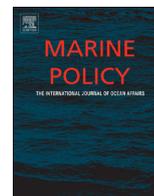




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Each fisherman is different: Taking the environmental perception of small-scale fishermen into account to manage marine protected areas



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ABSTRACT

One of the reasons for the failure of some Marine Protected Areas (MPAs) is the lack of respect for their boundaries and regulations, which intensifies the need to assess the attitudes of stakeholders affected by MPAs. To this end, it is necessary to know the perception and behavior of resource users in these areas in relation to the management process. This study addressed the perception of different groups of fishermen in three MPAs that allow sustainable use of resources on the Brazilian northeastern coast. The perception analysis was based on four aspects: biodiversity conservation, flexibility and adaptability of fishermen, participation in management and opinions about the MPA. The interviewed fishermen ($n=100$) were classified into natives or immigrants, \geq than 40 years old or < 40 , predominant use of selective or nonselective fishing gear and part or full time fishermen. The results showed that younger fishermen and the ones who use selective fishing gear presented a more conservation prone perception; nonselective fishermen and part-time fishermen were more flexible and adaptable to changes; and younger fishermen tended to agree more with the establishment of the MPAs. Taking these differences in perceptions among fishermen into account could serve as a basis for improvements in the management and conservation of fishing resources, besides helping predict possible future behavior due to changes in management policies.

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1. Introduction

The maintenance of marine ecosystems and biodiversity has been threatened by overfishing, illegal fishing, use of predatory extraction methods and users conflicts over resource use [1,2]. As a result, there is an urgent call for sustainable management [3], and one of the most well regarded alternatives proposed for that is the establishment of Marine Protected Areas (MPAs) [4,5].

The implementation of an MPA is only the first step: its effective management is fundamental to ensure the protection, restoration or sustainable exploitation of natural ecosystems. Also, it should be considered that the successfulness of an MPA, similar to any other type of resource management initiative, is the outcome of the interplay between two main aspects: the local ecological characteristics (e.g. the carrying capacity of the area) and the institutions in place, which could assure a higher level of users' acceptance and compliance [6–8].

The poor performance of an area subjected to management rules may be the outcome of inadequate governance or management model [4], or lack of knowledge on resource users' behavior, their perception and attitudes [9–13]. Responses and adaptations of users to new rules imposed by MPAs are one of the determinants to achieve management goals [5,14,15]. Thus, understanding the perceptions and attitudes of resource users in socio-ecological systems could help predict possible behaviors that lead to the success or failure of management systems. This involves knowing the influences that act upon users and their likely responses, so that both the costs and benefits of such management strategies can be assessed.

MPAs will generally limit or forbid fishing, amongst other activities, affecting for example, fishing effort, time available for fishing activity, species that can be caught, catch limits and gear allowed [16]. Such restrictions imposed by these MPAs, along with local socioeconomic characteristics, create heterogeneity of preferences and attitudes among fishermen, increasing the diversity of perceptions and behaviors in the system. This, in turn, could increase conflicts over the resources [16]. Thus, knowing the perception of different groups of fishermen can generate subsidies that will help reduce conflicts among users, permitting the proposal

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of fisheries management more likely to be respected and the maintenance of protected areas [17].

Although there are studies that address the issue of perception and attitudes associated with different socioeconomic and management variables [18–22], little is known about how the perceptions and attitudes of users of natural resources can influence management of protected areas and the socio-ecological resilience of the people living in them. Differences in perception among groups of fishermen could potentially influence the promotion of resilience of social-ecological systems, defined as the capacity of self-organization of the system and the users' capacity for learning and adapting to a new state [23]. A more conservationist behavior, for example, could help an ecological system support a higher diversity of species, while adaptable and learning-prone fishermen could support and participate more in the decision-making process of an MPA.

In this study, the objective was to compare some aspects of the perception among groups of fishers according to some criteria that have already been demonstrated to be important in the construction of perception, such as birth place, age, fishing selectivity and degree of dependence on fishing [9,15,17,24–27].

The following questions were investigated: (1) whether selective fishermen born in a place subject to the limitations of an MPA show more conservationist attitudes; (2) if young fishermen, nonselective ones and those not exclusively dependent on fisheries (part-time fishermen) tend to be more flexible and adaptable to changes in the reserves; (3) whether fishers born in the community under the influence of an MPA and full-time fishermen have greater participation in the establishment of management; and (4) if fishermen born in the community under the influence of an MPA tend to have more positive opinions regarding the MPA than immigrant fishermen. The understanding of environmental perception of different groups of fishermen can help establish improvements in conservation practices. This can lead to identifying groups that can offer support and groups that need to be worked on for a better understanding of the need for MPAs, aiming, for example, to reduce local conflicts and improve compliance. Thus, studies of this nature can help improve the performance of MPAs where the use and extraction of natural resources is permitted.

2. Material and methods

2.1. Study area

In Brazil, MPAs can be managed under different categories of parks, with varying levels of access to the resources, from no-take areas to areas that allow the sustainable extraction of the resources, and anything in between [28]. This research was done in three MPAs that allow the sustainable use of resources, all located on the Brazilian northeastern coast (Fig. 1).

