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Conserving Brazilian Sardine: Fisher's attitudes and knowledge in the Marine Extractive Reserve of Arraial do Cabo, Rio de Janeiro State, Brazil

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ABSTRACT

Due to the socioeconomic importance of sardines in the South Atlantic, the aim of this study was to evaluate the fishers' LEK and the attitudes towards conservation of *S. brasiliensis* in the fishing village of the Arraial do Cabo, Rio de Janeiro, Brazil. A total of 134 semi-structured interviews were conducted from April to July 2016. The LEK was classified as moderate (0.56) as well as the conservation attitudes (0.60). It was shown that there was a correlation between LEK and income of fishers. There were differences in LEK and attitudes regarding conservation of sardines in all educational groups analyzed in the sampling population. The LEK and the attitudes also show significant association with boat ownership, occupation and if the fisherman belonged to the local fishing association. As a way to improve fishers' attitudes in practice, we also encouraged the promotion of education among youth and adults is recommended so that the behavior of fishers becomes more favorable to the conservation of sardines in this fishing community. We also emphasize that local management must take into account the sociodemographic variables of fishers since these can influence LEK and their predisposition to conserve sardines. This approach would increase the likelihood of ensuring the efficient support of the local community in the conservation of this small pelagic fish.

1. Introduction

Biodiversity is facing an irrefutable crisis due to human population growth, which increasingly seeks biological resources, namely for energy demands and food requirements (Pacheco-Cobos et al., 2015). Presently, marine ecosystems exhibit a widespread environmental decline and a collapse of the unit fish stocks mainly due to overfishing (Myers and Worm, 2003). Moreover, the consequent possibility of ecological changes at all levels, altering the functioning and provision of ecosystem services, makes coastal environments even more susceptible to disturbance (Jackson et al., 2001; McCauley et al., 2015), namely anthropogenic climate change impacts, environmental degradation and other threats to ecosystem resilience and sustainability (McCauley et al., 2015).

In many marine environments, at an essential intermediate trophic level, the small pelagic fish species are more susceptible to the deregulation of their stocks when subjected to intensive exploitation (Cury et al., 2000). This group of fish is recognized as the most caught species and landed in capture fisheries worldwide (Metian, 2009). In the

southwestern Atlantic, the Brazilian sardinella (also known as Brazilian sardine), *Sardinella brasiliensis* (Steindacher, 1879) does not escape this pattern, being recognized as one of the most overfished clupeoids by commercial fleets on the Brazilian coast (Cergole et al., 2002).

The Brazilian sardinella is distributed in the southeastern Brazilian bight (SBB) between Cape São Tomé, Region of Campos dos Goytacazes, Rio de Janeiro State (22° S) to Cape Santa Marta, State of Santa Catarina (29° S) (Jablonski, 2007). This small pelagic fish species is highly dependent on recruitment because it has a short life cycle (Cergole and Dias-Neto, 2011; Dias et al., 2014). Due to these biological features, sardine stocks are exposed and vulnerable to intense overfishing, to environmental variations and to inadequate management of this fishing resource in a sustainable way (Cergole and Dias-Neto, 2011).

The history of sardine catches in the last decades is marked by a series of fluctuations and declines (Cergole et al., 2002; Dias et al., 2014). In 2000, there was a decreasing trend of minimum catches of approximately 20,000 tons at the Brazilian ports of Rio de Janeiro, Santos (State of São Paulo) and Itajaí (State of Santa Catarina) (Soares

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et al., 2011). In 2006, there was a slow and gradual recovery in the catches, reaching 83,917 tons landed in 2009 (Cergole and Dias-Neto 2011; Dias-Neto et al., 2011). However, in 2010 there was an indication of fluctuation with a decrease in catches to 62,133 tons and a slight recovery to 75,122 tons in 2011 (MPA, 2011).

The *S. brasiliensis* in 2015 represented about 77.8% of the fish catches (47,204 tons) of the State of Rio de Janeiro (FIPERJ, 2015), which reinforces the importance of this teleost to the commerce of this Brazilian state. In the municipality of Cabo Frio, for example, this fishing resource is the most landed in the fishing port (FIPERJ, 2015). In addition, it is recognized by the local population as a fish of great socioeconomic importance for the region (Coelho-Souza et al., 2012).

With all these difficulties of managing this biological resource, the survey of users' knowledge becomes of extreme importance since it recognizes and legitimizes traditional or informal ecosystem management (da Silva 2004). The incorporation of a framework that includes the fishermen and their knowledge in the decision making also can contribute decisively to increasing the success of marine ecosystem management (Lopes et al., 2013).

