Perceptions matter: how fishermen's perceptions affect trends of sustainability in Indian fisheries

DIVYA KARNAD, MAYURESH GANGAL and KRITHI K. KARANTH

Abstract Indian marine fisheries have expanded four-fold in the last 50 years in the form of open-access commons. Although studies predict that fish stocks are on the decline there is little evidence that these declines are being countered by changes in either fishing regulations or fishing practices. Fishermen rarely comply with regulations, instead operationalizing and directing the fishery on their own. In these circumstances understanding how fishermen perceive and use resources has significant management and policy implications. Our study examined fishermen's perceptions about the state of fish stocks and documents current fishing practice and management strategies in India. We surveyed 342 fishermen in two states, Tamil Nadu and Maharashtra. We found that 86% of fishermen perceived a decline in catch and 69% perceived a decline in bycatch. Fishermen adapt to these declines by increasing fishing area and time spent, changing their gear, and overlapping in fishing zones. The convoluted interactions between ineffective community and state regulations guiding their actions has prevented fishermen from developing successful models of sustainable fisheries management. We identified non-compliance with regulations and government incentives as an important livelihood opportunity. Non-compliance drives change in fishing practice by giving fishermen the flexibility to respond to perceived fish catch dynamics by modifying their practices. We recommend strengthening local fishing communities by enabling them to enforce fishing regulations locally and by scaling back of existing government incentives, to protect the sustainability of these fisheries.

Keywords Community-based management, fishing, India, perceptions, questionnaire, sustainability

Introduction

Marine fishing is estimated to be a USD 100 billion industry, with seafood comprising 19% of global human protein consumption (Botsford et al., 1997; Pauly, 2009). Fishing has severely affected marine ecosystems, and potentially has major spillover effects on food and livelihood security (Pauly et al., 2002). Fisheries are prone to serious lapses in regulation, monitoring and management because of their open access nature (Botsford et al., 1997; Cooke & Cowx, 2006). The lack of effective monitoring also results in failure to assess the true state of fisheries and stocks (Worm et al., 2009; Branch et al., 2011), particularly in developing countries. Stock assessment-based management in developing countries could prove unreliable (see Kasim et al., 2002, and Muthiah et al., 2003, for contradicting recommendations about seerfish exploitation) given the inconsistency of ecological baselines and lack of scientific knowledge about the multi-species fisheries in these countries. Management action based on single-species assessments also results in conflicts between regulating agencies and the multi-species nature of the actual fishery (Beddington et al., 2007). Inconsistent knowledge about multi-species fisheries and fishing practices contributes to fish declines and the imperiled state of many fisheries (Ban & Vincent, 2009).

National fisheries laws and international treaties are often not linked to the local realities that fishermen face (Allison, 2001). Local participation in fisheries management predicates understanding and building on the existing trends and patterns of resource use (St. Martin, 2001; Chan et al., 2007; Ostrom, 2007). Although better fishery management could create and preserve sustainable fishing practices, ensuring compliance with regulations requires local acceptance and participation (Bavinck & Johnson, 2008). Fishery managers must acknowledge that people's perceptions about a fishery influence their resource extraction patterns and local fisheries management (Castillo & Saysel, 2005; Beddington et al., 2007). These perceptions are particularly important in developing countries such as India, where centralized governance of fisheries is poorly enforced. Fishing behaviour, practice and the success of future management interventions is influenced by perceptions about the fishery (Hansen et al., 2011) but there have been few studies in India that have systematically documented these perceptions and practices.

The Indian fishery has expanded almost four-fold in the mechanized and industrial sectors over the last 50 years (Bhathal & Pauly, 2008) but despite an increase in marine exports (MPEDA, 2011) studies have predicted an overall decline in fish stocks (Bhathal & Pauly, 2008; Lobo et al., 2010). Our study explores these predicted declines by

DIVYA KARNAD* (Corresponding author) and MAYURESH GANGAL National Centre for Biological Sciences, Hebbal, Bengaluru, India. E-mail divyakarnad@hotmail.com

KRITHI K. KARANTH† Centre for Wildlife Studies, Bengaluru, India; and Wildlife Conservation Society, Bronx Zoo, New York, USA

*Current address: Department of Geography, Rutgers University, New Brunswick 08901, USA
†Also at: Nicholas School of Environment, Duke University, Durham, USA