Such MPAs are in the states of Rio Grande do Norte (State Sustainable Development Reserve Ponta do Tubarão, established in 2003 – hereafter Ponta do Tubarão) and Ceará (Extractive Reserve Batoque, established in 2003 – hereafter Batoque; Extractive Reserve Prainha do Canto Verde, established in 2009 – hereafter Prainha) (Table 1). The three MPAs were established after intense local demand, but they still lack a management plan defining the access and use of natural resources. Also, these MPAs are based on co-management schemes, in which the communities are supposed to have input in the decision-making. However, in the absence of a management plan, the rules in place are vague or based on general federal laws, such as closed periods for lobsters. No specific rules devised for these MPAs themselves were in place by the time of this study.

Batoque and Prainha are exclusively marine and federally managed, while Ponta do Tubarão is a state MPA that includes terrestrial and marine area (Table 1). The fishing communities within the MPAs or subjected to the MPAs regulations depend mostly on fisheries and clam extraction. The infrastructure conditions and job options for the three MPAs are deficient, according to the interviewees, with severe socioeconomic problems related to health access, violence, drugs and unemployment.

2.2. Fishermen's profile

One hundred fishermen were interviewed in the three MPAs, and all of them were men between 21 and 77 years old (44 ± 12.4 years), with an average fishing experience of 29 (± 13) years. Most fishermen (81%) claim to own their house and have an average

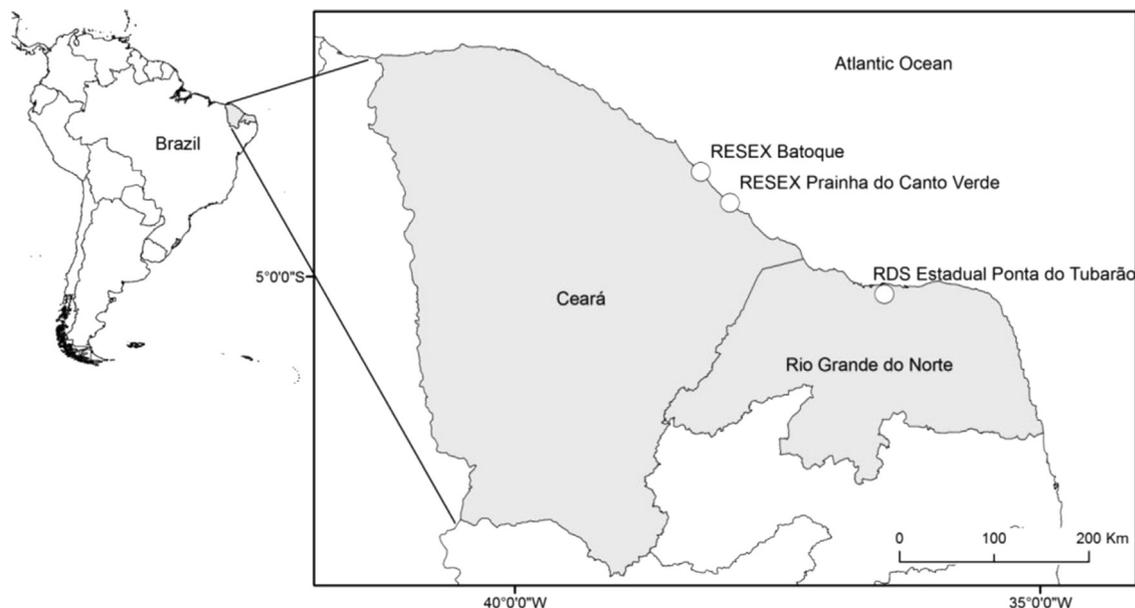


Fig. 1. Study area highlighting: State Sustainable Development Reserve Ponta do Tubarão ($5^{\circ}9'S$, $36^{\circ}27'W$), Extractive Reserve Batoque ($4^{\circ}0'6.13''S$, $38^{\circ}13'52.07''W$) and Extractive Reserve Prainha do Canto Verde ($4^{\circ}17'44.83''S$, $37^{\circ}57'20.22''O$), located on the northeastern Brazilian coast.

schooling level of 5.8 years (± 4.3). Half of the respondents claim to own their boats, being rafts (17%), motor boats (11%) and canoes (8%) the main types of vessels. The fishes: king mackerel (*Scomberomorus cavalla* – 86%), Spanish mackerel (*Sarda sarda* – 86%), horse-eye jack (*Caranx latus* – 73%), mutton snapper (*Lutianus analis* – 60%) and lobsters (*Panurilus argus* – 41%) are the main target species, which are caught mainly with hook and line (71%), gillnet (48%), and manzuá – a semi-fixed bottom trap (41%).

Overall, the three MPAs showed similar socioeconomic characteristics. The economic activities practised by the part-time fishermen, besides fishing, were similar in all of them, notably construction (50%) and agriculture (11%). All fishermen mentioned that at least one more person in the house fished as well.