It is known that the local ecological knowledge (LEK) also plays an extremely useful role specifically in the management of marine protected areas (MPAs), especially when small-scale fisheries are involved (Gerhardinger et al., 2009; Mellado et al., 2014; Braga et al., 2018; Martins et al., 2018). Fishermen involved in this type of marine area collaborate mainly in the part related to the regulation of fishing and its application (Heck et al., 2011). Populations of species with some degree of vulnerability, for example, can be aided by combining this local knowledge with marine and fisheries science (Hamilton et al., 2012a,b). However, there is a tendency to consider not relevant the interests of these local communities, which creates a lack of communication between the actors involved, which can contribute to the emergence of new conflicts, skepticism and difficulties in resource management (Daw and Gray, 2005; Mellado et al., 2014).

This LEK in question may be understood as the knowledge acquired through the experiences and observations of the local communities about natural resources (Olsson and Folke, 2001). The LEK can still be very useful in providing information on changes in marine resources, as well as complementing information provided on the evolution of fishing activity (Coll et al., 2014), and can also be a reliable source of data for improve fisheries management (Zukowski et al., 2011). This socio-ecological tool also makes it possible to extract local residents' attitudes on a particular resource as a way to improve conservation practices and determine their impacts on coastal management (Braga and Schiavetti, 2013; Fiallo and Jacobson, 1995). Therefore, the present work aimed to evaluate the local ecological knowledge (LEK) and the attitudes towards conservation of the Brazilian sardinella (*Sardinella brasiliensis*) in the fishing village of the Marine Extractive Reserve of Arraial do Cabo, Rio de Janeiro State, Brazil with the purpose of assisting in the management and conservation of this biological resource.

2. Material and methods

2.1. Description of the study site

The study was conducted in the city of Arraial do Cabo (22° 57' 57"S, 42° 01' 41"W, Fig. 1), Lagos microregion, Rio de Janeiro State, Brazil. This city has a resident population of 29,304 inhabitants with a territorial area of 158,952 km² (IBGE, 2017). The climate in Arraial do Cabo is classified as semi-arid hot (BSh in Köppen's classification), presenting five months of drought (Duarte, 1998). The mean annual temperature in this region is 25 °C and the mean annual rainfall is about 880 mm/year (Barbieré, 1984).

Arraial do Cabo attracted fishers over the years due to marine biological diversity supported by the upwelling at sea that increases primary productivity and ultimately, marine natural resources (Fischer et al., 2015). This region has a traditional fishing village with about

1000 active fishermen (Giglio et al., 2017), mainly concentrated in Anjos Beach (due to the presence of the Z-5 fishing association, fishing port, marine and jetty), Grande Beach, Prainha Beach and Pontal Beach.

This study site is located in the Marine Biome in the Southern Atlantic system, specifically in the Marine Extractive Reserve of Arraial do Cabo with approximately 56.601 ha (ICMBio, 2017). This Brazilian Marine Conservation Unit was created on January 3, 1997 and stands out for its ecological and social interests in the Southwestern Atlantic (ICMBio, 2017). This territorial space has the characteristic of enabling self-sustainable exploitation by extractive populations without damage to the conservation of renewable biological resources (ICMBio, 2017).

2.2. Fisher's interviews

The questionnaire was opportunistically applied to fishers from April to July 2016 on four beaches (Anjos Beach, Grande Beach, Prainha Beach, and Pontal Beach) with the highest fishing activity in the village of Arraial do Cabo. A trustworthy atmosphere with fishermen was established prior (Brook and McLachlan, 2008), to the application of the semi-structured interview script (Albuquerque et al., 2014). All fishers selected for the interviews had experience and direct contact with the main fishing gear for sardines (purse seiners). The approach to the fishermen was carried out mainly after the arrivals and before the departure of the fishing boats in these beaches. A short pilot study was conducted in Arraial do Cabo on a subsample of participants in order to better adapt this instrument of data collection (White et al., 2005). According to Huntington (2000), a well-designed questionnaire is needed to obtain accurate quantitative data. The fishermen interviewed in this pilot survey were kept in the sampling population used in the subsequent analysis.

The interviews took place only after the consent of the respondent and the explanation of the objectives of the work. The decision-making power to interrupt the interview was always respected by the researcher. The fieldwork researchers used notes and eventually electronic recorders to collect information during interviews (Albuquerque et al., 2014). The interviews applied in the present study were approved by the Ethics Committee of the Federal University of the State of Rio de Janeiro, Brazil (CAAE: 53819116.6.0000.5285). This study also was authorized by the Biodiversity Authorization and Information System (Sisbio-ICMBio/IBAMA/Brazil nr. 52333-1).

2.3. Questionnaire design

The questionnaire applied to fishers contained three sections [see Supplementary Material 1]. The first section contains information about socio-demographic variables of fishermen (age, level of education, monthly income, duration of stay in Arraial do Cabo, fishermen in activity or not, fishing experience, fishing effort, member on local fishing colony association and boat ownership).

