

Punishment and compliance: Exploring scenarios to improve the legitimacy of small-scale fisheries management rules on the Brazilian coast



Marjoleine A.M. Karper^a, Priscila F.M. Lopes^{b,c,*}

^a Wageningen University, Droevendaal 2, 6708 PB Wageningen, Netherlands

^b Federal University of Rio Grande do Norte, Department of Ecology, 59078-900 Natal, RN, Brazil

^c Fisheries and Food Institute, Santos, SP, Brazil

ARTICLE INFO

Article history:

Received 4 July 2013

Received in revised form

23 October 2013

Accepted 23 October 2013

Available online 11 November 2013

Keywords:

Fisheries management enforcement

Sustainable development reserves

Co-management

Fisheries compliance

Marine protected areas

ABSTRACT

This study investigated the effects of legal and societal punishment on fishermen's compliance behaviour, according to fishermen's age and level of dependency on fisheries, through the use of interviews and scenarios. Ninety-five fishermen living in a coastal park (Ponta do Tubarão Sustainable Development Reserve) in the Brazilian northeast, where controlled exploitation of natural resources is allowed, took part in this study. The results showed that age alone would not affect compliance, regardless of the level of enforcement. However, it was noticed that the fishermen who claimed to depend on the money provided by fisheries, regardless of their age, were more likely to say that they would not comply, even if enforcement were stricter. The scenario analysis showed that increased monitoring and punishment (including societal pressure) could enhance compliance, especially among younger fishermen, who claimed not to depend solely on fisheries. Therefore, fisheries management should also consider differences in social groups, and not focus solely on the enforcement and punishment mechanisms, assuring that livelihood options that consider different social needs are provided.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

It is widely accepted that fisheries are undergoing some difficulties worldwide, with some stocks already collapsed and others on the way to becoming economically non-exploitable [1,2]. Such changes affect stocks exploited by both industrial and small-scale fisheries. One of the main causes for such decline is overexploitation by fishermen [3]. To cope with these difficulties different types of management have been proposed and/or tentatively implemented over the years in order to enhance sustainable resource exploitation, steadier markets and fair access to the resources [3–5]. However, combining all these aspects into a single management strategy is a hard task, especially given that the success of these initiatives seems to be largely dependent on the compliance of the ones involved and affected by these measures, such as fishermen [3,6].

Reaching compliance in fisheries is not straightforward, as seen in multiple examples around the world, such as in Denmark [7],

Tanzania [8], the Southern Ocean (Antarctica) [9] and Ghana [10]. Non-compliance is a widespread issue that still challenges both researchers and management authorities [3]. Fish overexploitation, despite the existence of regulations, is one of the outcomes of non-compliance that also negatively influences food security, sustainable management possibilities, and socio-economic opportunities [3,7].

Becker [11] was one of the first scholars to come up with a theoretical model for explaining non-compliance behaviour that could be applied to fisheries. His model is based on the assumption that people are rational thinkers, more likely to commit crimes if the possible benefits that accrue to a criminal activity exceed the benefits of compliance. When people feel that the likelihood of getting caught for their wrongdoing is low, the chance that they will violate the rules increases [8,11,12]. The implementation of regulations, monitoring, enforcement, and punishment are defined as the most influential aspects to increase compliance behaviour [4,13–15]. A more effective enforcement implies higher compliance, just like more severe punishments do [8,16–19].

Even though Becker's model is commonly used, it has been criticised for lacking social aspects [6,18,20]. The likelihood of complying with management regulations in the case of fisheries

* Corresponding author at: Federal University of Rio Grande do Norte, Department of Ecology, 59078-900 Natal, RN, Brazil. Tel.: +55 84 3215 3441; fax: +55 84 3211 9205.

E-mail addresses: priscila@cb.ufrn.br, pmaccord@gmail.com (P.F.M. Lopes).

depends not only on the level of enforcement and the severity of punishment, but also on a person's attitude, motivations [6,10,21], age [6,10] and peer pressure [4,6]. For example, when there is little or no enforcement some fishermen, but not all, can feel indifferent towards the regulations. Also, fishermen are more likely to disregard the rules if they feel that the regulations in place are too strict and therefore could jeopardise their livelihoods [9,10,22]. Age also seems to matter in defining compliance level. Several examples in the literature suggest that young fishermen tend to have a higher rule-violation rate in comparison to the older fishermen [6,10]. One possible explanation is that older fishermen are likely to have more experience with the system in place and could be more aware of the consequences of overexploiting fish stocks, while younger fishermen would be more reluctant towards compliance because of lacking such experience [6,10,23]. Finally, the perception of the fairness of regulations in place and the decision on whether to comply or not can be enhanced by the behaviour and attitude of other fishermen. When the majority of fishermen tend to show non-compliance behaviour without suffering its consequences, some fishermen will tend to copy this behaviour, feeding the feeling of indifference towards the rules [6,19]. Likewise, direct peer and societal pressure can increase or decrease compliance, as it has been demonstrated by the seminal work of Sutinen [24] and later by Hønneland [20].

Hence, combining social and economic aspects can foster a more comprehensive understanding of compliance behaviour and attitudes towards regulations, which is especially relevant to achieving success in fisheries management. This study was done to add to the current body of knowledge on compliance, by focussing upon the role of enforcement associated with the different degrees of punishment, age, financial need, and societal pressure. The existing knowledge suggests that by increasing punishment mechanisms a higher rate of compliance can be achieved. However, it is not yet clear how far fishermen are willing to go to keep violating the rules and how high the punishments have to be to increase compliance. Moreover, the role of age in compliance, when interacting with other factors, is still not clear, as it is still not known, for example, if younger fishermen would be less or more affected by societal pressure and peer judgement than older ones. The current study draws on these issues, testing, specifically, if being younger and dependent on fisheries as the main source of income affects the compliance rate, according to the different levels of regular (e.g.: application of fees) and societal (e.g.: being ostracised) punishment. By combining these aspects into a single study, it was hoped that this understanding could help to create better fisheries management regulations, capable of benefiting both the conservation of natural resources and the livelihoods of fishermen's communities.

