporting good knowledge and 74% acknowledged the absence of tribal management plans or frameworks within tribal councils for conservation efforts (Fig. 2). Legal frameworks within tribal councils were mostly absent (97%). Nevertheless, all respondents agreed on the need for awareness programs to educate local communities about marine ecosystems and vulnerable species. Nearly 97% of respondents have encountered rare marine species during fishing; responses varied, with 44% releasing them and 27% consuming them (Fig. 3).

Table 2. Perception of stakeholders towards marine species and the level of compliance

Are you aware of the Wildlife Protection Act and protected marine species?	Percentage (%)
Yes	81
No	19
Are you aware of the need to place a species in protected status?	
Yes	72
No	14
Can't say	15
If yes to the above question, what could be the probable reason?	
Declining population	15
Overfishing	10
Rare species	28
Limited distributional range	25
Others	22
Are you aware of the responsible department for marine wildlife?	
Forest	63
Fisheries	6
Coast Guard	22
Marine Police	0
Others	9
For marine conservation, the steps taken at your personal level?	
No fishing of such species	52
Advising others to avoid fishing for such species	18
Others	30
Do you agree in group discussion at village level on protection and conservation of marine species?	
Yes	17
No	39
Can't say	44
If yes, then how often?	
Can't say	100
Is there any legal framework at the tribal council level?	
Yes	3
No	97
Can't say	0
Do you recommend the need for awareness programs for species conservation?	
Yes	100
No	0
Have you encountered any such rare marine species during fishing activities?	
Yes	97
No	3

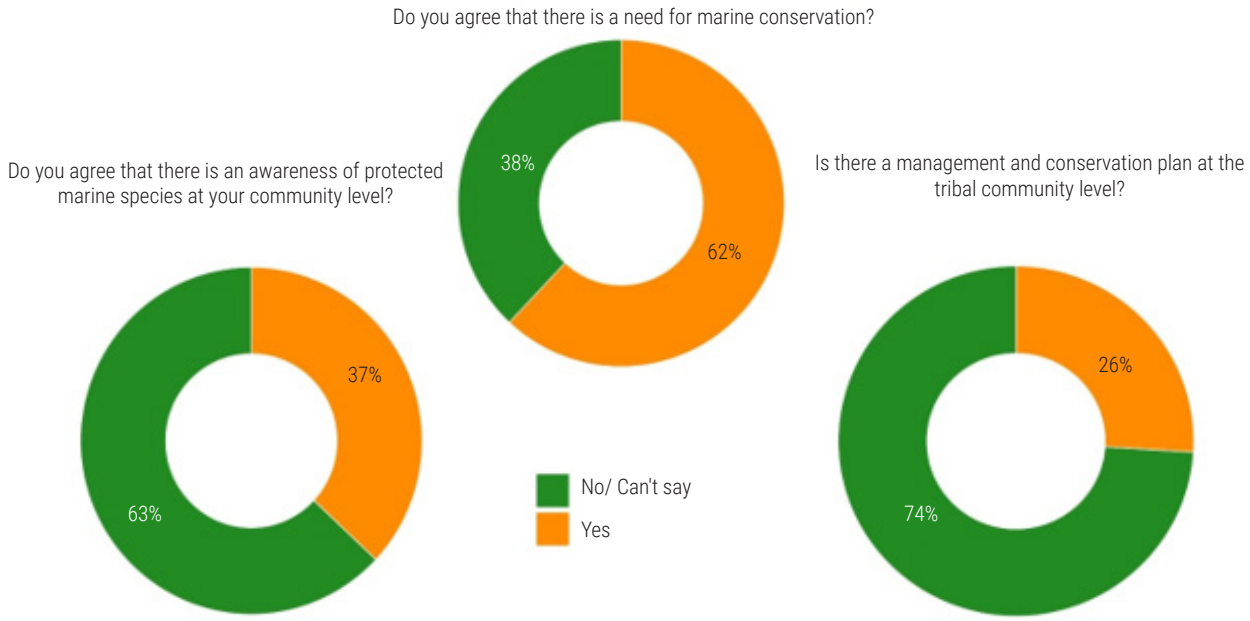

Fig. 2. Community perceptions on marine conservation awareness and management in Car Nicobar