In the second section, 11 statements were constructed in order to measure the local ecological knowledge about the Brazilian sardinella (*Sardinella brasiliensis*). The questionnaire contained questions about the biology and ecology of Brazilian sardinella (species identification, habitat, spatial and temporal distribution, schooling behavior, growth and maturation, reproduction and spawning, prey and predators and correct fishing periods). In the identification part of the species, the fishers observed a colored image of the sardine through an electronic device for recognition purposes (Fig. 2). At this interview point, the image was always shown to the fishermen in the same order at the beginning of the interview (Silvano et al., 2006).

In the last part of this instrument of data collection 10 statements were elaborate to measure the attitudes towards sardine conservation. The attitude in the present study was defined as the feeling of favor or disfavor of the individual in relation to this concept (Eagly and Chaiken, 1993). The questions in this section aimed to identify the fishers' tendency to conserve and/or protect this biological resource (sardines).

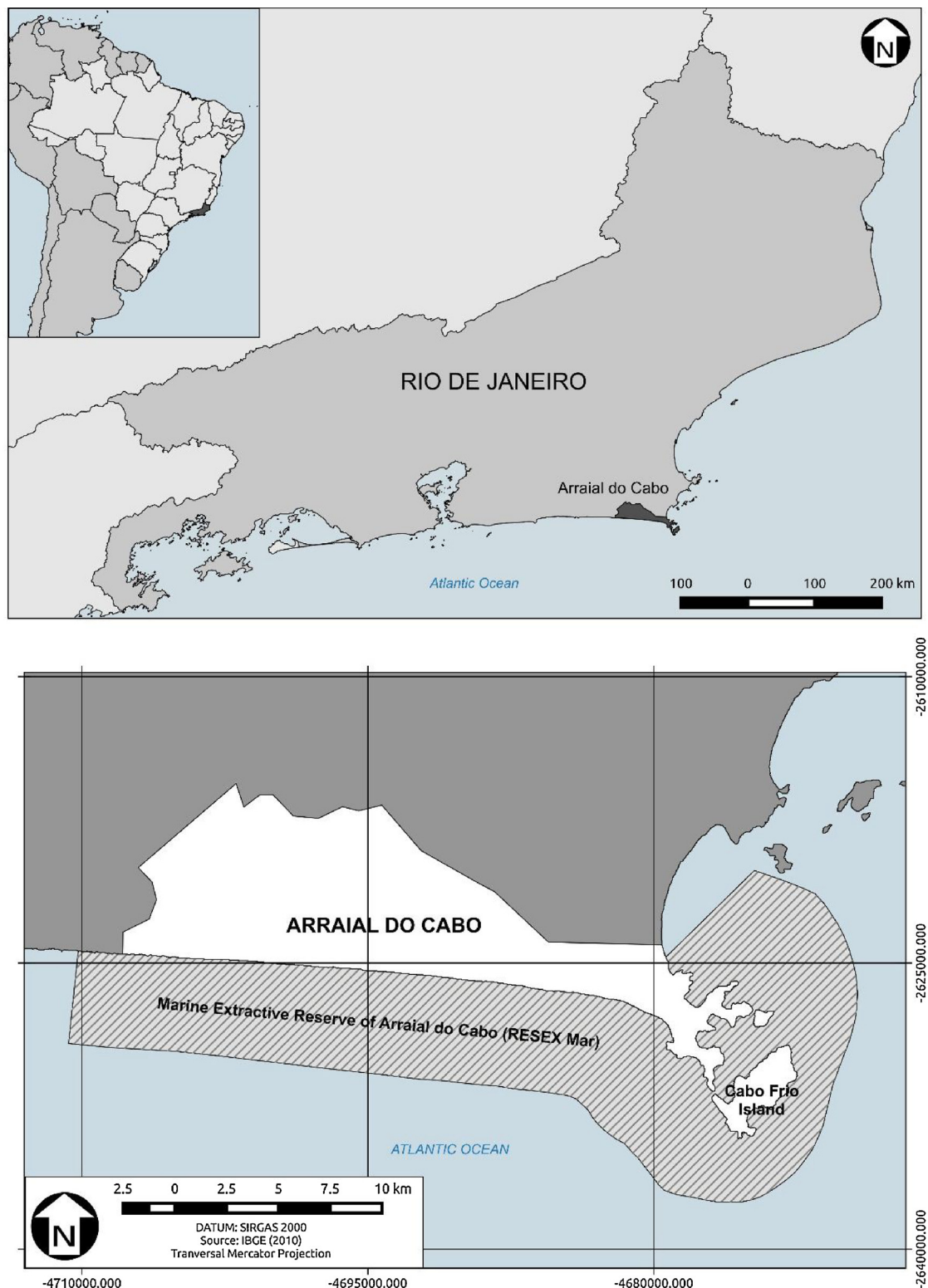


Fig. 1. Location of the municipality of Arraial do Cabo and the Extractive Marine Reserve of Arraial do Cabo, State of Rio de Janeiro, Brazil. Source: Zucherato, B.