2.3. Data collection

Fishermen were interviewed with the use of a semi-structured questionnaire, between 2010 and 2011: 40 fishermen from Ponta do Tubarão, 30 from Batoque and 30 from Prainha. Full-time active fishermen and fishermen that had been fishing in the region for at least 5 years were initially selected from a list of names provided by the fishermen's association in each region. Concomitantly, the snow-ball method was used, in which interviewees indicated other experienced fishermen that fulfilled the criteria established [29]. Full-time fishermen were chosen for representing the ones possibly more directly affected by the establishment of an MPA, although during the interviews it became clear that some of them (38%) in fact performed other economic activities on the side. These were later classified as part-time fishermen. The minimum fishing experience in the area, although arbitrarily defined, aimed to direct the focus to people who could have felt changes brought about by the MPA. Fishermen were free to take part or not in the research, after verbally informed of the goals of the research.

Table 1
Description of the Marine Protected Areas (MPAs) included in this study, which are placed on the northeastern Brazilian coast.

MPA	Total area (ha)	Marine area (ha)	Number of families	Established in
Ponta do Tubarão ^a	12.946	847	1000	2003
Batoque ^b	601	601	320	2003
Canto Verde ^c	29.794	29.794	300	2009

^a IDEMA (2004).

^b ICMBio (2011).

^c Community Association of Prainha do Canto Verde (2010).

Table 2

Variables assessed through questionnaires with fishers on northeastern Brazilian coast, with their respective acronyms used in the analyses.

Block	Variable	Acronym
Biodiversity conservation	Knowledge about environmental impacts on fish stocks (e.g. pollution, overfishing, industries),	KEFS
	Conservationist attitudes of fishers before the decline of fisheries (e.g. use of less destructive and intensive fishing gear and subsistence fishing only)	CA
	Compliance with existing fishing rules	CR
Flexibility and adaptability	Variety of resources exploited	VRE
	Flexibility to work in another activity	F
	Ability to adapt to changes brought about by resource management	AA
Participation in management	Involvement in community associations;	ICA
	Participation in environmental monitoring;	PEM
	Knowledge of existing rules	KR
Opinions about MPA	Agreement with the creation of the reserve	ACR
	Improvements after the creation of the reserve (perception of environmental and/or social changes)	IACR
	Desire to remain in the reserve	DRR

The questionnaire was divided into blocks of questions that approached fishermen's perceptions about biodiversity conservation, the establishment of the reserve and management of fisheries resources, besides information on the range of resources exploited and flexibility to learn new activities and adapt to changes caused by new fisheries management measures (Table 2). Data on socioeconomic characteristics of fishers and their communities and on fishery aspects were also collected through this questionnaire (Appendix E).

Answers that could support the effectiveness of the MPA were classified as positive and labeled with "yes" and answers with a negative effect were categorized as "no". For example, when addressing "biodiversity conservation", fishers that were able to identify the environmental impacts on the fish stock were classified as having a positive perception ("yes"), while those who could not associate specific behaviors or environmental causes for fish stock decline got a "no".

2.4. Data analysis

The reserves were not analyzed separately since there are not important differences between them in their socioeconomic aspects, regarding the questions that matter for this study. Instead, the fishermen of the sampled MPAs were classified into four groups, in order to have their perception compared. These groups, as specified before, have been shown to be responsible for different perceptions and behaviors in different studies. The groups were formed according to their age (younger – up to 40 years old; older – over 41 years old), birthplace (natives or immigrants), type of fishing (predominant use of selective or nonselective fishing gear) and dependence on fishing (full-time or fully dependent on fisheries and part-time fishers or not dependent). The age of a fisherman could affect his perception about an MPA and his conservation attitudes, as for example older fishermen could be more resistant to changing habits [30]. The origin of a fisherman could influence his attitude about management [9], with local fishermen showing greater care towards the environment than immigrant ones, as the first ones could be more attached to the local ecosystem. The main type of fishing performed by a fisherman could influence his perception given that the degree of specificity of his gear could promote differences in his knowledge about resources and, consequently, in his conservation attitudes [24]. Selective fishermen could be more effective gathering their target species, without directly harming other fish species. In contrast, nonselective fishermen use gears that are discriminant among target species (e.g. trawl net), potentially causing more environmental impacts than selective fishing gears. Finally, part-time fishermen could also show less care towards the

fishing resources for not depending exclusively on that resource [9,31].

To verify if such groups were associated to specific answers to the questionnaire, a Multiple Correspondence Analysis (MCA) was performed. This analysis allows the use of qualitative variables and is widely used with questionnaires in which the questions represent variables. The MCA analysis enables summarizing the correlations between variables, their categories and the individuals analyzed in graphs of easy visual interpretation [32]. In this case, the graph shows the proximity between these variables suggesting groupings according to the distances between the categories of fishermen.

To check for possible differences in the perception between groups of fishermen who showed some tendency to cluster in the MCA a Bayesian Analysis of Variance (ANOVA) was performed. For this analysis, the perception was measured in mean scores. The points obtained in the block of questions for each of the four categories (Biodiversity conservation, Flexibility and adaptability, Participation in the management and Opinions towards the MPA) were summed up: questions with positive answers (yes) earned one point, questions with a negative response (no) received no points. For example, if a fisher answered “yes” to all three questions in the biodiversity conservation category, he would receive three points (maximum score). Since each block had three questions, a fisher could get a maximum of three points and a minimum of zero for each approach of perception.