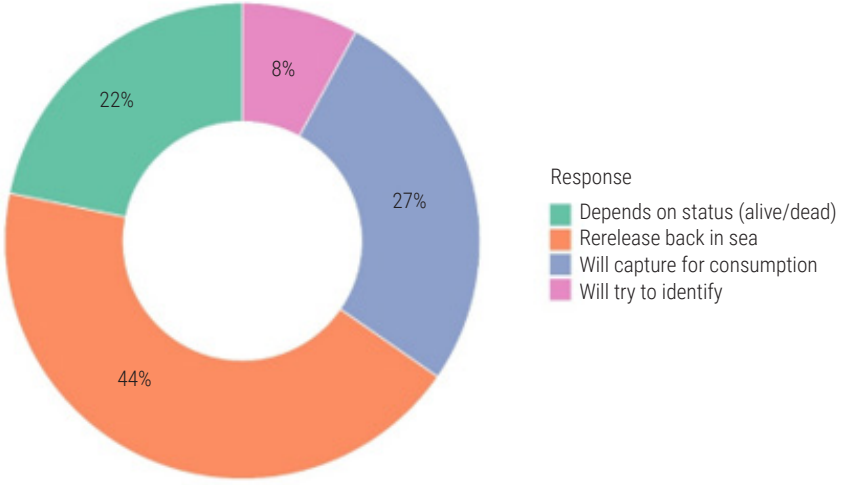

Fig. 3. Community responses to encounters with protected or rare marine species

Likert-scale responses of stakeholders

Respondents agree that species protection (Mean=4.02±0.68) and strict enforcement (3.97±0.62) are vital for the long-term sustainability of marine resources, which provide income and subsistence for their communities. However, they expressed less confidence in current management, giving moderate ratings to protection adequacy (3.73±0.67), community agreement (3.38±0.63), and poacher threat (3.01±1.08). The belief that protected species are generally not harvested received a moderate response (3.46±0.70). Statistical analysis revealed significant differences in responses ($p<0.05$), indicating variability in perceptions about marine faunal groups, conservation, and management (Table 3).

Generalised Linear Model (GLM) Analysis

GLM analysis revealed that fishing experience, age, and education all significantly influence awareness ($p<0.05$) (Table 4). Specifically, respondents with greater fishing experience and older age tend to have higher levels of awareness. Education emerged as the most influential factor, with illiteracy negatively impacting awareness and higher education levels (above graduation) having a positive effect. Among the tested predictors, education showed the strongest explanatory power (AIC=189.48), followed by age (AIC=208.85) and fishing experience (AIC=208.98). By contrast, the village-level model had a higher AIC (224.21), indicating lower explanatory power.

Table 3. Responses of stakeholders on five-point Likert scale (1=Strongly disagree, 2=Disagree, 3=No opinion, 4=Agree, 5=Strongly agree)

Particulars	Mean±SD	Sum of Squares	Mean Squares	F-Value	p-value*
There is a need for the protection of marine species	4.02±0.68	88.95	25.42	46.73	3.03×10^{-52}
Strict enforcement and monitoring is essential for conservation	3.97±0.62	74.87			
Adequate protection and care are already being given for species protection	3.73±0.67	88.13			
There is a good consensus among the tribal community regarding the protected marine species	3.38±0.67	86.15			
Threat of cross-border or outside poaching	3.01±1.08	227.98			
The current level of management will ensure the sustainable management of marine resources	3.38±0.63	78.15			
Protected species in general are avoided from harvesting, considering the resource importance	3.46±0.70	94.46			

*One-way ANOVA at p value<0.05; SD=Standard Deviation

Table 4. Generalised linear model (GLM) showing different factors on the level of awareness

Model	Category	β Coefficient	Odds Ratio (OR)	Standard Error	p-value*	AIC
Fishing Experience	1-50 Years	1.70	5.47	0.35	0.0000002	208.98
Age	16-75 Years	2.36	10.59	0.68	0.0003	208.85
Education	Illiterate	-2.06	0.13	0.86	0.016	189.48
	Below Tenth Grade	1.15	3.16	0.19	0.000000004	
	Graduation	1.53	4.62	0.76	0.043	
Village	Arong	0.79	2.20	0.54	0.144	224.21
	Big Lapathy	0.35	1.42	0.66	0.600	
	Chuckchucha	0.10	1.11	0.70	0.888	
	Kakana	0.51	1.67	0.85	0.546	
	Kinmai	-0.45	0.64	0.80	0.570	
	Kinyuka	0.31	1.36	1.27	0.808	
	Kimios	15.78	7.14×10^{6}	2399.54	0.995	
	Malacca	15.78	7.14×10^{6}	1696.73	0.993	
	Mus	0.13	1.14	0.80	0.873	
	Perka	0.92	2.51	0.94	0.329	
	Sawai	0.22	1.25	0.79	0.779	
	Tamaloo	1.70	5.47	1.17	0.148	
	Tapoiming	15.78	7.14×10^{6}	1199.77	0.990	
	Teetop	1.25	3.49	0.82	0.127	