2.4. Analytical methods

The data extracted from the semi-structural interviews were analyzed quantitatively and qualitatively considering all the information available (Marques, 1991), through an emic-etic point of view in which the local ecological knowledge was compared with the scientific literature (Harris, 1976). The level of education was classified into three

groups: A: Low level (illiterate and Elementary School 1 – up to 5 years of schooling); B: Basic level (Elementary School 2 6–9 years), and C: Intermediate level (Secondary school – 10–12 years). The local monthly income was converted into Euro currency (1 Brazilian Real – BRL = 0.29 Euro – € or EUR).

The section of the questionnaire about fisher’s LEK and attitudes towards the conservation of sardines was measured using the 3-point



Fig. 2. Image used for the identification of Brazilian sardinella (*Sardinella brasiliensis*). Source: Carvalho Filho, A. FishBase.

Likert scale (Likert, 1932). The knowledge and attitudes interval-level data varied between 0 and 1. To quantify the local ecological knowledge and attitudes towards sardine conservation of the fishermen, the questions were analyzed individually. The answers agreed with the published biological data of *S. brasiliensis* available in the scientific literature were attributed to the score 1, partially correct the score 0.5 and incorrect the score 0. For the statements about the favorable attitudes towards sardines conservation were assigned the score 1, for to moderate attitudes, 0.5; and unfavorable attitudes, 0.

Additive indicators of knowledge and attitudes were used for comparison purposes (Braga et al., 2017; Braga and Schiavetti, 2013). For the calculation of these indicators, the amount of the scores of each interviewee was initially performed. Then the value of the amount of each interviewee's score was divided by the maximum score possible. Thus, an overall average of the indices of all respondents was obtained for the creation of the average indicator of knowledge and attitudes. They were classified into three interval-levels (0–0.33: knowledge below average, unfavorable attitudes; 0.34–0.66: knowledge within average, moderate attitudes; and 0.67–1: knowledge above the average, favorable attitudes).

We conducted analysis of the data generated by the interviews through Project R for Statistical Computing version 3.3.2. (Team et al., 2016). The descriptive statistics of fishermen's profile included the standard deviation, mean and median of the analyzed variables. The normality test (Shapiro-Wilks) was applied initially to all the variables explored in this study. Subsequently, correlations (Spearman's rank test) and a non-parametric test (Kruskal-Wallis) were performed.

3. Results

3.1. Fishers' socioeconomic characteristics

In total 134 semi-structured interviews were conducted with fishermen from the village of Arraial do Cabo. This sample represents 13.4% of the total fishers currently on this important typical fishing village of the Southwest Atlantic. All fishermen were male, with an average age of 48.6 years (sd = 13.6). The minimum age was 20 years and the maximum was 87 years. The average fishing experience time was 27.1 years (sd = 12.2), ranged from 5 to 62 years. The average monthly income of the local fishers was 420.5 € (sd = 256.8 €), with a minimum of 87 € and a maximum of 2030 €. The average fishing effort per trip was 22.1 h (sd = 66.8 h), and the highest recorded fishing effort per trip was 720 h and the lowest fishing effort was 3.5 h (Table 1).

A total of 94 of respondents (70.1%) had low educational level, 25 fishermen (18.7%) had basic level and 15 fishermen (11.2%) had intermediate level of schooling. About sixty percent (N = 81) of the

Table 1

Fishers' socioeconomic profile from the village of Arraial do Cabo in the Southwestern Atlantic (N = 134–100% male).

Variables	Minimum	Median	Mean	Maximum	Standard Deviation (sd)
Age (years)	20.0	48	48.6	87.0	13.6
Fishing experience (years)	5.0	27	27.1	62.0	12.2
Income (EUR)	87.0	420.5	420.5	2030.0	256.8
Fishing effort (hours)	3.5	12	22.1	720.0	66.8

interviewees are natives of the city of Arraial do Cabo and almost forty percent (N = 52) are residents from some stage of life (since childhood: 21.6%, N = 29; since teenagers: 8.2%, N = 11; and since the age of majority: 9.0%, N = 12). Only one respondent is not resident in this fishing village. Of the informants approached, 60.4% (N = 81) were members of the Z-5 fishing association of Arraial do Cabo and only 27.6% (N = 37) owned their boat (Table 2).