The results of the Bayesian ANOVA are expressed as a probability distribution: the smaller the overlap between the confidence intervals, the greater the likelihood of finding differences in perceptions between the groups analyzed [33]. Here it was used an uninformative Jeffreys conjugated prior distribution to generate a simulated sample (3000 elements) of the posterior distribution. For that, precision values of the gamma distribution (1–3000) were generated. Then the variances were calculated for these precisions. Finally, vectors were simulated with multivariate normal samples. The histograms obtained from the analysis above show if the data follow a normal distribution, which would indicate if the difference between the mean scores tended to be positive [33].

The MCA analysis was done with the XLSTAT software [34] and the Bayesian ANOVA with R program [35], using the Mass package [36].

3. Results

3.1. Biodiversity conservation – Fishers’ perception

The fishermen’s perception about the biodiversity conservation showed that fishermen were born in the community have knowledge about the environmental impacts on fish stocks (KEFS) and tended to comply with the rules of use and access to resources (CR). The MCA analysis showed that fishers’ answers about the biodiversity conservation are mainly explained by axis 1 (approximately 57%) (Fig. 2).

When their scoring averages were compared by the Bayesian ANOVA the only findings statistically supported were that older fishermen and the ones who use selective fishing gear had higher averages of responses (more positive answers) when questioned about conservation. This partially supports the first hypothesis, as it was indeed expected better conservationist attitudes from selective fishermen, but also from native ones. There was little overlap between the confidence intervals of the two groups, indicating a substantial difference between them. Moreover, the chances of an older fisherman scoring better in the conservation aspect was higher than a younger fisherman by 92%. The same

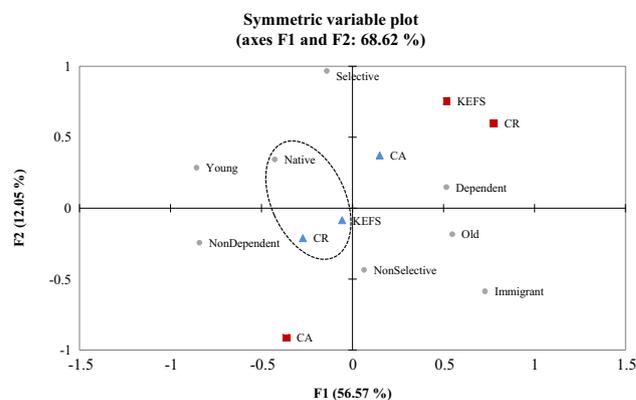


Fig. 2. Multiple Correspondence Analysis (MCA) among groups of fishermen and their perception about Biodiversity Conservation in three parks (Ponta do Tubarão, Batoque and Canto Verde), all located on the northeastern Brazilian coast. KEFS=Knowledge about environmental impacts on fish stocks; CA=Conservationist opinions; CR=Compliance with the rules. Birth place: Native/Immigrant; Age: Young/Old; Selectivity in fishing: Selective/Nonselective; Dependence on fishing: Dependent/Nondependent. Triangle=Yes; Square=No.

pattern was also observed for fishermen who use selective fishing gear, who had on average more positive points regarding conservation aspects than those using nonselective methods. Likewise, selective fishermen showed 88% of chance of having higher scores than nonselective ones (Table 3).

The most cited environmental impacts on fish stock were: garbage in the ocean/estuaries, general pollution, presence of fishermen from other places in the reserves that do not respect the rules, overfishing and predatory fishing, presence of oil industries, lack of enforcement and monitoring of the laws, and lack of sanitation. Positive environmental practices were cited by 70% of the fishermen, such as the use of sustainable gear, fishing only for subsistence and respect for the closed season (for the species that have it).

3.2. Flexibility and adaptability – Fishermen’s perception

When considering the questions that addressed the flexibility and adaptability of fishermen through the MCA analysis, axis 1 (one) explained approximately 78% of the data (Fig. 3). In this axis, there are clear similarities among the perception of fishermen older than 41 years, immigrants and who depend exclusively on fisheries (full-time), as these are the ones less flexible to work in activities other than fishing (F) and to adapt to changes (AA), and they are also those who do not explore different resources beyond fishes (VRE) (Fig. 3).

The Bayesian ANOVA confirmed the difference in perception between full-time and part-time fishermen and between selective and nonselective fishermen, as expected by one of the hypotheses raised here. Fishermen dependent on fishing had lower average score than nondependent ones, suggesting less flexibility and lower adaptive capacity of the first. However, although expected, age did not matter in the flexibility and adaptability approach. There was little overlap between the confidence intervals of the full and part-time fishermen, indicating a substantial difference between them. Moreover, the chances of a part-time fisherman scoring better in the flexibility and adaptation aspects than another who relies exclusively on this activity is greater by 98.6%. Fishermen using nonselective gear were more flexible and adaptable than the selective ones, as they showed a higher average score on the questions approaching such topics and little overlap between their confidence intervals. The likelihood of a nonselective fisher presenting a greater flexibility and adaptability score value than a selective one was 91% (Table 3).