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providing baseline information on fishermen's perceptions of the state of fish stocks and bycatch, documenting current fishing practices and management in the context of existing legal structures and exploring the potential for using sustainable techniques. We identify the main social and economic drivers of perceptions and highlight the key factors that have allowed fishermen to adapt in response to their perceptions. We hypothesize that an individual's socio-economic characteristics drive perceptions about the fishery and also influence an individual's willingness to use more sustainable fishing practices. Thus, we expect that more educated, richer and older fishermen would be more open to ideas of sustainability. We specifically compare fishing communities in the Indian states of Maharashtra and Tamil Nadu, as these states account for 20% of India's marine fish production (Ministry of Agriculture, 2010) but differ in fishing histories and laws (Simmonds, 1878; Thurston, 1890; Silas et al., 1985; Bavinck, 2003). As defining a fishing 'community' can be problematic (Leach et al., 1999), we expand the definition of communities to include spatial and socio-economic factors, to identify real community-binding forces. By highlighting the most important factors that influence perceptions and fishing practice we make recommendations to improve and develop better management plans for sustainable fisheries in developing countries such as India.

Study area

We selected study areas in two states, to represent the diverse set of ecological and social conditions in which fishing occurs on the eastern and western coasts of India (Fig. 1a). In Tamil Nadu, state fisheries are near-shore in coral reefs or sea grass beds (Sridhar et al., 2007), and fishermen constitute c. 10% of the population (Census, 2011). We focused on fishing villages in Ramnathapuram district (Fig. 1b), some of which are in the Gulf of Mannar Biosphere Reserve, a Marine Protected Area (Silas, 1977; Sridhar et al., 2007). Fishing along this 271 km coast was formerly conducted by non-mechanized gill-netting and has gradually become more mechanized (Bhathal & Pauly, 2008). The proximity of the international boundary with Sri Lanka, which at the closest point is c. 12 km from the shore, results in a narrow Exclusive Economic Zone, with mechanized trawl netters and artisanal fishermen using the same fishing space.

The Maharashtra state fisheries are coastal and offshore fisheries, which include species found on the continental shelf and in the open ocean (Srinath, 2003). The study area encompassed villages across the Ratnagiri district, which supports 67,615 fishermen, and Sindhudurg district, which has 25,375 fishermen (Fig. 1c; Government of Maharashtra, 2003). The mode of fishing ranges from traditional drag netting (*rampan*) to more modern purse-seining

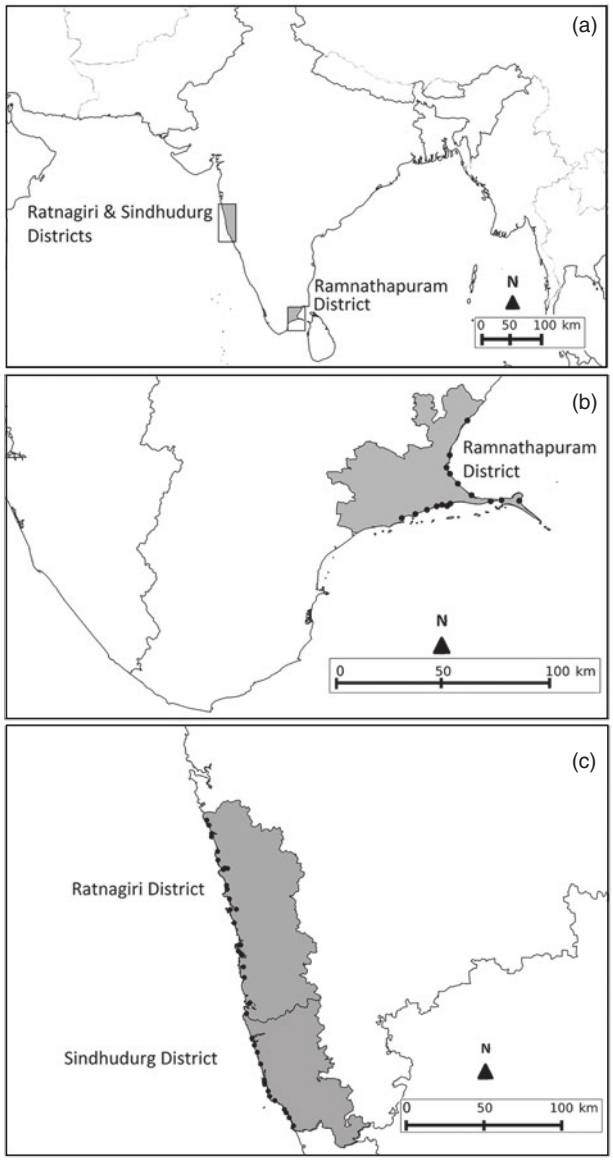

FIG. 1 (a) The locations of the study areas on the western and eastern coasts of India, and details of (b) Ramnathapuram district in Tamil Nadu, and (c) the Ratnagiri and Sindhudurg districts in Maharashtra. The black dots in (b) and (c) indicate the villages where surveys were conducted.

techniques. These fishing techniques can be used in a larger area because of India's wide Exclusive Economic Zone in this region.