*p-values are from Wald tests of GLM coefficients; Significance level $p < 0.05$

To interpretation of the logistic regression model, Odds Ratios (OR=exp(β)) were computed for each predictor. The analysis revealed that age (OR=10.59) and fishing experience (OR=5.47) were positively associated with awareness. Education was identified as the most influential socio-demographic factor, with those having formal education showing greater awareness than the reference group. Conversely, illiterate individuals had significantly lower odds of awareness (OR=0.13). Overall, village effects were mostly non-significant, suggesting that awareness depends more on individual traits than location.

Level of awareness for marine fauna and taxonomic groups

Although the Wildlife (Protection) Act, 1972 applies to the Andaman and Nicobar Islands, the conservation context in Car Nicobar is shaped by the statutory protection of certain traditional hunting rights of the Scheduled Tribes of the Nicobar Islands under Section 65 of the Act. Our survey found that respondents had 100% awareness of well-known Endangered, Threatened, and Protected (ETP) species such as sea turtles, saltwater crocodiles, sharks, dolphins, and sea cucumbers, likely due to their cultural significance, frequent sightings, and links to local livelihoods. Sea turtles are often caught for food, while fishermen from Teetop and Sawai villages believe that sharks in their inshore waters prey on their long-line catches (Fig. 5). In contrast, awareness of less-familiar fauna such as corals (89%) and giant groupers (86%) was moderate, largely shaped by specific fishing or diving experiences. Knowledge of species such as guitarfish (27%) and sawfish (26%) was limited, as sightings are rare in local waters. Although corals are visible daily during fishing, many locals mistake them for calcium stones or rocks and are unaware of their vital ecological roles in maintaining the islands' marine ecosystem.

Discussion

Stakeholder support is essential for implementing strategies that effectively conserve and monitor coastal ecosystems (Nguyen *et al.,* 2023; Brun *et al.,* 2024; Demmler and Stoll-Kleemann, 2025). Understanding stakeholders' perceptions, indigenous knowledge, and traditional practices is a key approach to sustainable marine management (Proulx *et al.,* 2021), as it ensures their involvement

in decision-making and resource co-management. This is especially relevant for islands like Car Nicobar, a small, flat island of 132 sq km surrounded by the sea, where the local population's livelihoods depend heavily on marine resources (Kiruba-Sankar *et al.,* 2020).

Conservation challenges in Car Nicobar

The study revealed that Nicobarese fishers are strongly committed to conserving their resources, yet their efforts are hampered by weak community-level institutions and limited knowledge of various species. Governance tools like Marine Protected Areas (MPAs) support marine conservation and raise awareness of ocean ecosystems (Jentoft *et al.,* 2007). However, in Car Nicobar, balancing conservation goals with the open-access nature of resources presents a unique challenge. The finding aligns with global studies that recommend combining formal rules with local incentives, leadership, and social capital to effectively manage small-scale fisheries, rather than relying solely on regulations (Gutierrez *et al.,* 2011). Typically, successful co-management involves multiple factors, such as clear ownership, accountable leadership, participatory decision-making, monitoring, sanctions, and conflict resolution, with performance improving as more of these elements are in place (Gutierrez *et al.,* 2011).

Patterns of species awareness

Fishers of the Andaman Islands were generally aware of charismatic groups such as mammals, reptiles, and cnidarians, but less so of less-visible groups such as elasmobranchs, fish, sea cucumbers, and molluscs (Patankar, 2019). Similarly, the study highlights how cultural value, visibility, and usefulness shape ecological knowledge among Nicobarese tribal fishers. Awareness was highest for commonly encountered or culturally/economically important species, moderate for corals and giant groupers, and lowest for rarely seen species like guitarfish and sawfish. This pattern is consistent with earlier studies showing that local ecological knowledge is shaped by direct resource use, cultural practice, and repeated interaction with marine ecosystems (Stori *et al*., 2019; Proulx *et al*., 2021). These findings suggest that conservation strategies in Car Nicobar should account for the uneven distribution of local knowledge.