Table 3

Summary of the statistics of the posterior distributions of the parameters evaluated in the Bayesian ANOVA analyzed for the four approaches of perception adopted here: biodiversity conservation, flexibility and adaptation, participation in management and opinions about the MPA. Q1=Quantile 2.5%; Q2=Quantile 97.5%; μ =Mean; SD=Standard deviation; P=Probability (%). Significant values are shown in bold.

Fishermen's categories	Biodiversity conservation					Flexibility and adaptation					Participation in management					Opinions about the MPA					
	Q1	Q2	μ	SD	P	Q1	Q2	μ	SD	P	Q1	Q2	μ	SD	P	Q1	Q2	μ	SD	P	
Birth place																					
Immigrant	2.07	2.52	2.30	0.11	75	1.31	1.88	1.59	0.14	64	1.58	2.12	1.84	0.14	62	1.56	2.23	1.89	1.17	54	
Native	2.22	2.57	2.40	0.09		1.32	1.73	1.52	0.11		1.59	2.00	1.79	1.11		1.64	2.16	1.90	1.13		
Age																					
< 40 years	2.11	2.45	2.28	0.09	92	1.29	1.73	1.51	0.11	72	1.65	2.06	1.85	1.11	75	1.55	2.05	1.81	1.13	88	
≥ 40 years	2.27	2.70	2.49	0.11		1.34	1.88	1.62	0.14		1.48	2.00	1.74	0.13		1.74	2.36	2.05	1.16		
Use of selective fishing gear																					
Not selective	2.14	2.47	2.30	0.08	88	1.42	1.82	1.62	1.10	91	1.63	2.04	1.84	1.10	72	1.67	2.16	1.91	1.12	58	
Selective	2.24	2.74	2.49	0.13		1.08	1.69	1.38	1.16		1.46	2.04	1.74	1.15		1.52	2.24	1.87	0.18		
Dependence on fishing																					
Dependent	2.16	2.51	2.34	0.09	64	1.20	1.61	1.40	0.11	98	1.61	2.03	1.82	0.11	68	1.64	2.15	1.90	0.13	51	
Not dependent	2.17	2.61	2.39	0.11		1.53	2.04	1.79	0.13		1.52	2.05	1.79	1.13		1.57	2.22	1.89	0.17		

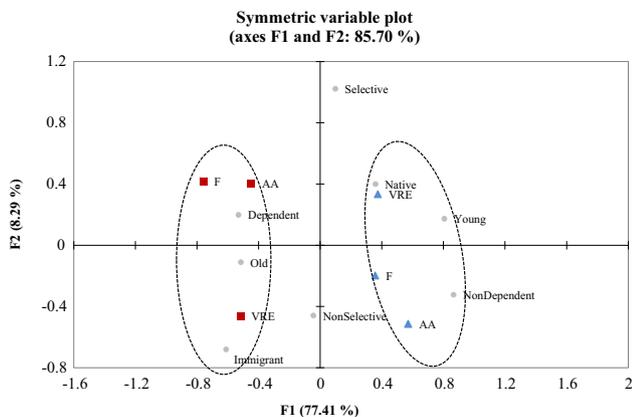


Fig. 3. Multiple Correspondence Analysis (MCA) among groups of fishermen and their perception about Flexibility and adaptability in the three parks (Ponta do Tubarão, Batoque and Canto Verde), all located on the northeastern Brazilian coast. VRE=Variety of resources exploited; F=Flexibility to work in another activity; AA=Ability to adapt to changes brought about by resource management. Birth place: Native/Immigrant; Age: Young/Old; Selectivity in fishing: Selective/Nonselective; Dependence on fishing: Dependent/Nondependent. Triangle=Yes; Square=No.

Most fishermen (66%) said they could stop fishing and do something else if necessary. If those fishermen could no longer fish, according to them, they would work on construction (19%), security jobs (18%) or work for local companies (e.g. oil, salt and wind energy ones) (13%).

3.3. Participation in management – fishermen's perception

In this approach, the fishermen's perception did not show clear any visual pattern and the MCA poorly explained the data (axis 1=42.5%; axis 2=22.31%). Apparently, nonselective fishermen would have a greater knowledge of existing rules (KR), greater involvement in community associations (ICA) and participate more in environmental monitoring (PEM) than selective fishermen (Fig. 4). However, no difference was observed when their scoring averages were compared by the Bayesian ANOVA (Table 3). Hence, the hypothesis that native and full-time fishermen would have a greater participation in the management was not confirmed.