3.2. Fishers' knowledge

The average index of local ecological knowledge of fishermen was 0.56. The median of the indicator was 0.58. The lowest index was 0.29 and the highest was 0.79. Of these fishers, 3.7% have below average knowledge, 82.1% have average knowledge, and 14.2% have above average knowledge when compared to the scientific literature. According to the scale adopted, the fisher's local ecological knowledge

Table 2

Characteristics of the profile of respondents from the fishing village of Arraial do Cabo, Brazil (N of fishermen = 134–100% male).

	N	%
Education Level (years of schooling)		
Low (0–5 years)	94	70.1
Basic (6–9 years)	25	18.7
Intermediate (10–12 years)	15	11.2
Time of residence		
Native	81	60.4
Since childhood	29	21.6
Since teenagers	11	8.2
Since the age of majority	12	9.0
Not Resident	1	0.8
Members of the Z-5 fishing colony	81	60.4
Boat owners	37	27.6

of Arraial do Cabo on sardines was considered moderate.

3.3. Attitudes towards biological conservation

The average index of attitudes of fishermen scored 0.60. The median of the index was also 0.60. There was only one informant who obtained the average index equal to 0 and one that obtained the maximum index equal to 1. According to the established classes, 3.8% had non-favorable attitudes, 63.4% moderate attitudes and 32.8% had favorable attitudes towards the conservation of sardines. All five fishers (3.8%) who had negative attitudes towards sardines were not boat owners, and only one fisherman had the monthly income lower than the average of all respondents (145 €). Data obtained allow us to classify the attitudes of this fishing village regarding the conservation of Brazilian sardinella as moderate.

3.4. Ecological knowledge, attitudes, and fishers' socioeconomic characteristics

Only the age of the fishermen presented a normal distribution. Spearman's (r) rank tests showed a positive and significant correlation between the index of local ecological knowledge and the income of the fishers ($N = 134$, $S = 266090.0$, p -value < 0.001 ; Fig. 3). There was no correlation between index of local ecological knowledge and conservationist attitudes ($N = 134$, $S = 371894$, p -value = 0.28).

Comparing all groups of different education level, Kruskal and Wallis (H) tests showed a difference of the index of local ecological knowledge ($K = 211.2483$, $df = 1$, p -value < 0.001 ; Fig. 4a) and index of attitudes regarding conservation of sardines ($K = 209.351$, $df = 1$, p -value < 0.001 ; Fig. 4b) among the fishers interviewed in Arraial do Cabo. There was a significant difference between the associated and non-associated fishermen of the Fishing Association Z-5, and the index of LEK ($K = 209.5753$, $df = 1$, p -value < 0.001 ; Fig. 4c), and the index of attitudes ($K = 208.4307$, $df = 1$, p -value < 0.001 ; Fig. 4d). There was also significant statistical differences between the fishermen owners and non-owners, in relation to the index of LEK ($K = 209.5753$, $df = 1$, p -value < 0.001 ; Fig. 5a), and the index of attitudes ($K = 210.8745$, $df = 1$, p -value < 0.001 ; Fig. 5b). Finally, our results showed that there was also a significant difference between those who live exclusively on fishing and the others that have another source of income in relation to index of LEK ($K = 208.7276$, $df = 1$, p -value < 0.001 ; Fig. 5c) and the index of attitudes ($K = 207.2318$, $df = 1$, p -value < 0.001 ; Fig. 5d).

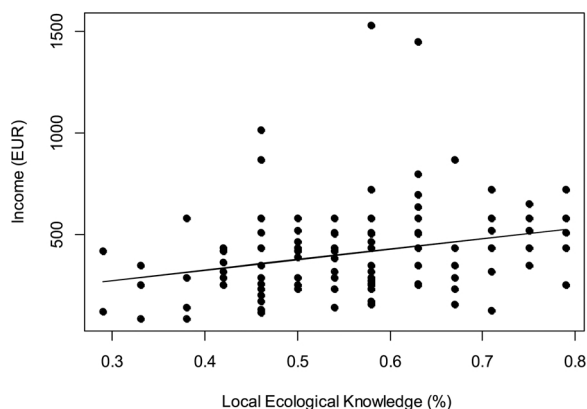


Fig. 3. The correlation between the income of fishermen (EUROS) and the index of local ecological knowledge about Brazilian sardinella.

4. Discussion

4.1. Fishers' knowledge

The search for evaluating the ecological knowledge of local communities has shown that this auxiliary tool can provide important insights for the conservation of biodiversity (Braga et al., 2017; Braga and Schiavetti, 2013). The ecological index used to evaluate the knowledge of fishermen about the ecology and biology of Brazilian sardinella showed that their knowledge was moderate (0.56) when compared to the scientific literature. The same pattern (0.55) occurred with fishermen from the westernmost fishing community of Europe (with the species *Sardina pilchardus*, Walbaum, 1792) specifically located in the city of Peniche, Portugal and near the Berlengas Marine Nature Reserve (Braga et al., 2017). In a study that sought to evaluate the knowledge of chelonians in the South of Bahia, Brazil, fishermen presented also an average knowledge (0.43) (Braga and Schiavetti, 2013).