2. Material and methods

2.1. Study region

This study was done with fishermen of three coastal communities (Diogo Lopes, Barreira and Sertãozinho), which represent the only coastal villages located within the boundaries of the Sustainable Development Reserve Ponta do Tubarão, on the Brazilian northeastern coast (between $-36^{\circ}50'20''$ W and $-5^{\circ}06'75''$ S, $-36^{\circ}48'22''$ W and $-5^{\circ}14'49''$ S) (Fig. 1). The total area of the reserve is 12,960 ha and encompasses several ecosystems, such as mangroves, shrub land, and dunes [25]. This reserve was established in July 2003, as a result of an intensive common effort and of manifestations by fishermen and other local people against land encroachment for developments, such as shrimp farms and the construction of a resort, in order to assure the exclusive right to the land [26].

A Sustainable Development Reserve (SDR) implies a park category where resource exploitation is allowed as long as it is done sustainably. A management plan is supposed to regulate all the resource use, but, in this specific case, even after almost a decade since its establishment, only a provisory and very loose pre-management plan defines the local rules [26]. This means that the place is subjected to the same fisheries management regulations that apply to the NE coast, including lobster and crab regulations (closed seasons and minimum sizes), minimum distance from the coast for trawling, shrimp closed season, minimum depth for setting a gillnet, among many others. Also, in a SDR, communities are supposed to participate in the management, by helping to establish the rules, doing part of the monitoring and the enforcement, in a co-management arrangement.

2.2. Data collection

As a first step, open qualitative interviews were held with researchers and graduate students, who were acquainted with the reserve and the communities, in order to obtain a more complete understanding of the real level of regulations and enforcement regarding fisheries management and community involvement in the co-management. They were also asked questions concerning the status of the conservation of the reserve and the socio-economic situation of the communities (education, age, and number of fishermen). These preliminary interviews helped to shape the interviews and make them applicable to the fishermen.

The interviewed fishermen were found through the snowball sampling method, in which the fishermen interviewed first suggested other names that fit the criteria established. In this study, the criteria used were: a fisherman had to be fishing in the area for more than 5 years and had to be older than 18. The minimum fishing experience in the area was a way to assure that the fisherman was aware of the local regulations and their level of enforcement, besides being already established in the community, with friends and acquaintances. Even though the minimum age to work as a fisherman in Brazil is 16, here 18 was adopted because this is usually when fishermen are already independent or actively providing for their families.

A total of 95 interviews were held in the three communities, each one lasting on average 30 min. A structured questionnaire was used, which was pre-tested and then adapted. The interview gathered information on socio-economic aspects (age, education, household structure, income), fishing activities (level of dependence, gear, main target species), knowledge of existent regulations, monitoring, and enforcement and punishment. Fishermen were also asked if under the current level of enforcement and punishment they would comply with the regulations and why, even though it was clear that at the time of the study the level of enforcement varied from low to non-existent. At the end of the interview, fishermen were faced with hypothetical scenarios of different levels of punishment, assuming that enforcement was done regularly. Studies using scenarios, including some done with fishermen, have showed that people can relate to hypothetical situations, which could help foresee the consequences of management changes [27,28]. Fishermen were asked to imagine situations in which punishment was relatively low and then others where it was higher, and how this would influence their behaviour regarding compliance (Table 1). The difference between low and high punishment was defined as time without gear or equipment (e.g.: having the boat seized for one week versus one month), time in prison (e.g.: one day versus one month) and value of a fine (R\$100 versus R\$500 – Brazilian money). Fishermen were also asked to say if they would comply or not if there were some sort of social sanction, such as being ostracised by family and friends. To all these questions, fishermen could answer “yes” (they would comply), “maybe” or