Methods

Questionnaire survey

We interviewed 352 fishermen, using a semi-structured questionnaire across both study sites. To refine the questionnaire we conducted a pilot study in Tamil Nadu in December 2010. Each respondent was informed of the goals of the study, contact information of the interviewers

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was provided and verbal consent was sought from the respondents. Some respondents agreed to be recorded or videographed and, upon their encouragement, these interviews were collated into a short documentary for display within each of their communities. The final questionnaire consisted of 37 questions covering demographics, fishing vessels, distance travelled, regular fishing areas, target and bycatch species, perceptions of change in catch, and willingness to change. The questionnaire was designed to incorporate a mix of multiple choice and open-end answers, as well as some repeat questions to triangulate and detect fabricated responses (Denzin, 1970). Leading questions were avoided by careful framing of each question in both Marathi (spoken in Maharashtra) and Tamil (spoken in Tamil Nadu). We ensured that information provided about fish was comparable by asking for a measure similar to catch per unit effort (CPUE), rather than annual catch sizes. Fishermen were asked if they noticed a difference in the amount of catch at each fishing attempt (dip of net or toss of line) in the present compared to what they used to obtain 5 or 10 years ago. In addition to the authors, volunteers who spoke the local dialect and represented a cross-section of religions (an important consideration in some of the fishing communities) were trained as interviewers. We used a modification of the snowball sampling approach (Goodman, 1961), in which respondents were asked to introduce us to users of other types of fishing gear or techniques. Our final interviews with fishermen were conducted from January 2011 until the end of March 2011, and focused on fishermen. Respondents were interviewed by trained volunteers who spoke the same dialect and belonged to the same religion. This strategy was particularly useful in Tamil Nadu, where the responses of fishermen were likely to be biased by the faith of interviewers and the language they spoke (A. Lobo, pers. comm., 2010).

This questionnaire allowed us to examine perceptions of fishermen, their fishing practices and their intentions with regard to fishing techniques and sustainability but it did not allow us to determine whether these perceptions were based on the real dynamics of fish stocks. The focus of this study was instead to examine fishing behaviour in response to fishermen's perceptions, whether or not these perceptions reflected the actual state of the ecosystem. We also set out to examine how willing they would be to change to more sustainable practices.

Data on the spatial distribution of fishing effort were collected using a participatory geographical information system approach (Quan et al., 2001). A map-based interview was conducted with volunteer fishermen, to collect local knowledge, as suggested by Close & Hall (2006), by showing respondents maps on which were marked locations of local fish landing sites and prominent coastal features. The respondents were oriented to the maps and the information provided was validated by having these maps checked by other respondents (including those from other villages in each study site). Interviewees, who were not comfortable with marking locations directly on the map, verbally identified their fishing grounds and this information was transferred onto the map by the interviewers, who were familiar with the area and type of information provided by respondents.

Government fishing regulations, schemes and subsidies

We searched for and collated laws related to the fisheries in the study regions, to understand how legislation might affect fishing practices. We identified the major state-level fisheries laws from FAO (2012) and conducted searches using Google, Google Scholar and Web of Knowledge, using the keywords India, Tamil Nadu, Maharashtra, Gulf of Mannar, Ratnagiri, fishing, fisheries, law, act, rules, NCDC [National Co-operative Development Corporation], and fishing schemes, to identify further orders that modified these laws and affected fishing communities. We limited our search to documents that could have had an effect after India gained independence in 1947. By asking questions such as 'When did you change fishing practices?' (followed by prompts for timeline) and 'What prompted you to change your fishing practices?' (if applicable), 'Have you found certain government schemes useful?', 'Are there any species that are prohibited from being caught by law?', 'Are there any fishing practices that are considered illegal?' and 'Are you aware of people using illegal practices or catching prohibited species?' we tried to identify the awareness of fishermen with respect to fishing rules and the importance of financial schemes in encouraging certain fishing practices.

Analysis

We used classification trees (De'ath & Fabricius, 2000) to model the drivers of perceptions and analyse willingness to adopt new methods. We chose variables that represented social and cultural values (e.g. education, religion), economic values (e.g. income, sale of bycatch) and fishing practices (e.g. experience, gear used). The variables used to generate classification trees are listed in Table 1. As the variables influencing perceptions were likely to differ between states, we explored the predictors of fishermen's perception of change both separately and by pooling data. To identify important predictors and verify the accuracy of the models, we built conditional inference random forests (Breiman, 2001). The χ^2 test was used for comparison of perceived declines in Tamil Nadu and Maharashtra. We analysed the predictors of willingness to change separately for each state. Analysis was carried out with Excel 2003 (Microsoft, Redmond, USA) and the packages *rpart* (Therneau & Atkinson, 2012) and *party* (Hothorn et al., 2006) in *R v. 2.12.1* (R Development Core Team, 2012).