In a neotropical ecosystem in northeastern Brazil, fishermen's knowledge provided evidence as a scientific complement to what is said about fish biodiversity and structures in each food web (Rosa et al., 2014). In two other marine and freshwater ecosystems, in Brazil, the small-scale local fisher's provided important data on fish ecotoxicology, with results that stimulate the expected cooperation between researchers and artisanal fishers (Silvano and Begossi, 2016). In situations where there is a lack of scientific data, local knowledge can also be a reliable source of data, as demonstrated by fishermen in the northern Irish Sea, where spatial extraction data were available (Shepperson et al., 2014). Using qualitative-quantitative interview techniques, Olsson and Folke (2001) observed that members of a community in western Sweden had a considerable local ecological knowledge of crayfish population, as well as their resource dynamics at the ecosystem level. Data from fishermen from the Spanish Mediterranean Sea and the Gulf of Cadiz on abundance, size composition and catches of fish species were correlated with available scientific evidence (Coll et al., 2014). Finally, the same study also demonstrated that the local ecological knowledge of these fishers can also be useful to complement quantitative information generated from fishing activity as a means of monitoring the effects of fishing and climate change on the Mediterranean (Coll et al., 2014).

4.2. Attitudes towards biological conservation

It is known that the attitudes that a local community presents about a biological resource is of great importance for its conservation (Alexander, 2000). On occasions where self-interest and livelihoods are in some degree of threat, conservation support is almost always facilitated (Kideghesho et al., 2007). In this way, understanding attitudes becomes crucial to better understand why people choose certain choices and behave the way they do (Winter et al., 2005). In the evaluation of fishermen's attitudes in five species of sea turtles in the south of Bahia, Brazil, no fishermen with negative attitudes were registered and the average attitudes indicator was 0.69 (Braga and Schiavetti, 2013). In a fishing community on the west coast of Portugal, the average indicator of attitudes was 0.76 and none of the respondents also showed negative attitudes towards the conservation of European sardines (Braga et al., 2017). The attitudes of rural landowners have also been generally favorable to the conservation of Overberg Coastal Renosterveld (OCR), a highly-endangered vegetation grassy-shrubland of Cape Floral Region (CFR) in South Africa. In this case, the average index of attitudes to conservation was 0.6 (Winter et al., 2005).

In the Pacific Ocean, 89% of local Costa Rican fishermen support shark conservation when their fishing practices are not affected (O'Bryhim et al., 2016). An assessment of local attitudes towards forest elephant conservation in four villages in a protected area around the northern Congo showed general positive attitudes (Nsonsi et al., 2017). In the Kalakad-Mundanthurai Tiger Reserve (KMTR) in South India,