Role of education in conservation awareness

The GLM analysis indicates that education plays a key role in raising awareness of marine species and vulnerable marine fauna, which in turn shapes conservation attitudes among Nicobarese tribal fishers. Respondents with formal education, especially those with a tenth standard or higher, demonstrated considerably greater knowledge. This underscores that even basic education can improve understanding of marine biodiversity, the significance of protected status, and the ecological roles of species. A study by Patankar (2019) in the Andaman Islands found high awareness of protected marine species despite limited education, as these species are closely linked to local livelihoods. While most respondents in this study (81%) are aware of the Wildlife (Protection) Act, 1972, understanding the Act is distinct from recognising marine species in daily life. Species awareness arises from local experience, whereas legal awareness requires knowledge of policies, which is less common. To quickly improve fishers' knowledge, short, culturally relevant curricula could be developed that cover species identification, release protocols, legal basics, and the ecological roles of corals and sea cucumbers. These could be delivered through tribal councils, schools, and fisher associations. Similar programmes that combine traditional knowledge with scientific content have successfully improved rule acceptance and reduced accidental captures of protected species elsewhere (Hicks *et al*., 2014).

Traditional ecological knowledge and conservation values

Reducing the impacts of fisheries is particularly challenging in inshore communities, where endangered species may be valued for consumption (Booth et al., 2023). In Car Nicobar, conservation efforts are guided by Section 65 of the Wildlife (Protection) Act, 1972, which safeguards specific hunting rights granted to the Scheduled Tribes of the Nicobar Islands. Therefore, conservation strategies must balance respecting these traditional rights with the goal of protecting species. The survey reveals strong awareness of culturally significant megafauna such as turtles, dolphins, and sharks, but less familiarity with species such as guitarfish, sawfish, and corals. This finding is further supported by Kiruba-Sankar *et al.* (2026), who showed that TEK of Nicobarese fishers helped identify olive ridley turtle nesting sites in Car Nicobar.

Despite open access to resources, fishing communities often ignore marine fauna like dolphins, viewing them as sea pets. Regarding sea cucumbers, opinions vary: some fishers say they were once consumed but are no longer caught for food today. This underscores the importance of traditional ecological knowledge (TEK) as both an asset and a gap. Research shows that TEK can guide seasonal closures, size and gear regulations, and spatial protections, especially when integrated into local management or customary arrangements (Johannes, 2002; Jupiter et al., 2014). For Car Nicobar, implementing LMMA-style tools within traditional governance could formalise practices such as the voluntary release of rare species.

An apparent contradiction emerged from the survey results, while 72% of respondents supported protecting vulnerable marine species, 27% reported consuming rare species when they encountered them. This finding suggests that conservation awareness and conservation behaviour do not always align. In Car Nicobar, marine resources constitute an important component of subsistence and cultural practices, and behavioural decisions may therefore be influenced by livelihood needs, food security considerations, traditional customs, and customary access rights. Furthermore, the absence of formal tribal-level conservation regulations may limit the translation of positive conservation attitudes into consistent conservation practices. These findings highlight that awareness is a necessary but insufficient condition for behavioural change and that effective conservation interventions should combine education with locally accepted governance mechanisms and community-based management measures.

Geographic isolation and awareness gaps

Knowledge of social issues and conservation updates differs significantly between the Andaman and Nicobar island groups, mainly

due to their geographical isolation. The Andaman group has better connectivity within the archipelago, with a mixed population of mainland settlers and local communities that have benefited from improved infrastructure, education, and awareness programmes over time. In contrast, the Nicobar group is geographically dispersed and isolated, limiting communication and knowledge sharing and often resulting in lower awareness levels, including marine conservation. The nature of the customary access regime for marine resources among aboriginal tribes on Car Nicobar Island offers an alternative to the restricted access to marine resources for several indigenous peoples worldwide (Davis and Jentoft, 2001). Against this backdrop, this study highlights distinct awareness patterns among Nicobarese fishers, with very high recognition of culturally significant and frequently encountered species like turtles, crocodiles, sharks, dolphins, and sea cucumbers, but relatively low awareness of ecologically essential but less visible groups like corals, giant groupers, guitar fish, and saw fish.