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TABLE 1 Results of the classification trees indicating the primary variables that explained fishermen's responses to each of our main questions. The variables used in analysis are in parentheses after each question, and misclassification rates are quoted for all trees.

Question (variables)	State	Sample size	Primary factors	Secondary factors	Misclassification rate
Perceived trends in fish catch (bycatch use, education, effort, employment, experience, gear, income, religion, state, schemes & subsidies, traditional occupation)	Tamil Nadu & Maharashtra	342	Individual characteristics	Subsidies	14%
	Tamil Nadu	183	Individual characteristics	Income	16%
	Maharashtra	141	Individual characteristics		12%
Perceived trends in bycatch (bycatch use, education, effort, employment, experience, gear, income, religion, state, traditional occupation)	Tamil Nadu & Maharashtra	324	State	Bycatch use, individual characteristics	14%
	Tamil Nadu	183	Bycatch use	Gear	16%
	Maharashtra	141	Bycatch use	Religion	31%
Willingness to adopt sustainable techniques (effort, employment type, experience, income, lineage, religion)	Tamil Nadu	190	Efforts	Experience & education	37%
	Maharashtra	135	Efforts	Income & experience	52%

Fishing zones were collated from map-based interviews, by georeferencing the locations provided, using Quantum GIS (Quantum GIS Development Team, 2009). The fishing zone maps were classified based on gear type to determine how different gear users spread out in the sea and whether they claim to follow spatial regulations. The fishermen in Tamil Nadu delineated their fishing zones based on distance from the shore, whereas those in Maharashtra reported sea floor depths. These depths were converted to distances using bathymetry maps from C-MAP (Jeppesen, 2007) and transferred onto the digital maps.

Results

We analysed the responses of 188 fishermen from 23 villages in Tamil Nadu and 154 fishermen from 39 villages in Maharashtra, after discarding 10 interviews for which triangulation indicated the fishermen were fabricating responses. All respondents were male except for one female respondent in Maharashtra who fished. The majority of respondents were aged 20–45 years. Most respondents had not completed high school education and had spent a mean of 24 years fishing. More respondents claimed to discard bycatch in Tamil Nadu than in Maharashtra. The characteristics of respondents are summarized in Table 2.

Perceptions

In response to our question about perceptions of change in fish-catch over the last 20 years, 82.6% of respondents in Tamil Nadu perceived a decline in fish caught compared to 89.6% in Maharashtra ($\chi^2 = 7.69$, $P = 0.02$). Eighty-three percent of small-scale fishermen in Tamil Nadu stated that large-scale trawling was responsible for declines. In Maharashtra 30% of trawler owners surprisingly reported trawling as a cause for fish decline and 26% stated that industrial gear was responsible for overfishing. Other reasons cited included the use of illegal gears (22%), the 2004 Indian Ocean tsunami (18%) and pollution (13%), fishing during the monsoon ban in Maharashtra, night trawling and the use of small mesh size nets.

In response to our question ($n = 324$) about perceptions of change in bycatch over the same period, most respondents (95%) did not recognize the category 'bycatch' as they did not go out with the intention to target solely one or a few species, only 'preferring or hoping to catch more lucrative species' (translation from interviews in Tamil Nadu). Only the purse-seiners tended to have definite targets. Most respondents spoke of their catch in terms of higher and lower economic values that were more and less preferred, respectively. In Tamil Nadu 73% of respondents perceived a decrease in lower economic value species compared to 65% in Maharashtra ($\chi^2 = 8.54$, $P = 0.01$).

Drivers of perceptions

The most important predictors of perceptions about catch identified by both the classification trees (Fig. 2) and the random forest analysis ($n = 342$, c statistic = 0.87) were individual characteristics of fishermen, such as their experience, religion, receipt of government schemes and subsidies, and sale of bycatch. Experienced fishermen whose families had been engaged in this livelihood for several generations were more perceptive of declines in Tamil Nadu. They described very high rates of decline during open-ended answers, making comparisons with hearsay about catch from previous generations. Older Tamil Nadu fishermen noticed declines over the last 22 years but only

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TABLE 2 Detailed individual, social, economic and fishing characteristics of respondents in fishing communities of Maharashtra and Tamil Nadu (Fig. 1).