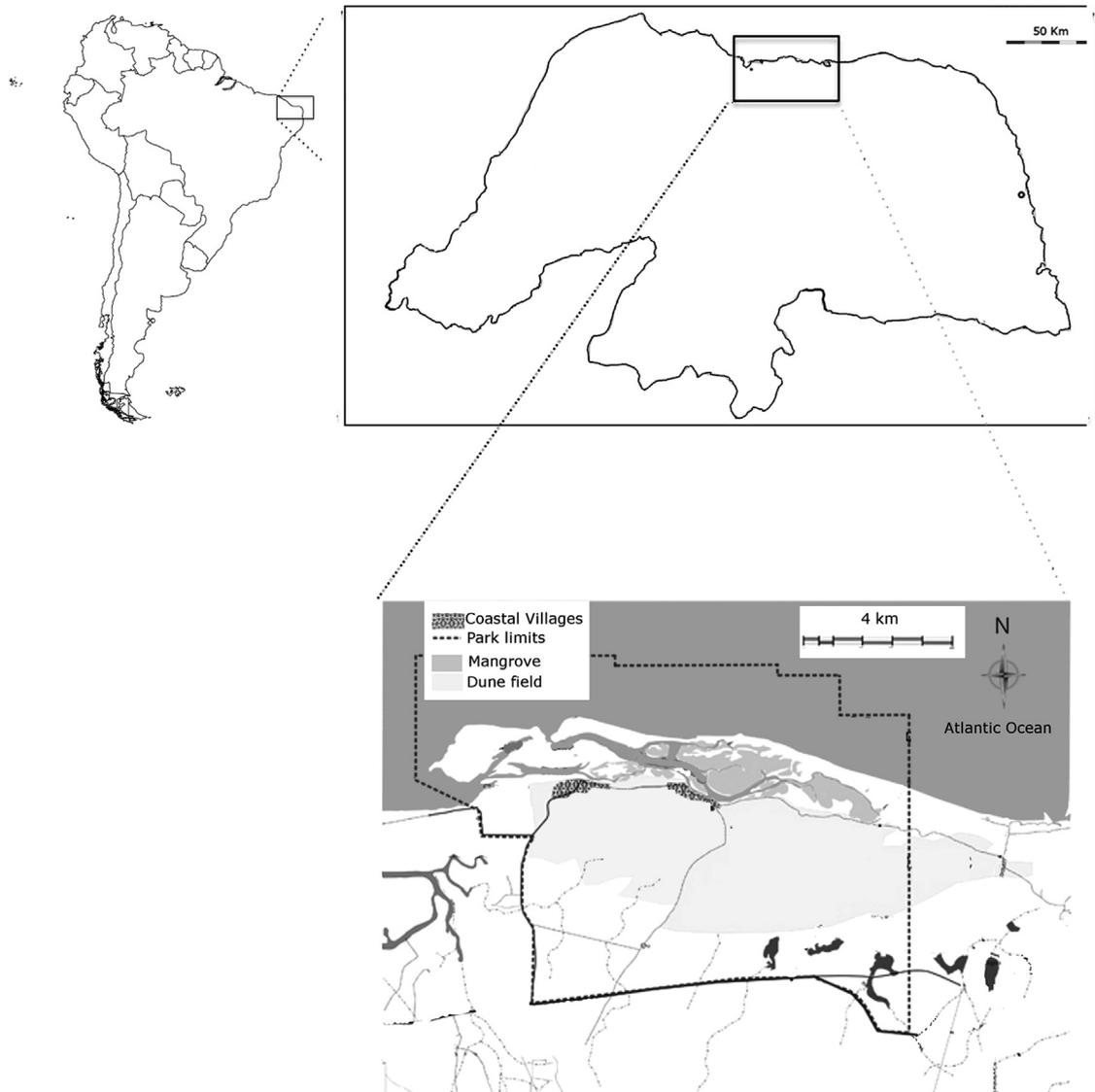


Fig. 1. Map showing the location of the study area “Sustainable Development Reserve Ponta do Tubarão”, NE Brazilian coast.

Table 1

Hypothetical scenarios regarding levels of punishment and social pressure that could affect compliance towards fisheries management regulations, proposed to the fishermen of the Sustainable Development Reserve of Ponta do Tubarão, Brazilian NE coast. To each question, a fisher could answer “yes”, “no” or “maybe”, which was converted to a 3-point Likert Scale.

Would you comply to the regulations if you/your:		
Low punishment	High punishment	Social/Moral
L1. Boat was seized for 1 week	H1. Boat was seized for 1 month	S1. Friends stopped talking to you
L2. Gear was seized for 1 week	H2. Gear was seized for 1 month	S2. Family stopped talking to you
L3. All equipment was seized for 1 week	H3. All equipment was seized for 1 month	S3. Whole community stopped talking to you
L4. Were arrested for 1 day	H4. Were arrested for 1 month	
L5. Got a fine of R\$ 100,00 ^a	H5. Got a fine of R\$ 500,00	

^a At the time of the interview, a fisher from Ponta do Tubarão was making on average R\$ 608,70.

“no” (they would not comply despite an increase in enforcement). These three possible answers were translated into a 3-point Likert scale (Table 1).

The scenarios for low and high punishment were designed based on possible punishments already established by law (e.g.: losing gear and equipment), although currently the duration of a sanction is not clearly defined. In other parts of the country

there are reports of fishermen losing their gear and never being able to recover them again [29], although in the studied region no sanction at all is usually the observed pattern. The value of the hypothetical fine was established after considering the official minimum wage at the time of the study (R\$540,00 – US\$ 333,33 in June 2011). A low punishment would correspond to about 20% of a minimum wage and a high punishment to about 93%. The two

arbitrarily defined cut-off points intended to propose two situations – one of a mild and one of a deeper blow on the average income.

At the time of the study, fishermen were making on average R\$ 608,70 (\pm R\$195,03) from fisheries [30]. Although the income of the interviewed fishermen is highly variable according to the season, most fishermen depend on a minimal wage paid by the government during the two months of the closed period. Even though fishing is a laborious activity, the main fish species caught at the reserve are sold for very cheap. Sardines, for example, were being sold for US\$ 0.14/kg, while flying fish were sold for US\$ 23.00 per thousands in 2006 [31].

2.3. Data analysis

To test if age influences compliance and behaviour, depending on the level of punishment, fishermen were divided into young (below 40) and old (40 or older). Although this cut-off point was arbitrarily defined, it was intended to follow the same age divisions that have been used in studies on Brazilian fishermen (e.g.: [32]). This led to 47 fishermen being tagged as 'young', and 44 fishermen being tagged as 'old'. A chi-square test was used to compare the frequency of answers (yes, no, maybe) between the young and the old fishermen regarding their current level of compliance with the existing regulations. The same test was also used to compare if these two groups would agree to change their behaviour under a stricter level of enforcement.

As explained above fishermen were asked why they would (not) comply with the current regulations. Their main answer (17%) for not complying was the need for the money provided by the fisheries. Many fishermen claimed that due to financial issues they felt they were forced to disobey the regulations. Compliance meant, in their eyes, insufficient income to support their families and their livelihoods. Based on that, multiple correspondence analyses (MCA) were performed to compare how age would interact with the need of money coming from fisheries in defining behaviour under different scenarios. In total three MCAs were run to test the attitude and behaviour concerning low punishment, high punishment, and social or moral aspects.

3. Results

For 77% of the interviewed fishermen, fisheries were their only economic activity and were done primarily in the ocean (61%) or in the ocean and in the local estuary (15%). When in the ocean, fishermen can stay out for up to a week. The weekends were also said to be busy with preparing their next fishing trip and mending of boats and gear. The interviewed fishermen owned (54%) or worked on motorised boats (34%) or canoes (motorised or not). The most commonly used fishing gears were gillnets (56%) and bottom trawling (19%), although other methods targeting different species can also be practised (e.g.: diving for lobster). Although all

interviewed fishermen mentioned that they mostly commercialise their catch, 79% of them also set aside part of their catch for family consumption (Table 2).