The perception results reveal an important management opportunity. While respondents strongly supported species protection (4.02±0.68) and strict enforcement and monitoring (3.97±0.62), their confidence in current management effectiveness (3.38±0.63) and community consensus (3.38±0.67) was considerably lower. This suggests that the primary challenge is not a lack of conservation intent but rather the absence of effective local mechanisms to translate support into action. Given the strong cultural cohesion of Nicobarese society and the existing role of tribal councils in local governance, community-led approaches such as participatory monitoring, reporting of rare-species encounters, voluntary release protocols, locally managed marine areas (LMMAs), and village-level conservation rules could help bridge this implementation gap. By building on the already high level of support for conservation, these mechanisms may strengthen compliance, improve stewardship, and enhance the effectiveness of marine resource management in Car Nicobar.

Climate threats and adaptive management

Island fisheries are now experiencing heightened thermal stress, extreme events, and shifting species distributions (Krishnan *et al.,* 2011; 2012; Roy *et al.,* 2017a, b). Low awareness among local communities about coral reefs and their ecological roles needs attention and further outreach among the Car Nicobar fishers. Meanwhile, planning for food security should consider the impacts of bleaching and the variability of nearshore productivity, as the Island reefs are vulnerable to reef bleaching events (Krishnan *et al.,* 2011). Incorporating climate indicators, such as temperature anomalies and coral condition, into community monitoring can help trigger adaptive measures, like seasonal or effort adjustments, before thresholds are crossed. Future research involving larger samples and more detailed datasets could utilise these methods to gain a deeper understanding of the factors influencing conservation behaviour and decision-making.

The study revealed that Nicobarese fishers in Car Nicobar have a strong preference for conservation and a deep understanding of culturally significant species, including turtles, dolphins, sharks, and sea cucumbers. However, community institutions and formal systems remain underdeveloped. Education is crucial in raising awareness, alongside age and fishing experience, emphasising the importance of education and knowledge sharing in fostering change. The frequent sightings of rare species and diverse responses, like release or consumption, highlight a gap between awareness and action that can be addressed through locally accepted rules, clear protocols for encountering rare species, and community-led monitoring. For a small island that's highly vulnerable to climate change, it needs three crucial steps to improve the management: (i) Integrating customary norms into tribal council rules; (ii) Evaluating locally managed marine areas to protect key habitats; (iii) Increasing awareness about low-profile but threatened species like guitarfish, sawfish, and corals.

However, broader community-level conclusions require the inclusion of women, youth, and other stakeholder groups in future studies. A limitation and future direction for this study is that our male-only sample reflects the fishing demographics but overlooks the views of women and young people across the value chains. The observed gap between conservation attitudes and resource-use behaviour indicates that awareness programmes alone may not achieve conservation outcomes unless they are supported by community-based institutions, locally accepted rules, and livelihood-sensitive management interventions. Future research should incorporate these groups, assess LMMA pilots, and connect ecological indicators with adaptable community regulations. Additionally, future studies should explore how factors like fishing gear, target species, habitat use, and encounter frequency influence conservation knowledge and attitudes.

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References

Advani, S., Sridhar, A., Namboothri, N., Chandi, M. and Oommem, M. A. 2013. Emergence and transformation of marine fisheries in the Andaman Islands. *Dakshin Foundation and ANET Publication*, 29 p. https://doi.org/10.13140/RG.2.2.15554.68804.

Berkes, F. and Nayak, P. K. 2018. Role of communities in fisheries management: "One would first need to imagine it". *Marit. Stud.*, 17: 241-251. https://doi.org/10.1007/s40152-018-0120-x.

Booth, H., Ramdlan, M. S., Hafizh, A., Wongsopatty, K., Mourato, S., Pienkowski, T., Adrinato, L. and Milner-Gulland, E. J. M. 2023. Designing locally-appropriate conservation incentives for small-scale fishers. *Biol. Conserv.*, 277: 109821. https://doi.org/10.1016/j.biocon.2022.109821.

Brun, V., Madarcos, J. R. V., Celis, A. J., Creencia, L. A., Gurney, G. G. and Claudet, J. 2024. Assessing stakeholder perceptions to guide social and ecological fit of marine protected areas. *Science*, 27(18): 110952. https://doi.org/10.1016/j.isci.2024.110952.

Davis, A. and Jentoft, S. 2001. The challenge and the promise of indigenous peoples' fishing rights-from dependency to agency. *Mar. Policy*, 25(3): 223-237. https://doi.org/10.1016/S0308-597X(01)00014-8.