Characteristics	Tamil Nadu	Maharashtra
Age in years (%)		
<20	3	0
20–45	75	61
46–65	20	34
>65	2	5
Education (%)		
Below 10th grade	77	66
Below 12th grade	5	23
Below graduation	2	5
Graduate	2	6
None	14	0
Income (INR) per year (%)		
<10,000	6	1
10,000–50,000	38	39
51,000—1 lakh	34	25
1–5 lakhs	21	26
>5 lakhs	2	9
% of fishermen using gear		
Gill net	73	57
Hook	12	4
Trawl	29	47
Time spent at sea per year (days)		
Mean	141	175
Range	26–338	75–336
Fishing experience (years)		
Mean	24	24
Range	1–65	2–50
Use of bycatch (%)		
Sale	15	77
Discard	100	22
Personal consumption	82	22
Religion (%)		
Christian	45	1
Hindu	50	68
Muslim	4	29
No response	1	2
Response of fisherman to perceptions of decline (%)		
More fishing area	23	66
More time spent	16	60
Changed gear	25	16
Changed target	14	5

current generation Maharashtra fishermen noticed declines (over the last 10 years). Fishermen with over 50 years of fishing experience, who were Christians from Tamil Nadu or Muslims in Maharashtra, were more likely to perceive catch declines. Religion also emerged as an important predictor when the responses from each state were analysed separately (Table 1).

Another important predictor was government schemes and subsidies. Among those who availed themselves of subsidies, 80% perceived decline in fish catch and were more likely to fish for > 74 days per year. During the interviews many fishermen expressed a need for further subsidies, for them to make ends meet. The details of how these predictors interacted with each other are illustrated in Fig. 2.

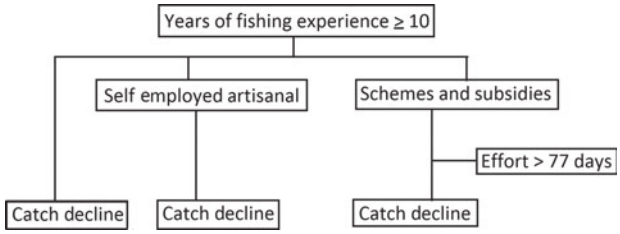

FIG. 2 The classification tree indicating the most important drivers of perceptions of catch.

Perceived declines in bycatch (lower-value species) were greater in Tamil Nadu than in Maharashtra. An important factor predicting perceptions of decline was the use of bycatch for sale and personal consumption. Eighty-four percent of respondents who sold bycatch operated trawl nets in Tamil Nadu (n = 183). Muslims were more likely to be trawl boat owners or workers in Maharashtra. Perceptions of decline in bycatch were also related to the religion of the respondent. A greater proportion of Muslims and Christians perceived declines as they constituted 75% of the respondents who sold these low-value species. This model had a low misclassification rate (Table 2) and high variable accuracy (c statistic = 0.87), suggesting that the predictions are reliable.

Response to perceptions

Fishermen initiated several responses to catch declines. More fishermen in Tamil Nadu (10%) reported shifting their fishing practices to target new species compared to Maharashtra (3%; $\chi^2 = 10.31$, $P = 0.001$). The change in fishing area is greater in Maharashtra than in Tamil Nadu ($\chi^2 = 22.1$, $P < 0.001$), where 67% of Maharashtra fishermen have increased the spatial extent of their fishing zones (Table 1). Some Tamil Nadu fishermen (25%) admitted to changing their fishing gear from traditional to gill or trawl nets.

There was a high degree of spatial overlap between the users of different fishing gears. Fishermen using gill nets travelled large distances that were comparable to the distances travelled by trawl fishermen, who generally had much larger boats with more powerful engines (Fig. 3). Fishermen on smaller boats achieved these distances by camping in villages along the way. Both purse-seining and trawling were conducted in zones that are legally designated for artisanal use only (Ministry of Agriculture, 2004). The mean estimated fishing ground in Maharashtra was c. 3,000 km^2 and in Tamil Nadu it was > 7,000 km^2.