Despite the fishermen's perception about involvement in community associations (ICA) have been meaningless, most respondents (85%) said to be part of some sort of local organization, but only 59%

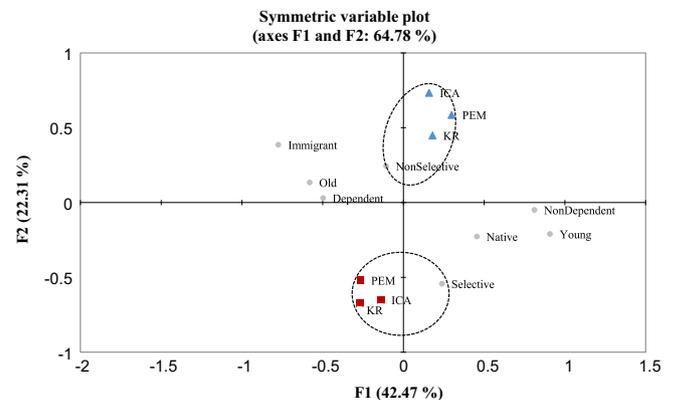


Fig. 4. Multiple Correspondence Analysis (MCA) among groups of fishermen and their perception about approach Participation in management in the three parks (Ponta do Tubarão, Batoque and Canto Verde), all located on the northeastern Brazilian coast. ICA=Involvement in community associations; PEM=Participation in environmental monitoring; KR=Knowledge of existing rules. Birth place: Native/Immigrant; Age: Young/Old; Selectivity in fishing: Selective/Nonselective; Dependence on fishing: Dependent/Nondependent. Triangle=Yes; Square=No.

of respondents said to actively participate, especially in the fishermen's association (65%).

3.4. Opinions about MPAs – fishermen's perception

All groups of fishermen expressed desire to remain in the reserve (DRR), although the MCA analysis showed again no consistent result, with all compared groups very close to each other on axis 1 (axis 1=51%) (Fig. 5).

However, the Bayesian ANOVA supported significant differences in perception among younger and more experienced fishermen, with these last ones showing higher scores, suggesting their more positive opinions regarding the MPA. The chances of an older fisherman showing a higher score than a younger one were of 88% (Table 3). Here, the hypothesis that native fishermen would show a more positive perception was not confirmed.

Summarizing, the MCA graphical analyses and the Bayesian ANOVA confirmed differences in the perception of the different groups of fishermen: (1) older and selective fishermen were suggested to have more conservationist perception (Fig. 6a and b), (2) full-time fishermen and the ones who use selective gear tend to be less flexible and show lower adaptive capacity (Fig. 6c, and d), (3) and older fishermen had more positive opinions about

the MPA (Fig. 6e). Fig. 6 shows the posteriori sample distribution following the significant differences observed between the groups of fishermen analyzed, based on the mean scores obtained in the approaches of perception. The normal distribution indicates that these differences tend to be positive.

4. Discussion

The inclusion of social knowledge in the management process represents a new era of natural resource management [1,37,38]. Despite the effort dedicated to the establishment of MPAs and of management policies, their impact on the perception and behavior of fishers has not received enough attention. By focusing on the importance of knowing the perception of fishermen in order to support better performance of fishery management strategies, this study showed that such perception could be skewed according to the social or economic segment analyzed.

In general, different groups responded differently according to the category of perception considered. For example, it was observed that older and selective fishermen tend to comply more with management rules than those younger than 40 years and who do not use selective gear, but birthplace and degree of fishery dependence were not a factor. Some examples in the literature show that fishermen using different types of gear may show differences in perception regarding MPAs [25,39,40]. In this specific case study, these potentially non-compliant ones correspond to 39% and 64% of the total estimated of fishermen of the reserves, respectively. This suggests the need to focus on compliance issues especially with the younger and nonselective fishermen in future management plans, whereas the ecological effectiveness of the marine reserves depends essentially on the level of compliance of rules by users [41]. This should not be ignored, as fisheries compliance is key to sustainable management [42]. Furthermore, traditional compliance strategies believe that the behavior of fishermen is influenced by the costs and benefits of their actions [43], thereby policies need to integrate socio-economic priorities ensuring fishermen's livelihood, avoiding the generation of conflicts due to non-compliance with rules in the communities [17].

The hypothesis that the birthplace would affect compliance, with local fishermen caring more about the local regulations, was

not confirmed. Perhaps, the fact that immigrant fishermen were living in these communities for a relatively long time (average of 36 years for the three MPAs) may have masked the results. It would be ideal to check for differences in compliance between local and outside fishermen in the future, especially given that outsiders are less subjected to peer and community pressure [17,44].

Differences were also expected between immigrants and natives regarding their perception about biodiversity conservation, since fishermen coming from other places would probably have more recent social and cultural relations with the local environment. Specifically, this lack of familiarity and attachment was expected to reflect in this research as a lower concern for the biodiversity conservation. The social background of fishermen has been shown to influence their perceptions, while the specific cultural and social characteristics of communities may contribute to differences in their attitude [9]. However, no significant differences were identified between the two groups, perhaps because the original communities these immigrants came from are rather similar and geographically close to the studied ones, or again due to the long time immigrants have already spent in the MPAs.