Demmler, R. A. and Stoll-Kleemann, S. 2025. Understanding public perceptions of marine threats: Awareness and concern among residents and visitors of the German Baltic Sea coast. *Front. Mar. Sci.*, 12: 1596331. https://doi.org/10.3389/fmars.2025.1596331.

Dobson, A. J. and Barnett, A. 2018. *An introduction to generalized linear models*, 4th edn. Chapman and Hall/CRC, USA..

Evans, L. S., Buchan, P. M., Fortnam, M., Honig, M. and Heaps, L. 2023. Putting coastal communities at the center of a sustainable blue economy: A review of risks, opportunities, and strategies. *Front. Mar. Sci.*, 4: 1032204. https://doi.org/10.3389/fpos.2022.1032204.

FAO. 2015. *Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication*. Food and Agriculture Organisation of the United Nations, Rome. Italy.

Fonner, R., Bellanger, M. and Warlick, A. 2020. Economic analysis for marine protected resources management: Challenges, tools, and opportunities. *Ocean Coastal Manage.*, 194: 105222. https://doi.org/10.1016/j.ocecoaman.2020.105222.

George, G., Krishnan, P., Kamal-Sarma, Kirubasankar, R., Goutham-Bharathi, M. P., Kaliyamoorthy, M., Krishnamurthy, V. and Kumar, T. S. 2011. Integrated potential fishing zone (IPFZ) forecasts: A promising information and communication technology tool for promoting green fishing in the islands. *Indian J. Agric. Econ.*, 66(3): 513-519. https://doi.org/10.22004/ag.econ.204773.

Gordon, H. S. 1954. The economic theory of a common-property resource: The fishery. *J. Polit. Econ.*, 62(2): 124-142. https://doi.org/10.1016/S0092-8240(05)80048-5.

Gutierrez, N., Hilborn, R. and Defeo, O. 2011. Leadership, social capital and incentives promote successful fisheries. *Nature*, 470: 386-389. https://doi.org/10.1038/nature09689.

Hamelin, K. M., Charles, A. T. and Bailey, M. 2024. Community knowledge as a cornerstone for fisheries management. *Ecol. Soc.*, 29(1): 26. https://doi.org/10.5751/ES-14552-290126.

Hicks, C. C. and Cinner, J. E. 2014. Social, institutional, and knowledge mechanisms mediate diverse ecosystem service benefits from coral reefs. *Proc. Natl. Acad. Sci. U. S. A.*, 111(50): 17791-17796.

Jefferson, R., McKinley, E., Capstick, S., Fletcher, S., Griffin, H. and Milanese, M. 2015. Understanding audiences: Making public perceptions research matter to marine conservation. *Ocean Coastal Manage.*, 115: 61-70. https://doi.org/10.1016/j.ocecoaman.2015.06.014.

Jentoft, S. 1989. Fisheries co-management: Delegating government responsibility to fishermen's organizations. *Mar. Policy*, 13(2): 137-154. https://doi.org/10.17730/humo.48.4.k045637kv 290u886.

Jentoft, S. and Chuenpagdee, R. 2009. Fisheries and coastal governance as a wicked problem. *Mar. Policy*, 33(4): 553-560. https://doi.org/10.1016/j.marpol.2008.12.002.

Jentoft, S., McCay, B. J. and Wilson, D. C. 1998. Social theory and fisheries co-management. *Mar. Policy*, 22(4-5): 423-436.

Jentoft, S., van Son, T. C. and Bjorkan, M. 2007. Marine protected areas: A governance system analysis. *Hum. Ecol.*, 35: 611-622. https://doi.org/10.1007/s10745-007-9125-6.

Johannes, R. E. 2002. The renaissance of community-based marine resource management in Oceania. *Annu. Rev. Ecol. Syst.*, 33(1): 317-340.

Jupiter, S. D., Cohen, P. J., Weeks, R., Tawake, A. and Govan, H. 2014. Locally-managed marine areas: Multiple objectives and diverse strategies. *Pac. Conserv. Biol.*, 20(2): 165-179. https://doi.org /10.1071/PC140165.