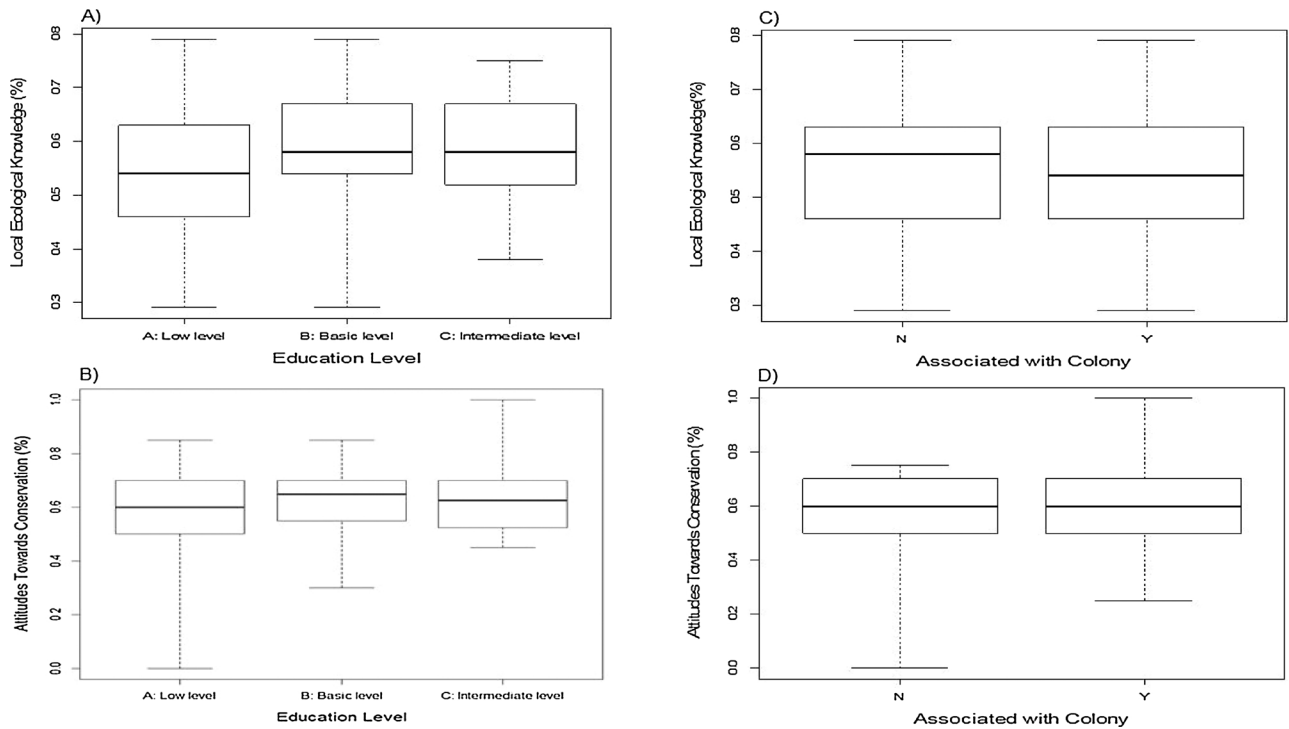


Fig. 4. A) Comparison of the LEK index among educational levels; B) Comparison of the attitudes index among educational levels; C) The variation of the LEK index among fishers associated with Z-5 Fishing Colony and non-associated fishers; D) The variation of the attitudes index among fishers associated with Z-5 Fishing Colony and non-associated fishers (N: not associated, Y: associated).

61% of respondents from the local community presented positive attitudes towards tiger conservation (Arjunan et al., 2006). In addition, Arjunan et al. (2006) indicates this type of conservationist perception assessment as a good indicator of the interests of resource used by the community around the Tiger Reserve. In contrast to our study, the conservationist attitudes of ranchers about wild dogs in South Africa

were generally negative where there is hunting around the farms (Lindsey et al., 2005). However, the author makes clear that even with this negative trend of attitudes towards this local community, there are still possibilities to improve the conservation of these animals on ranchland in southern Africa (Lindsey et al., 2005). In Finland, fishermen from Lake Pihlajavesi also followed this negative trend and were