The hypothesis that fishing dependency affects the flexibility of fishermen was confirmed. Fishermen that said they did not rely exclusively on fishing were more flexible to work on others activities and showed a greater ability to adapt to changes in the management, suggesting greater social resilience of this group. In a study on perception in Egypt, there was a direct relationship between conservation attitudes and aspects of resource dependence, in which high levels of dependency limit fishermen's support of conservation [45]. Thus, a higher variation in the range of resources exploited can positively influence the perception of fishers towards conservation and resource management. Differences in flexibility were also observed between selective and nonselective fishermen, with the latter ones being more flexible and adaptable. The variety of resources exploited can explain these differences. For example, selective fishermen depend on fewer species and have the skill developed for the use of one specific fishing gear. For these fishermen, the collapsing of a stock exploited by them would mean a much harder blow than to fishermen who exploit multiple stocks.

On the other hand, age did not affect fishermen's flexibility, although previous studies approaching fishermen's adaptability to climate change showed significant differences between ages [46,47]. Here it was expected that younger fishermen would be more flexible to work in other activities, as they would be more willing to look for different jobs and learn different activities [47]. Older fishermen can feel trapped between the feeling of being too old to learn something new and too young to retire [30].

Also, no difference was observed between any groups in terms of involvement in management, even though the expectation was that native and fisheries dependent fishermen would commit more, since they have a longer direct relationship with the resources present in their community and would benefit more directly of healthy resources, respectively. Although, all groups of fishermen analyzed had relatively low participation level (59%) in the management, it was expected a higher participation, given that the three MPAs are based on co-management arrangements. Taking active part in the decision-making seems to be one of the factors contributing for the success of co-managed areas [6,48,49], as well as having organized communities with strong leadership [8].

Native fishermen were expected to show more positive opinions about the establishment of the MPA in their area, due to an expectation of these fishermen showing some concern and attachment for their future of their local natural resources. The expectation about natives having a more positive approach as a whole was already dismissed earlier, when approaching their perception on

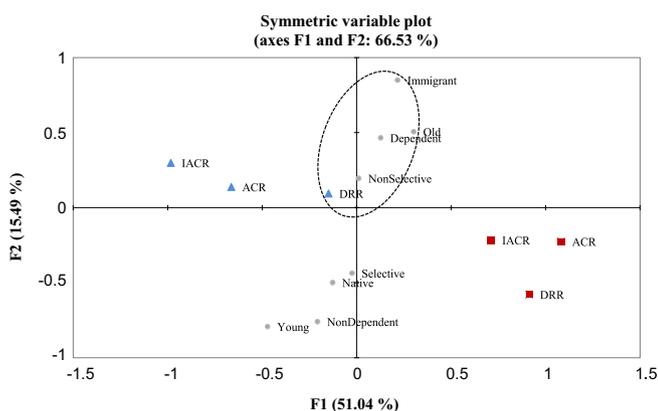


Fig. 5. Multiple Correspondence Analysis (MCA) among groups of fishermen and their perception about Opinions about the MPA in the three environmental reserves (Ponta do Tubarão, Batoque and Canto Verde), all located on the north-eastern Brazilian coast. ACR=Agreement with the creation of the reserve; IACR=Improvements after the creation of the reserve; DRR=Desire to remain in reserve. Birth place: Native/Immigrant; Age: Young/Old; Selectivity in fishing: Selective/Nonselective; Dependence on fishing: Dependent/Nondependent. Triangle=Yes; Square=No.