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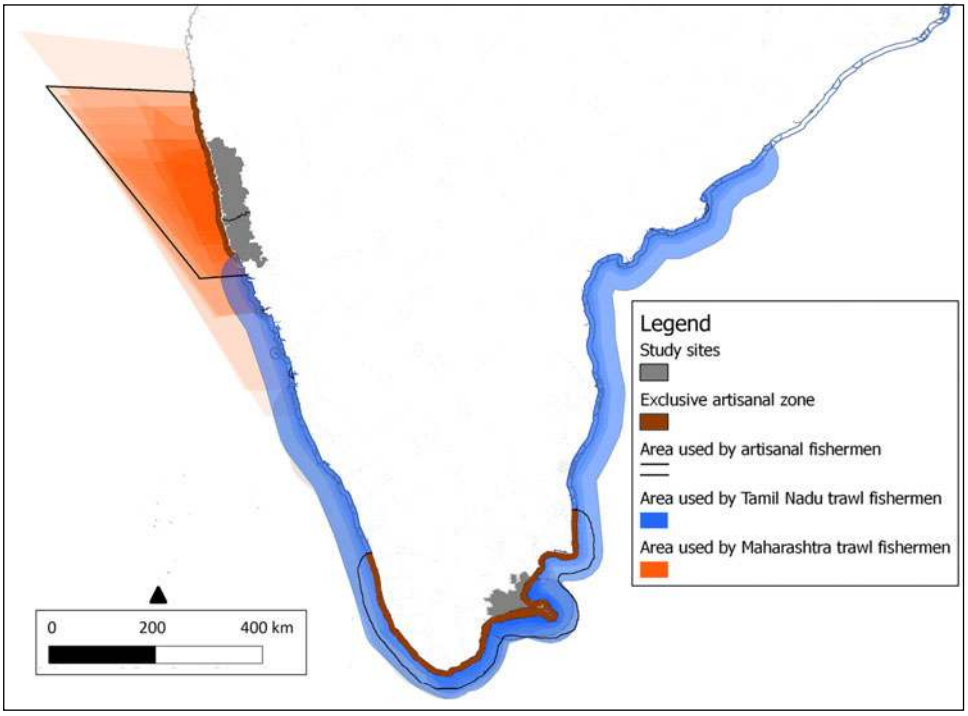

FIG. 3 Overlap in areas used by artisanal (n = 178), trawl (n = 62) and purse-seine (n = 39) fishermen. The areas of most intense use are indicated by the most intense colour. The double line around the coastal boundary of India indicates the limits of the exclusive artisanal zone.

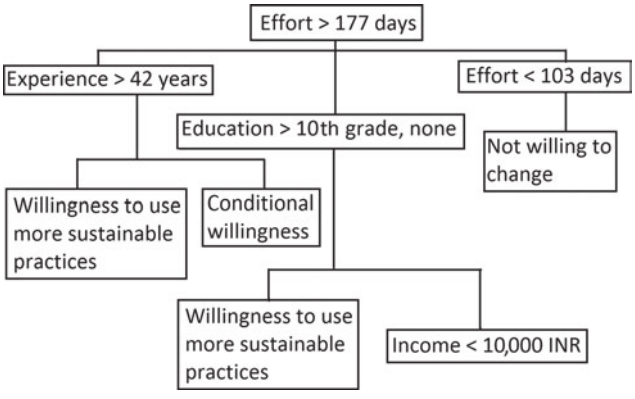

FIG. 4 The classification tree indicating the most important drivers of willingness to use sustainable alternatives for fishing.

Willingness to use sustainable practices

The classification trees for willingness to change to sustainable practices (Fig. 4) identified fishermen who spent more days at sea as more likely to accept new modes of fishing. Respondents who fished for > 177 days and those with > 42 years of fishing experience were more accepting of changing fishing methods and using sustainable technology. In Tamil Nadu 62% of fishermen were willing to change their mode of fishing only under certain circumstances (45% were in favour of government implementation of new methods or banning current methods). In Maharashtra 55% of fisherman were willing to change their mode of fishing, and 30% of those were agreeable to change without any preconditions. Many stated that falling fish prices 'due to the development of aquaculture' (translation from interviews) exacerbated 'the effect of declining catches'. While they recognized that practices must change to sustain their livelihood, fear of adopting new techniques mainly stemmed from the perceived associated risks and loss of profit. Those who fished for < 103 days per year were less willing to change (Fig. 4). A significant factor influencing responses was profit, with 7% of the total respondents ready to change provided the new mode was profitable. The results of these classification trees are also summarized in Table 1.

Influence of regulations and government schemes

We found two types of government initiatives that affect fisheries in post-colonial India: government schemes that encourage certain fishing practices and regulations that limit or discourage fishing practices (Table 3). Most fisheries schemes that affect the study sites seem to be aimed at mechanizing the fleet and modifying gears. Central government-sponsored schemes have promoted the development of offshore deep-water vessels since 1997 in Maharashtra but there have been no similar schemes in Tamil Nadu. Tamil Nadu fisheries, however, have fuel subsidies for existing craft (Government of Tamil Nadu, 1983). In open-ended answers, trawl-vessel owners in Maharashtra stated that the National Co-operative Development Corporation's schemes to subsidize trawlers encouraged them to switch from gill net fishing to trawling. Many stated that they might not have

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TABLE 3 Fishery regulations and schemes in the states of Tamil Nadu and Maharashtra that are intended to regulate fishing. Sources: Government of Tamil Nadu (1983), Kolhatkar (1983), Government of Maharashtra (2003).