Kiruba-Sankar, R., Adamala, S., Barman, J., Saravanan, K., Praveenraj, J., Yuvaraj, E., Kumar, G. and Ahmed, S. Z. 2023b. Aboriginal tribes' knowledge of the endangered freshwater turtle *Cuora amboinensis* from Car Nicobar, a remote oceanic island in the Bay of Bengal. *Fishes*, 8(10): 517. https://doi.org/10.3390/fishes8100517.

Kiruba-Sankar, R., Krishnan, P., George, G., Kumar, K. L., Angel, J. R. J., Saravanan, K. and Roy, S. D. 2021. Fisheries governance in the tropical archipelago of Andaman and Nicobar-opinions and strategies for sustainable management. *J. Coastal Conserv.*, 25(1): 16. https://doi.org/10.1007/s11852-021-00808-5.

Kiruba-Sankar, R., Kumar, K. L., Angel, J. R. J., Salim, S. S., Saravanan, K., Krishnan, P., Ravikumar, T. and Roy, S. D. 2020. Impact evaluation of marine fisheries interventions among tribal fisher commune of Car Nicobar Island, India. *J. Mar. Biol. Assoc. India*, 62(1): 84-89. https://doi.org /10.6024/jmbai.2020.62.1.2065-11.

Kiruba-Sankar, R., Kumar, K. L., Saravanan, K. and Praveenraj, J. 2019. Poaching in Andaman and Nicobar coasts: Insights. *J. Coastal Conserv.*, 23: 95-109.

Kirubasankar, R., Roy, S. D., Grinson-George, S. K., Krishnan, P., Kumar, S. R., Kaliyamoorthy, M. and Goutham-Bharathi, M. P. 2013. Fishery and exploitation of *Epinephelus malabaricus* from Andaman Islands. *Asian Fish. Sci.*, 26: 167-175. https://doi.org/10.33997/j.afs.2013.26.3.004.

Kiruba-Sankar, R., Saravanan, K., Adamala, S., Selvam, K., Kumar, K. L. and Praveenraj, J. 2023a. First report of marine debris in Car Nicobar, a remote oceanic island in the Nicobar archipelago, Bay of Bengal. *Reg. Stud. Mar. Sci.*, 61: 102845. https://doi.org/10.1016/j.rsma.2023.102845.

Kiruba-Sankar, R., Adamala, S., Jha, D. K., Barman, J., Saravanan, K., Praveenraj, J., Yuvaraj, E. and Ahmed, S. K. Z. 2026. Guided by local ecological knowledge: Indigenous fishers' identify new nesting site of Olive ridley turtles in Car Nicobar Island, Bay of Bengal. *J. Coastal Conserv.*, 30: 3. https://doi.org/10.1007/s11852-025-01185-z.

Krishnan, P., George, G., Vikas, N., Immanuel, T., Goutham-Bharathi, M. P., Anand, A., Kumar, K. V. and Kumar, S. S. 2012. Tropical storm off Myanmar coast sweeps reefs in Ritchie's archipelago, Andaman. *Environ. Monit. Assess.*, 185(6): 5327-5338. https://doi.org/10.1007/s10661-012-2948-7.

Krishnan, P., Roy, S. D., George, G., Anand, A., Murugesan, S., Kaliyamurthy, M., Vikas, N. and Soundararajan, R. 2011. Elevated sea surface temperature induces mass bleaching of corals in Andaman. *Curr. Sci.*, 100(12): 1800-1804.

Kurien, J. 1998. Traditional ecological knowledge and coastal sustainability: New meaning to Asian coastal proverbs. *Ecol. Appl.*, 8(S2): 2-10. https://doi.org/10.1890/1051-0761(1998)8[S2: TEKAES]2.0.CO;2.

Levine, A. S., Richmond, L. and Lopez-Carr, D. 2015. Marine resource management: Culture, livelihoods, and governance. *Appl. Geogr.*, 59: 56-59. https://doi.org/10.1016/j.apgeog .2015.01.016.

Morf, A., Moodie, J., Gee, K., Giacometti, A., Kull, M., Piwowarczyk, J., Schiele, K., Zaucha, J., Kellecioglu, I., Luttmann, A. and Strand, H. 2019. Towards sustainability of marine governance: Challenges and enablers for stakeholder integration in transboundary marine spatial planning in the Baltic Sea. *Ocean Coastal Manage.*, 177: 200-212. https://doi.org/10.1016/ j.ocecoaman.2019.04.009.