3.1. Fishermen's attitude regarding fisheries control and compliance

The great majority of fishermen (91%) were aware of the existence of regulations in the reserve, especially concerning the lobster closed period (41%, from December to May) and the lobster minimum size (41%; 20.2 cm total length for *Panulirus argus* and 17.2 cm for *P. laeviscauda*). However, more than half of the fishermen (56%), when asked about their perception of "others" complying or not with the regulations, acknowledged that there is no compliance towards these regulations in the reserve, especially due to financial difficulties (17%), lack of enforcement (12%), the fact that everybody else does not respect the regulations (8%), and the possibility of earning more money by breaking the rules (5%). One fisherman even said that going against the regulations is cultural, something typical of Brazil.

When fishermen were asked whether, under the given amount of control, they would comply or not, 24% affirmed that they do not respect the current legislation, although 7% of the ones that affirmed to respect ($n=72$) based their answer on the fact that they do not fish lobster, confirming that they were only aware of this particular legislation. Older fishermen tended to say they respected the regulations more often than the younger ones, but a slightly higher proportion of younger fishermen said they would start complying if fisheries control became stricter. However, there was no statistical difference between the level of compliance (current or under stricter control) between the younger and the older fishermen (chi-square, $p < 0.05$) (Fig. 2). Most fishermen (56%) also considered that the chances of being caught doing something forbidden in the local fisheries was low or very low, while 34% considered the odds high or very high.

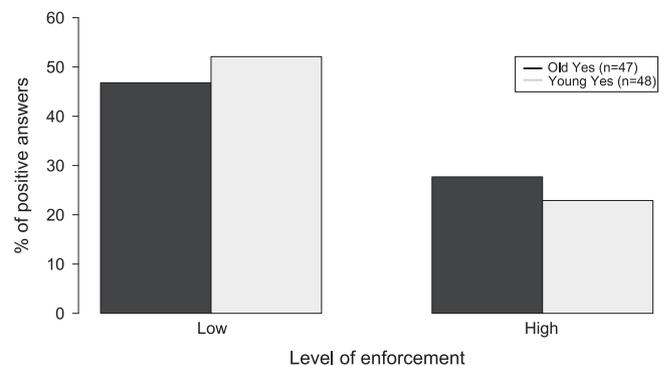


Fig. 2. Fishermen that affirmed they would disrespect the rules if there were a low and a high level of enforcement, respectively, according to the two age groups considered (younger > 40 years old; older: 40 and < 40; $N=95$). Numbers are given in percentages.

Table 2

Summary of the characteristic of the studied fishermen from Ponta do Tubarão Sustainable Development Reserve, northeast Brazil ($n=95$).

Age	%	Job	%	Fishing location	%	Fishing frequency per week	%
18–40	52	Fishing	77	Ocean	61	1	6
41–80	48	Fishing + side job	23	Estuary	15	2–4	25
				Ocean/Estuary	24	5–7	69
Function		Boat		Gear		Use of catch	
Boat owner/boss	55	Canoe	33	Gillnet	56	Commerce	21
Employee	34	Motorised boat	56	Bottom trawling	19	Commerce and consumption	79
Single Fisher ^a	11	Other	11				

^a Not part of a boat crew or who does not have other fishermen working for him.

3.2. Punishment and compliance – exploring scenarios

When fishermen faced a low punishment scenario, regardless of age, the ones who claimed to need the money were the ones most likely to say they would not comply with the regulations. The MCA analysis showed that the relationship between fishermen's attitude and low punishment is best explained by the F1 axis (with 65.9%), followed by F2 axis (21.4%) (Fig. 3, Appendix A). Fig. 3 shows that the group of young fishermen who claimed not to need the money (Young/No Need) tended to answer yes (they would comply) or secondarily “maybe” to all the questions on low punishments. On the right side of the figure it is clear that older fishermen (Old/Need) who claimed to need the money showed negative behaviour regarding compliance (Old/Need), especially if their punishment was having their boat, gear, and equipment seized for one week. The two other groups of fishermen (Old/No Need and Young/Need) did not show such a clear preference, although the first tended to say they would comply in case they had to pay a small fine of R\$100 and the last tended to answer “maybe they would comply” in case their punishment was having the boat seized for one week.

When fishermen were presented a higher punishment scenario, older fishermen, who claimed to need the money, were the ones who still said they would not comply with the regulations, regardless of the higher risks involved. The MCA analysis showed that fishermen's answers are mainly explained by the F1 axis (94.8%) (Fig. 4, Appendix B). All the questions presented to fishermen were significant on the F1 axis, especially regarding assertive answers (yes or no). This suggests that higher punishments would very likely result in more compliance, but older fishermen, in need of the money, would keep disobeying the rules.

When fishermen were faced with social punishment, again older fishermen in need of the money, followed by younger fishermen who also claimed to need the money, would be the ones to insist on not complying, although the two groups differed in how they would react to different kinds of social isolation. In this MCA analysis, F1 axis explained 88.3% of the grouping

(Fig. 5, Appendix C). The three questions presented to fishermen (being ostracised by friends, family, and the whole community) were important in defining this axis, again with the assertive answers (yes or no). Older and younger fishermen who claimed to need the money are separated on the right side of the figure, closer to negative answers, representing non-compliance. Older fishermen, in need of money, tended to reject compliance regardless of whether their friends, family, and community would stop talking to them. On the other hand, younger fishermen who claimed to need the money, would comply if the punishment was the community stopping talking to them, but would still insist on not complying if their family punished them socially. Fishermen who claimed to not need the money would comply with the regulations in order to avoid all sorts of social punishment.