Date	Policy*	State	Effect
1969	Gear subsidy	Maharashtra	
1978	NCDC loans for vessel purchase	Maharashtra	60% repayable loan at 9.5% interest
1981	Marine fishing regulation	Maharashtra	
1983	Trawl fishing restrictions	Maharashtra	Inshore fishing restriction & ban on night trawls
1988	Mechanized fishery promotion	Maharashtra	A mix of subsidies & loans for motors
1995	NCDC loans for vessel purchase	Maharashtra	
1996	Trawl fishing restrictions	Maharashtra	Monsoon trawl ban
1997	NCDC loan for offshore vessels	Maharashtra	Loans for vessels with high-power engines & onboard coolers
1999	Purse-seine restrictions	Maharashtra	Inshore fishing restriction & port restrictions
1977	Trawl fishing restrictions	Tamil Nadu	High-court order permitting night trawling only on alternate nights in the Pudukottai & Ramnathapuram districts
1979	Trawl fishing restrictions	Tamil Nadu	Government order restricting 3 nautical mile zone for artisanal fishery in Ramnathapuram & Tuticorin
1983	Marine fishing regulation	Tamil Nadu	Legislating closed seasons, fishing licences, inshore trawling restrictions, fishing at river mouths & mesh size restrictions
1991	Relief scheme	Tamil Nadu	To tide over lean months & closed seasons
1997	Motorization of traditional vessels	Tamil Nadu	Half the cost of engine provided & gear purchasing subsidies
1990	Fuel subsidy	Tamil Nadu	
2005	Tsunami relief	Tamil Nadu	Provision of motorized boats & new gear

*NCDC, National Co-operative Development Corporation

considered switching except that this scheme made trawl vessels seem more affordable.

Government regulations are based at the level of the state and have been further modified at smaller scales, such as districts, by high court and fishery department orders (Bavinck, 2003). In response to open-ended questions about prohibited and illegal activities, fishermen told us about the following regulations.

In 1983 Maharashtra banned trawling at night (Kolhatkar, 1983), a regulation with which compliance is high, and Tamil Nadu created a closed season lasting 2 months and legislated the need to purchase fishing licenses (Government of Tamil Nadu, 1983), with which compliance is low. Monsoon trawling was banned later in Maharashtra (Kolhatkar, 1983). This was soon followed by a relief scheme in both states to tide fishermen over the closed season but access to the relief money was difficult because of the bureaucracy involved.

Artisanal, trawl-boat and purse-seine fishermen were all aware of a legally designated artisanal fishing zone within 3 nautical miles (4.8 km) off the coast. Respondents using gill-nets in Tamil Nadu supported this legislation but revealed that trawl and purse-seine boats fish in these waters. Respondents using the latter types of gear also admitted fishing in shallow waters (Fig. 3), saying that species of highest economic value were found in coastal near-shore waters. Trawl-boat owners and workers reported not following spatial regulations because of the economic constraints of high fuel costs associated with fishing further from shore.

Discussion

Our study confirms that fishery management at the study sites is largely ad hoc. The majority of the fishermen (83% in Tamil Nadu and 90% in Maharashtra) perceived declines in total catch, as a consequence of which they have modified their fishing practices. Our hypothesis that an individual's socio-economic characteristics would drive perceptions was confirmed with respect to factors such as experience and income. However, more detailed analysis by state and for lower economic value species suggested that factors such as religion, receipt of government schemes and subsidies, and sale of bycatch are also important drivers of perceptions. Our hypothesis that more educated, wealthier and more experienced fishermen would be more willing to use more sustainable fishing methods was not supported. Fishermen spending more time at sea were more open to changing their fishing methods, and most fishermen were only open to more profitable methods. Government schemes and subsidies allowed fishermen to shift to new vessels, gear and targets. However, compliance with government regulations pertaining to the new fishing technologies, particularly those intended to limit the spatial distribution of different gear users, was poor. Non-compliance with regulations, combined with utilization of government-sponsored schemes and subsidies, allowed fishermen to create new livelihood opportunities. Thus, modifying the government's input into fisheries could prove an important management tool.

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We observed that individuals with differing fishing experience vary in their expectations. As change in fish catch size was noticed by older generations of fishermen in Tamil Nadu, compared to Maharashtra, the decline in the Tamil Nadu fishery probably occurred earlier. Given this difference in perceptions we believe that each generation is adjusting their expectations to the current scenario. This is symptomatic of the shifting baseline syndrome (Pauly et al., 2005). The pattern in Maharashtra is different as it has a more recent history of industrialized fishing, particularly bottom trawling.