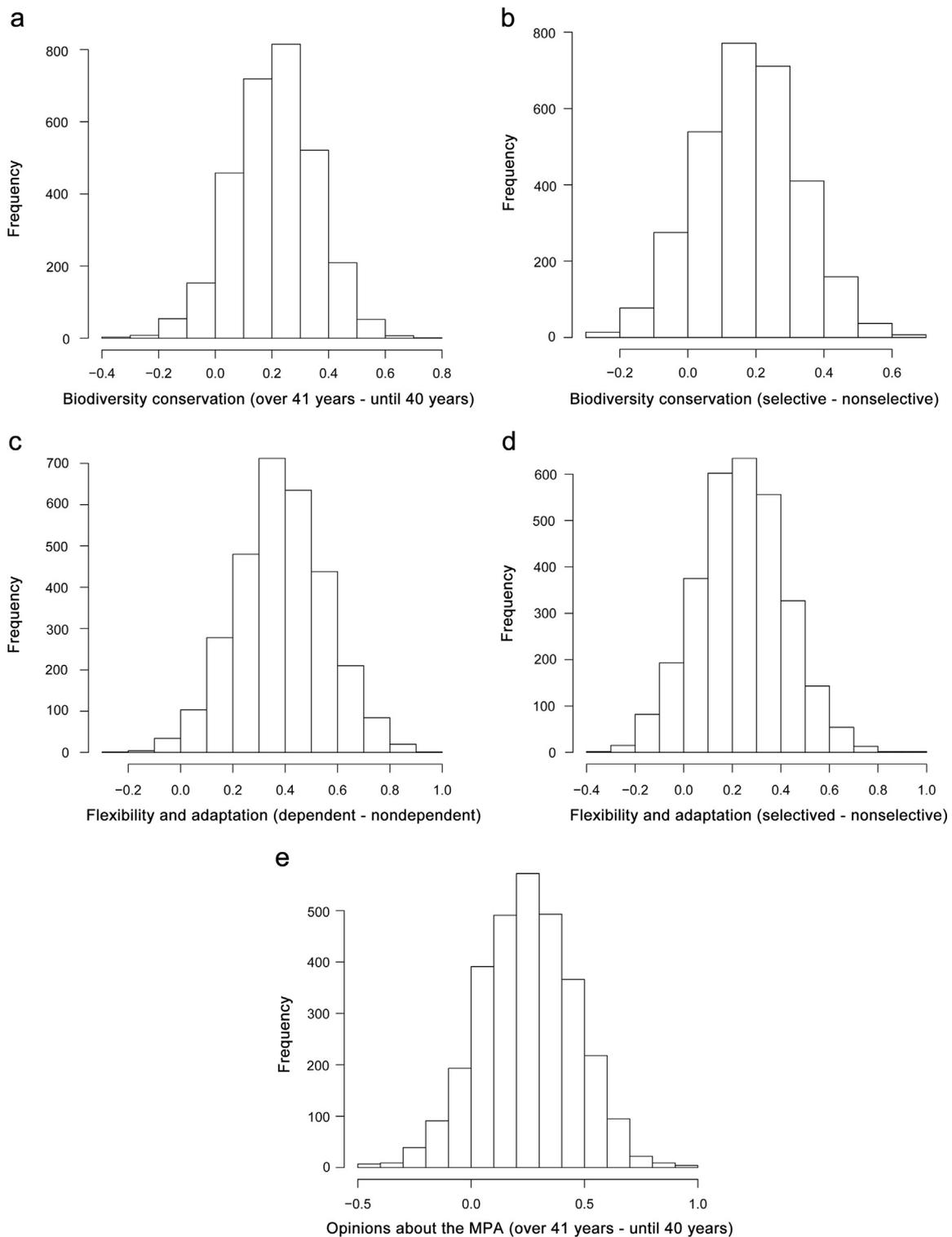


Fig. 6. Histograms of the posterior samples distribution for the difference between the score means of groups of fishermen for each perception approach used in this study. It only showed the histograms of the significant Bayesian ANOVA. Axis X brings the category of perception and, in parenthesis, the variable that showed significance for that approach.

compliance and biodiversity conservation. A more positive approach towards the MPA was observed only among older fishermen, regardless of their origin, something also observed in Mozambique [50]. Indeed, other studies have suggested that age can influence fishermen's actions and perceptions relative to fisheries management, with young fishermen tending to have negative attitudes towards compliance behavior [6,51–54].

Understanding environmental attitudes and behavior of important stakeholders, such as fishermen, is relevant for conservation, as they could help predict possible responses to new management policies before they are implemented and also help understand their answers to existing policies [31]. Incorporating social knowledge in the management process can contribute to reduce conflicts, promote greater social support, decrease the social costs

inherent to resource protection [55–57] and reduce the uncertainty associated with implementing management strategies [58]. Hence, knowing the perception and involving fishermen in resource management can facilitate the development of conservation strategies by evaluating the costs and benefits of such actions and by enhancing their performance and efficiency. Furthermore, the inclusion of social aspects, through stakeholder participation, in resource management can help maintain the social–ecological resilience of the system by making it more participatory.

The failure of some government-based initiatives [59,60] highlights the need to test more participatory alternatives in fisheries (e.g. real co-management and community based management) [61–63]. Also, it is important to abandon static models in favor of adaptive strategies, as there is evidence that such strategies could not only improve environmental but also social resilience and reduce their vulnerability [64]. This would happen through the flexibility of a system of adaptive governance, open to changes and new learning, with division of responsibilities, able to absorb future events on a broader scale and heterogeneity considering the socio-ecological system. Such a system would be prepared to absorb and accommodate unexpected changes, and different perceptions among the groups of users.

An effective participatory management can be essential to the management of the reserves analyzed here and to similar situations in Brazil or where MPAs allow the sustainable use of resources, because fishermen are more likely to comply and divulge the management measures if they were consulted, understood the relevance and contributed to the formulation of such measures [51,65,66]. Thus, understanding the key factors that determine the future behavior of communities and encourage resource users to comply with the policy management is an important point to be discussed in the field of conservation and sustainable management of fishery resources.

5. Conclusions

This study helped better understand the perceptions of different groups of fishermen towards MPAs and other management measures. A more stratified approach to develop fisheries management measures should consider the type of gear fishers use, their degree of dependence on fishing resources and their age, possibly among other factors, in order to minimize conflicts and increase compliance.

The variation in the perceptions held by different groups of fishermen will probably result in variations in the levels of understanding and acceptance of conservation interventions. Thus, focusing on actions to solve problems or gaps in the understanding of different groups of fishermen can provide more effective management strategies. Whereas, incorporating different perceptions into management plans is expected to increase the rate of adoption and compliance with needed fisheries restrictions [67]. This suggests that, even for small communities analyzed in this study, several programs, such as environmental education, monitoring of fishing, involvement of stakeholders in management and those that can encourage alternate livelihood strategies, will be needed to effectively establish practices of sustainable use of fishery resources.

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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.2014.09.019>.

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