4. Discussion

4.1. Fishermen's attitude regarding fisheries control and compliance

Over the years many studies have been conducted to obtain a greater understanding of criminal behaviour and compliance [8,11]. In the case study evaluated here, the fishermen perceived the current intensity of detection as very low, creating chances for them to break the regulations. One of the arguments given by the fishermen to explain their lack of compliance, was that “it was simply possible to do so”, due to lack of control. In a study of compliance behaviour in Danish fisheries both the type (e.g.: discursive measures) and the dimension (e.g.: intensity of communication and persuasion) of control and enforcement are of great importance to compliance behaviour of fishermen [7]. Compliance behaviour has been shown to increase when the probability of detection increases [17], especially for fishermen with higher investments in fisheries (e.g.: larger vessels) [33], supporting the theoretical predictions made by Becker [11]. Hence, it is no surprise to find a situation on the Brazilian NE coast where there is total disregard for fisheries management, as the resource is treated as open access. Even though the interviewed

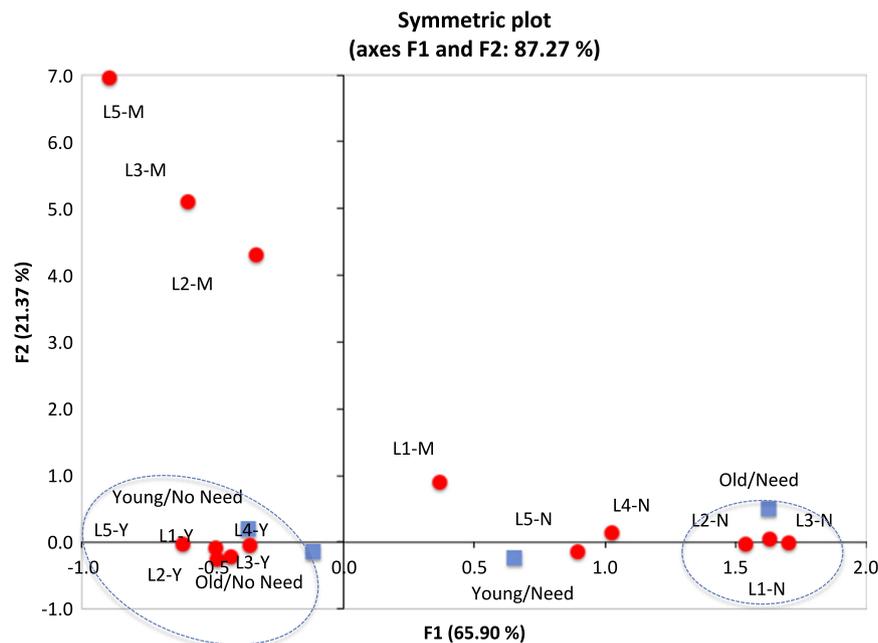


Fig. 3. Multiple Correspondency Analysis regarding fishermen' answers to questions representing a scenario of low punishment to people who did not follow fisheries management regulations. Fishermen were classified in four categories represented by squares (Old/Need=5; Old/No Need=40; Young/Need=13 and Young/No need=37) regarding their age and level of dependency on money coming from fisheries. Circles represent the variables with their categories: “L” followed by a number and a capital letter represent, respectively, the different questions asked to fishermen (L1 – boat seized for one week; L2 – gear seized for one week; L3 – equipment seized for one week; L4 – being arrested for one day; L5 – paying a fine of R\$100) and the answers given by them (Y=Yes; N=No; M=Maybe).

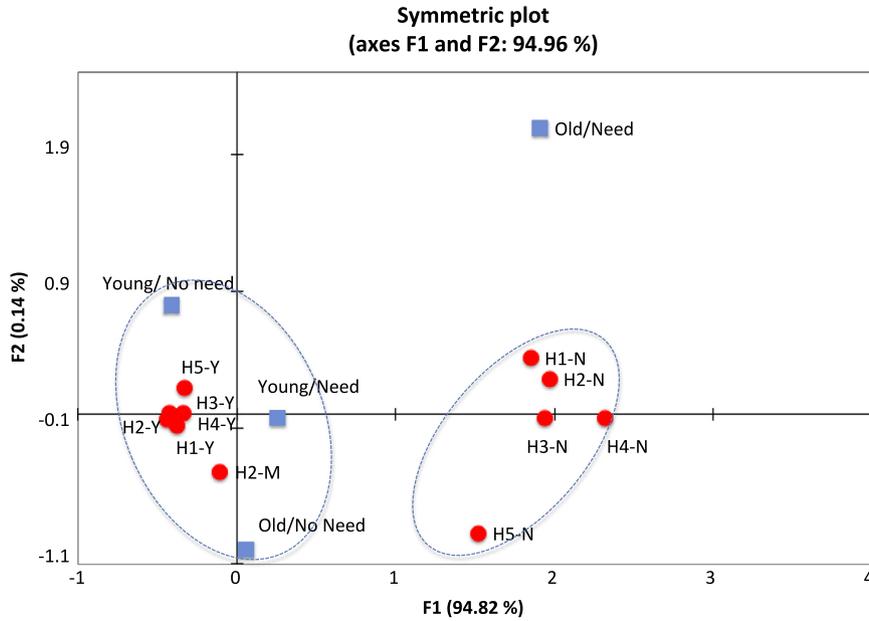


Fig. 4. Multiple Correspondency Analysis regarding fishermen' answers to questions representing a scenario of high punishment to people who did not follow fisheries management regulations. Fishermen were classified in four categories represented by squares (Old/Need=5; Old/No Need=40; Young/Need=13 and Young/No need=37) regarding their age and level of dependency on money coming from fisheries. Circles represent the variables with their categories: "H" followed by a number and a capital letter represent, respectively, the different questions asked to fishermen (H1 – boat seized for one month; H2 – gear seized for one month; H3 – equipment seized for one month; H4 – being arrested for one month; H4 – paying a fine of R\$500) and the answers given by them (Y=Yes; N=No; M=Maybe).