We found that fishermen respond to perceived catch decline by changing preference for species, fishing areas or gear. Although regulations prevented the use of certain gear such as dynamite, or the use of gear in certain areas, such as inshore trawling, fishermen did not comply because they perceived benefits in terms of increased catch when using illegal fishing practices. Hence, many fishermen preferred to adopt techniques being subsidized or encouraged by the government, as risks were perceived to be fewer and responsibility was shared with the authorities. Thus it appears that government schemes have achieved their long-term intention of increasing seafood export through mechanization of the fleet, but social and ecological sustainability of fisheries has been compromised in the process.

Opportunities for community-based management

Opportunities for local fisheries management exist in some communities, where local decisions are adhered to and upheld (Bavinck, 1996). However, according to the respondents of this study, their communities have been ineffective in creating common property management regimes that restrict resource access to members of the community. The maps of fishing regions indicate perceived overlaps in fishing grounds, which could be responsible for reported conflicts between groups using different gear. Consequently, the community appears to be divided by gear use, with a large percentage of gill-netters blaming industrialized fishing for declines in catch. In Maharashtra purse-seining is relatively new, and most trawl-boat owners blamed purse seines for the perceived decline in catch. The lack of law enforcement pertaining to gear-based fishing zones is the main source of contention among users of different gear.

At the same time the fishery has expanded spatially (Fig. 3) and temporally (Table 1). Maharashtra fishermen have expanded their fishing area (Table 1), which is not possible in Tamil Nadu because of the proximity of the international boundary with Sri Lanka. Additionally, fishermen in both areas spend a lot of time at sea and, given the limitations of fishing during storms, the monsoon, constraints of pay load, ice carrying and engine capacity, there may not be many opportunities for fishermen to increase their effort. Fishermen are driven to fish as much as possible, without consideration for community rules or state boundaries (Fig. 3).

The absence of a homogenous, unified community to create and enforce local rules could result in a free-for-all as described in the Tragedy of the Commons (Hardin, 1968). At the same time externally imposed quotas or rules seem to cause severe socio-economic upheavals (Copes & Charles, 2004). The recognition that a fishery can be managed at a local level provides an opportunity for future conservation interventions. Rather than focus effort on government interventions that will not result in compliance, investments could be made in grass-roots community empowerment to establish, monitor and enforce rules.

Improving fishing practice and sustainability

We found that fishermen with more experience are more likely to perceive declines and are more willing to change their practices. Thus, awareness efforts need to be focussed on the younger generation of fishermen. However, this group requires some assurance of profits or shared responsibility in losses, such as is perceived in government schemes. This reliance on the government as a buffer, despite obvious flouting of laws in other cases, has been documented elsewhere, such as in Kenya (McClanahan et al., 2005). There is often verbal agreement between government and resource user groups but actual enforcement or compliance is lacking.

The lack of clear distinctions between targets and bycatch, and the use of bycatch to buffer fishing losses (Lobo et al., 2010), suggests that regulations banning individual species or creating species-specific quotas will not be well received by the fishing communities. Thus, using detailed stock assessments to identify species-specific catch limits cannot improve management in this system. These factors suggest that fishing needs to be decoupled from the dynamics of the market before it can become sustainable. Jentoft (2000) suggests that a viable fishery can only be achieved by a well-functioning, cohesive and well-governed fishing community. Building the social health of the community needs input, not only at the local level but also from supporting structures such as the government. Fishermen themselves suggest that they could enforce gear-based zonation laws if the government would provide police support for making arrests. Some trawl boat owners in Maharashtra suggested that controlled fishing could be achieved by removing fuel subsidies and interest-free loans.

Our study shows two ways to help fishing communities create a sustainable fishery. Firstly, revision of government schemes to encourage sustainable fishing practices would allow fishermen to see sustainable fishing techniques as viable alternatives to their current modes of fishing. Fishermen are also open to adopting schemes generated

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by non-governmental organizations if they have confidence in their profit-generating potential. They also want these organizations to share in the responsibility for any losses that occur. Secondly, the respondents to this study do not always comply with existing regulations but would like to enforce some regulations on the fishery if supported by the appropriate government authority. Currently the fisheries are managed by the fishing communities, by default, so it is important that conservation interventions empower these communities to monitor and regulate their fisheries. Given the perceived state of the fishery, the failure to regulate and implement these changes will eventually lead to the death of the fishing industry in these areas.

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Biographical sketches

Divya Karnad is a marine and coastal ecologist interested in human–wildlife interactions, particularly in fisheries, conservation and policy. She engages with public discourses on conservation policy through newspapers and other media. Mayuresh S. Gangal currently works as an independent researcher in marine ecosystems. Krithi K. Karanth is a conservation ecologist with interests in species extinctions and distributions, human–wildlife conflicts, land-use change, and the policy implications of conservation interventions in India.

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