Nguyen, M., Duong, M. T., Nguyen, M., Mutai, N., Jin, R., Nguyen, P., Le, T. and Vuong, Q. 2023. Promoting stakeholders' support for marine protection policies: Insights from a 42-country dataset. *Sustainability*, 15(16): 12226. https://doi.org/10.3390/su151612226.

Ostrom, E. 1990. *Governing the Commons: The evolution of Institutions for Collective Action*. Cambridge University Press, UK.

Patankar, V. J. 2019. Attitude, perception and awareness of stakeholders towards the protected marine species in the Andaman Islands.

Ocean Coastal Manage., 179: 104830. https://doi.org/10. 1016/j.ocecoaman.2019.104830.

Patankar, V., D'Souza, E., Alcoverro, T. and Arthur, R. 2016. For traditional island communities in the Nicobar archipelago, complete no-go areas are the most effective form of marine management. *Ocean Coastal Manage.*, 133: 53-63. https://doi.org/10.1016/j.ocecoaman.2016.09.003.

Proulx, M., Ross, L., Macdonald, C., Fitzsimmons, S. and Smit, M. 2021. Indigenous traditional ecological knowledge and ocean observing: A review of successful partnerships. *Front. Mar. Sci.*, 8: 703938. https://doi.org/10.3389/fmars.2021.703938.

R Core Team. 2025. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria.

Ravikumar, T., Krishnan, P., Ram, N., Sankar, R. K., Roy, S. D., Ahmed, S. K. Z. and Neethiselvan, N. 2015. Hodi, a traditional craft of Nicobari tribe. *Indian J. Tradit. Knowl.*, 14(1): 161-168.

Ravikumar, T., Ram, N., Krishnan, P., Sankar, R. K., Sachithanandam, V. and Roy, S. D. 2016. Subsistence fishing methods of Nicobari tribes using traditional knowledge. *J. Mar. Isl. Cult.*, 5: 79-87. https://doi.org/10.1016/j.imic.2016.05.002.

Relano, V., Mak, T., Ortiz, S. and Pauly, D. 2022. Stakeholder perceptions can distinguish 'paper parks' from marine protected areas. *Sustainability*, 14(15): 9655. https://doi.org/10.3390/su14159655.

Roy, S. D., Krishnan, P., Patro, S., George, G., Velmurugan, A., Sankar, R. K. and Ramachandran, P. 2017a. Wetlands of small island nations in South Asia *vis-à-vis* the mainland and island groups in India. In: Bak, P. (Ed.), *Wetland science: Perspective from South Asia*, pp. 31-48. https://doi.org/10.1007/978-81-322-3715-0_2.

Roy, S. D., Krishnan, P., Velmurugan, A., Anand, A., George, G., Sankar, R. K. and Swarnam, T. P. 2017b. Wetlands of tropical islands under changing climate: A case from Nicobar group of islands, India. In: Bak, P. (Ed.), *Wetland science: Perspective from South Asia*, pp. 205-224. https://doi.org/10.1007/978-81-322-3715-0_11.

Roy, S. D. and Krishnan, P. 2005. Mangrove stands of Andaman *vis-à-vis* tsunami. *Curr. Sci.*, 89: 1800-1804.

Seaside Sustainability 2023. The role of coastal communities in ocean sustainability. *Seaside Sustainability*. https://www.seasidesustainability.org/post/the-role-of-coastal-communities-in-ocean-sustainability (Accessed 06 May 2025)

Stori, F. T., Peres, C. M., Turra, A. and Pressey, R. L. 2019. Traditional ecological knowledge supports ecosystem-based management in disturbed coastal marine social-ecological systems. *Front. Mar. Sci.*, 6: 571. https://doi.org/10.3389/fmars.2019.00571.

Veitayaki, J. 2008. Traditional and community-based marine resources management system in Fiji: An evolving integrated process. *Coastal Manage.*, 26: 1-18. https://doi.org/10.1080/ 08920759809362342.

Yanda, P. Z., Mwajombe, A. R. and Gwambene, B. 2023. Coastal communities' livelihoods conditioned by resource use dynamics and changing environments in Lindi Region, south-eastern Tanzania. *Mar. Policy*, 150: 105532. https://doi.org/10.1016/j.marpol.2023.105532.

Yuvaraj, E., Dharanirajan, K., Narshimulu, S. and Narshimulu, G. 2015. Post disaster assessment of impact of cyclone Lehar in South Andaman Island. *Curr. Sci.*, 108: 85-89.