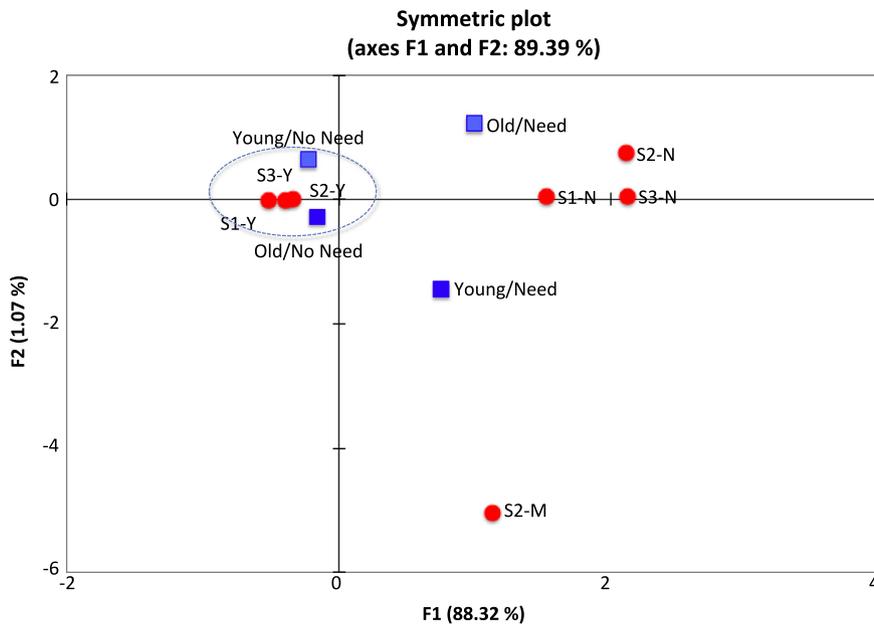


Fig. 5. Multiple Correspondency Analysis regarding fishermen' answers to questions representing a scenario of social punishment (ostracism) to people who did not follow fisheries management regulations. Fishermen were classified in four categories represented by squares (Old/Need=5; Old/No Need=40; Young/Need=13 and Young/No need=37) regarding their age and level of dependency on money coming from fisheries. Circles represent the variables with their categories: "S" followed by a number and a capital letter represent, respectively, the different questions asked to fishermen (S1 – friends ostracise the fisher; S2 – family ostracise the fisher; S3 – whole community ostracise the fisher) and the answers given by them (Y=Yes; N=No; M=Maybe).

fishermen live in a park and are supposed to be involved in its management through taking part in the decision-making and the enforcement of management measures, the real situation suggests a paper park, with free access to fishing resources. A former study in the area had already suggested that the establishment of the park, which was based on a just social movement, aimed mostly to assure the right to the land without giving due consideration to the management obligations that a sustainable development reserve requires [26].

In this study, a general behavioural difference between the younger and the older fishermen concerning compliance was not observed, regardless of the level of enforcement, with only a slight tendency of the younger ones claiming to comply more. Most studies that relate age to compliance show that the younger ones are often the ones behaving as the wrongdoers [6,10], expectations that are not specifically bound to fisheries alone [23,34–37]. Some believe that older people would be more sensitive to threats of

sanctions than younger ones due to social stakes gained over the years, such as status [35,37–39]. Here, however, since no difference was observed between the two groups, it is only possible to speculate on the slight tendency of older fishermen affirming that they would keep not complying even if the enforcement level increased. Perhaps older fishermen would perceive the regulations as illegitimate due to their longer experience with the top-down system, as there seems to be a linear correlation between compliance and legitimacy [12,40], but further studies would be necessary to confirm that on the Brazilian coast. Three older fishermen mentioned that they have lost all confidence in the government, since, according to them, the government abused their confidence in the past, by tricking them into agreements they did not want.

4.2. Punishment and compliance – exploring scenarios

Studies show that an increase in the severity of the punishments, associated with effective enforcement in the fisheries, can lead to greater levels of compliance behaviour [3,7]. The current study also supports these findings, but brings to the fore the need to consider multiple aspects that can act together in defining compliance. Specifically, this study suggests that age and being in a difficult financial situation matter and interplay with each other. People who need the money from fisheries are more likely to cheat the system, especially if they are middle-aged, even under hypothetically harsher punishments.

Some authors argue that when fishermen do not see any alternative for supporting their families other than violation they tend to continuously break the rules [41]. The findings of this current study reinforces that when no alternatives are given to fishermen's livelihood, compliance will not be met or it will come at a higher cost, through high levels of enforcement and punishment. Thus, fisheries management should be associated with providing alternatives to livelihoods, as management is likely to restrict fisheries to a certain degree [42]. Also, these alternatives should take into account the different age segments, with their respective needs. Middle age fishermen, for example, seem to be more resistant to changes and more attached to the way they already do things, while at the same time they may feel they might not be able to learn anything new and adapt to a new system [43].

Besides, it is also important to consider the relevance of social and moral aspects for the success of enforcement and compliance. There is evidence that many people, though having the ability to act as 'free-riders', meaning showing non-compliance behaviour, choose to invest in public goods because they 'wanted to do the right thing', not because the law demand they do so [18]. In the current study, moral issues seemed to be a more relevant determinant of fishermen's compliance than the different levels of punishment: fishermen, except for the few middle-aged ones in need of money, said to be more likely to comply if doing otherwise would result in them being ignored by family and friends. Losing the respect of friends, family or even of the whole community would lead to a change in attitude and behaviour regarding compliance.

However, in a situation where there is no enforcement, as the one described here, peer pressure can also work the other way around. Fishermen that see their peers violating the rules have a higher probability of disobeying them as well [6]. Both the morals of others and the personal morals will influence the behaviour of the individual [6,18,44]. Also, if a fisherman complies while his peers break the rules, such as fishing in a closed season, others would already have caught the fish he could have caught in the open season. In the absence of enforcement or punishment, which characterises an open access situation, the complying fisherman is the only one to lose, describing the typical tragedy

of the commons [45], appropriately called "tragedy of the fishermen" [46]. There seems to be no way out for a fisherman facing an open access situation. Non-compliance is the optimal behaviour, despite its negative consequences in the long term, such as overfishing.

Therefore, the development of a management regime should be associated with the establishment of property rights, which in a park such as the one described in this study would have to be a co-management regime, with the government sharing the management and enforcement responsibilities with the communities in the area (according to the Brazilian law on Sustainable Development Reserve – Law 9.985, July 18th 2000). On paper, the studied area is already a co-management regime, but the local reality shows no real involvement of the locals. A participatory regime would help establish or restore legitimacy and trust, two factors that can affect either positively or negatively the attitude and behaviour of the fishermen [5,6,33,47]. Once there are trust and legitimacy then moral issues, such as the relevance of the community opinion on ones behaviour, will play a positive role. Reinforcing the role of a community in the management of legitimate fisheries measures will only empower it and make societal pressure even more important determinants of management success.

5. Conclusion

The main purpose of this study was to evaluate how age and being in financial need interact to define compliance in open access fisheries and how these two factors could affect compliance behaviour if there were top-down and societal enforcement of fisheries regulations. These fishermen are faced with regulations existent on paper, but hardly ever enforced. Despite that, fishermen were aware of some of the main regulations, especially concerning important commercial species, such as lobsters, and many claimed to tend to follow them.

Punishment mechanisms, tested through scenarios that supposed enforcement, showed to be important to reach compliance, but not necessarily the most important ones. Social aspects, such as how the community, friends and families see the non-compliant fisherman, were more significant incentives to compliance. Future research should investigate specifically how external opinion, livelihood alternatives, and age could shape the success of fisheries management, as well as how to use these issues to develop better management initiatives.

This research also suggests that installing control, monitoring, and punishment mechanisms alone may not be enough to hinder free-riding. Fear should not drive management success, as it will eventually fail, especially where lack of money and personnel thwart the keeping of an effective enforcement system, common in tropical developing countries. This is especially true in small local communities, who greatly depend on these resources for their livelihood and are not able to quickly change to alternative sources of income. Legitimacy of management rules, associated with local empowerment, can shape fishermen's opinions and behaviour, and as such could result in higher levels of compliance. Therefore, fisheries management should go beyond proposing and enforcing management rules establishing where, how, when, and how much to fish. It should give the proper consideration to the existent livelihood alternatives, create new ones, if necessary adapted to the different groups' needs and desires, including different age groups. It should also empower the fishermen and the community to develop pride and turn peer and general societal pressure into a positive and reinforcing aspect of management.

Role of the funding source

This study was performed with no funding source.

Acknowledgements

We thank Monalisa Rodrigues, Brunno Freire, Lia Cruz, Fernanda Lourenço, Priscila Araújo and Carol Lira for assisting with fieldwork. Also, thanks to Kasia Chudzik for reviewing the language. We would like to thank IDEMA for giving us a permit to perform this research in a state park and for offering its facilities. At last, we would like to thank the communities of Diogo Lopes, Barreira, and Sertãozinho for their cooperation and for providing all of the information for this study.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.marpol.2013.10.012>.

References

- [1] Worm B, Barbier EB, Beaumont N, Duffy JE, Folke C, Halpern BS, et al. Impacts of biodiversity loss on ocean ecosystem services. *Science* 2006;314:787–90.
- [2] Costello C, Ovando D, Hilborn R, Gaines SD, Deschenes O, Lester SE. Status and solutions for the World's unassessed fisheries. *Science* 2012;338:517–20.
- [3] Hauck M, Kroese M. Fisheries compliance in South Africa: a decade of challenges and reform. *Mar Policy* 2006;30:74–83.
- [4] Crawford BR, Siahainenina A, Rotinsulu C, Sukmara A. Compliance and enforcement of community-based coastal resource management regulations in North Sulawesi, Indonesia. *Coastal Manage* 2004;32:39–50.
- [5] Read AD, West RJ, Haste M, Jordan A. Optimizing voluntary compliance in marine protected areas: a comparison of recreational fisher and enforcement officer perspectives using multi-criteria analysis. *J Environ Manage* 2011;92:2558–67.
- [6] Hatcher A, Jaffry S, Thébaud O, Bennett E. Normative and social influences affecting compliance with fishery regulations. *Land Econ* 2000;76:448–61.
- [7] Nielsen JR, Mathiesen C. Important factors influencing rule compliance in fisheries lessons from Denmark. *Mar Policy* 2003;27:409–16.
- [8] Eggert H, Lokina RB. Regulatory compliance in Lake Victoria fisheries. *Environ Dev Econ* 2010;15:197–217.
- [9] Österblom H, Sumaila UR. Toothfish crises, actor diversity and the emergence of compliance mechanisms in the Southern Ocean. *Global Environ Change* 2011;21:972–82.
- [10] Akpalu W. Fisher skills and compliance with effort-limiting fishing regulations in a developing country: the case of Ghana. *Int J Soc Econ* 2011;38:666–75.
- [11] Becker GS. Crime and punishment: an economic approach. *J Political Econ* 1968;76:169–217.
- [12] Tyler TR. *Why people obey the law*. New Jersey: Princeton University Press; 2006.
- [13] Colding J, Folke C. Social taboos: “invisible” systems of local resource management and biological conservation. *Ecol Appl* 2001;11:584–600.
- [14] Ostrom E. *Governing the commons: the evolution of institutions for collective action*. Cambridge: Cambridge University Press; 1990.
- [15] North DC. *Institutions, institutional change and economic performance*. Cambridge: Cambridge University Press; 1990.
- [16] Furlong W. The deterrent effect of regulatory enforcement in the fishery. *Land Econ* 1991;67:116.
- [17] Kuperan K, Sutinen JG. Blue water crime: legitimacy, deterrent and compliance in fisheries. *Law Soc Rev* 1998;32:309–38.
- [18] Sutinen JG, Kuperan K. A socio-economic theory of regulatory compliance. *Int J Soc Econ* 1999;26:174–93.
- [19] Sutinen JG, Gauvin J. An econometric study of regulatory enforcement and compliance in the commercial inshore lobster fishery of Massachusetts. In: Neher PA, Arnason R, Mollett N, editors. *Rights based fishing*. Dordrecht: Kluwer Academic Publishers; 1989. p. 415–28.
- [20] Hønneland G. A model of compliance in fisheries: theoretical foundations and practical application - a social learning approach. *Ocean Coastal Manage* 1999;42:699–716.
- [21] Serbruyns I, Luysaert S. Acceptance of sticks, carrots and sermons as policy instruments for directing private forest management. *Forest Policy Econ* 2006;9:285–96.
- [22] Gambino M, Malvarosa L, Placenti V. Fishery regulation, perceptions and compliance: the fishermen responses. XV Conferenza EAFE. Brest; 2003. p. 42–96.
- [23] Leung SF. An economic analysis of the age-crime profile. *J Econ Dyn Control* 1994;18:481–97.
- [24] Sutinen JG. Measuring and explaining noncompliance in federally managed fisheries. *Ocean Dev Int Law* 1990;21:335–72.
- [25] Dias TLPD, de Salles R. Diagnóstico da pesca artesanal e proposta de plano de ordenamento da pesca na Reserva de Desenvolvimento Sustentável Ponta do Tubarão (Macau-Guamaré/RN). Natal: IDEMA; 2006.
- [26] Lopes PFM, Silvano RAM, Begossi A. Extractive and sustainable development reserves in Brazil: resilient alternatives to fisheries? *J Environ Plann Manage* 2011;54:421–43.
- [27] Cinner J, Folke C, Daw T, Hicks CC. Responding to change: using scenarios to understand how socioeconomic factors may influence amplifying or dampening exploitation feedbacks among Tanzanian fishermen. *Global Environ Change* 2011;21:7–12.
- [28] Shaw A, Sheppard S, Burch S, Flanders D, Wiek A, Carmichael J, et al. Making local futures tangible: synthesizing, downscaling, and visualizing climate change scenarios for participatory capacity building. *Global Environ Change* 2009;19:447–63.
- [29] Begossi A, Lopes PFM, Oliveira LEC, Nakano H. *Ecologia de Pescadores da Baía de Ilha Grande*. Sao Carlos: Editora Rima; 2010.
- [30] Silva EF, Oliveira JEL. Impactos socioeconômicos e ambientais da Reserva de Desenvolvimento Sustentável Ponta do Tubarão - RN. VII Congresso Brasileiro de Unidades de Conservação do Brasil. Centro de Convenções, Natal; 2012. p. 1–2.
- [31] Dias TLPD. Os peixes, a pesca e os pescadores da Reserva de Desenvolvimento Sustentável Estadual Ponta do Tubarão (Macau-Guamaré/RN) [Dissertation]. Joao Pessoa: Federal University of Paraíba; 2006.
- [32] Hallwass G, Lopes PFM, Juras AA, Silvano RAM. Fishing effort and catch composition of urban market and rural villages in Brazilian Amazon. *Environ Manage* 2011;47:188–200.
- [33] Jagers SC, Berlin D, Jentoft S. Why comply? Attitudes towards harvest regulations among Swedish fishermen. *Mar Policy* 2012;36:969–76.
- [34] Freeman RB. The economics of crime. In: Ashenfelter O, Card D, editors. *Handbook of labor economics*. Amsterdam: Elsevier; 1999. p. 3530–71.
- [35] Torgler B, Valev NT. Corruption and age. *J Bioecon* 2006;8:133 (14).
- [36] Hirschi T, Gottfredson M. Age and the explanation of crime. *Am J Sociol* 1983;89:552–84.
- [37] Sampson RJ, Laub JH. Crime and deviance in the life course. *Annu Rev Sociol* 1992;18:63–84.
- [38] Cutler SJ, Kaufman RL. Cohort changes in political attitudes: tolerance of ideological nonconformity. *Public Opinion Q* 1975;39:69–81.
- [39] Denese A, Vlosky DA, Vlosky RP. Exploring age-related environmental attitudes in the context of wood product certification. Baton Rouge: Louisiana State University Agricultural Center; 1999.
- [40] Nielsen JR. An analytical framework for studying compliance and legitimacy in fisheries management. *Mar Policy* 2003;27:425–32.
- [41] Peterson A, Stead SM. Rule breaking and livelihood options in marine protected areas. *Environ Conserv* 2011;38:342–52.
- [42] Mangi SC, Roberts CM, Rodwell LD. Reef fisheries management in Kenya: preliminary approach using the driver–pressure–state–impacts–response (DPSIR) scheme of indicators. *Ocean Coastal Manage* 2007;50:463–80.
- [43] Marshall NA, Marshall PA. Conceptualizing and operationalizing social resilience within commercial fisheries in Northern Australia. *Ecol Soc* 2007;12:1.
- [44] Sumaila UR, Alder J, Keith H. Global scope and economics of illegal fishing. *Mar Policy* 2006;30:696–703.
- [45] Hardin G. The tragedy of the commons. *Science* 1968;162:1243–8.
- [46] Rotherham ID. Cultural severance and the end of tradition. *Landscape Archaeol Ecol* 2010;8:178–99.
- [47] Vos BI, Tatenhove JPMv. Trust relationships between fishermen and government: New challenges for the co-management arrangements in the Dutch flatfish industry. *Mar Policy* 2011;35:218–25.