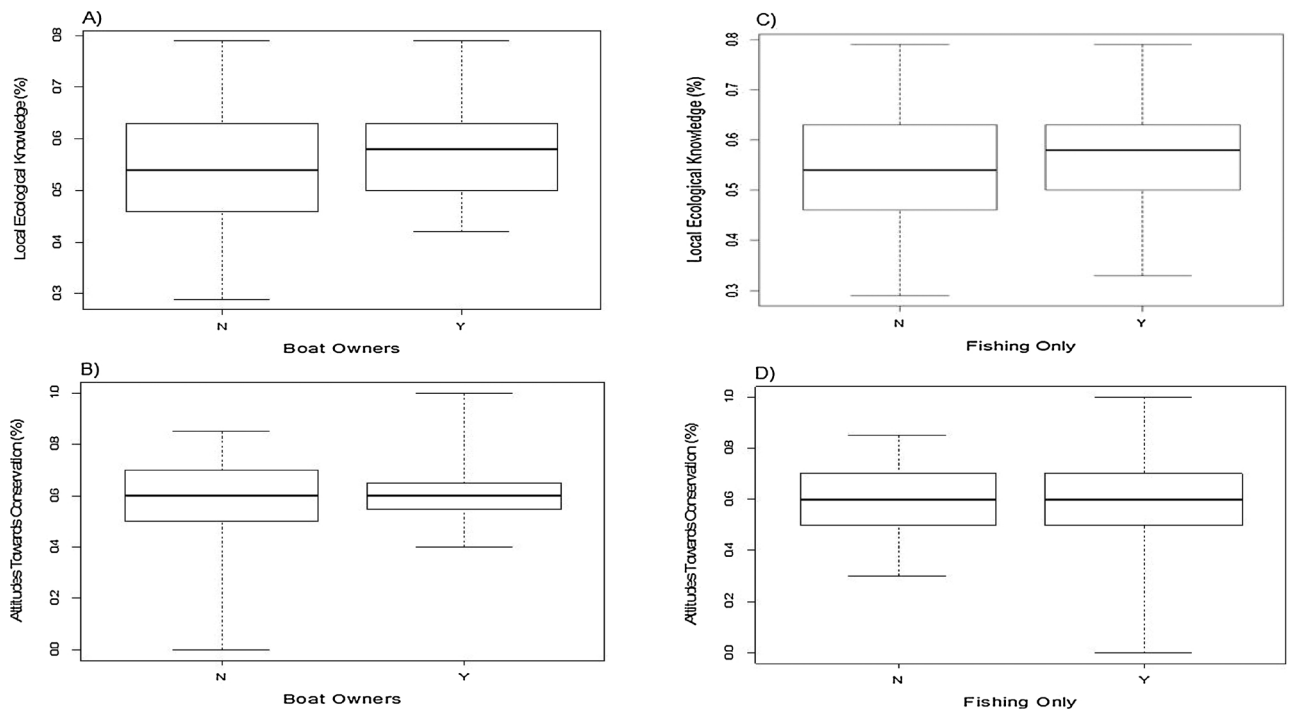


Fig. 5. A) The difference of the LEK index between owners and non-owners of boats; B) The difference in the index of attitudes between owners and non-owners of boats. (N: fishermen not owners of boats, Y: fishermen owners of boats); C) The variation of the LEK index among fishermen who live exclusively from fishing or not. D) The variation of the attitudes index among fishers who live exclusively from fishing or not. (N: not fishing only, Y: fishing only).

not in favor of the conservation of the only endemic mammal in this country – Saimaa ringed seal (Tonder and Jurvelius, 2004). In this case, a conflict of interest between conservationists, local owners, summer cottage owners and commercial fishermen was elucidated. The latter, for example, shared the idea that it was unnecessary to use financial resources for the protection of this animal (Tonder and Jurvelius, 2004). This makes clear how local knowledge and social learning may be important for a better understanding of the local situation for more successful co-management of resources (Berkes, 2009).

4.3. Knowledge, attitudes, and fishers' socioeconomic characteristics

The current study showed that fishers with higher income tended to have more local ecological knowledge (Fig. 3). The informants with the most significant income are usually masters of fishing, and boat owners in the community of Arraial do Cabo. As a result, fishers from higher income may have had this propensity to present more accurate informal knowledge about sardines, as these individuals typically have more experience with fishing and as a result are more knowledgeable about biological and ecological aspects of sardines. In contrast to the present study, in Braga et al. (2017) there was no significant correlation between income and index of LEK on European sardines.

The variation in attitudes regarding the conservation of Brazilian sardinella among fishermen in the fishing community in question was not explained by LEK. However, in another tropical community in Brazil, the fishers have shown more favorable attitudes towards conservation of sea turtles when LEK was lower (Braga and Schiavetti, 2013). In the case of Tampa Bay boaters, along the Gulf of Mexico on the west coast of Florida, United States, knowledge about Florida manatees was highly associated with attitudes towards conservation of this marine mammal (Aipanjuguly et al., 2003). In Peniche, Portugal, when Fisher's LEK of European sardines was higher, there was a tendency for attitudes regarding the conservation of this clupeoid to be more positive (Braga et al., 2017). In the Peniche fishing village, informants are not using the available LEK for their benefit. These fishermen may be willing to conserve sardines because of troubling information linked to the vulnerability of sardine populations on the Portuguese Atlantic coast and because of personal conclusions about what they are reporting during fishing trips, which necessarily should not be occurring integrally in Arraial do Cabo.

In the present study, there were significant differences in LEK among the groups of education level (low level, basic level, and intermediate level). The most homogeneous group was intermediate level (Fig. 4a). In this general way, there is a tendency for more educated fishers to present a more accuracy LEK on sardines. Possibly, the most qualified fishermen may be tended to seek more varied sources of information, which served to compose and solidify the LEK in sardines.

In the study with another species of sardine in the Iberian Peninsula, it was not possible to state that LEK was related to educational levels (Braga et al., 2017). The same trend was observed in Aipanjuguly et al. (2003). However, in the latter case, the researchers reinforce the idea of the need to educate boaters and the general public as a way to avoid harassment of the manatee, thus contributing to the higher incorporation of knowledge by this local community. Therefore, this educational recommendation can provide a better basis for the management of manatee conservation in Tampa Bay, United States (U.S) (Aipanjuguly et al., 2003).

Factors influencing conservationist attitudes may help to improve conservation objectives (Kideghesho et al., 2007). One variable that stands out in relation to environmental awareness is education, since it usually explains environmental causalities as well as pro-environmental behavior (Zsóka et al., 2013). In Arraial do Cabo, the fishers' level of education influenced the extent of their conservationist attitudes about Brazilian sardine and the highest values in the attitude index were observed in the most advanced schooling class (Fig. 4b). Thus, there may be a tendency for fishers with higher levels of schooling to have

more positive conservationist attitudes. Even so, the promotion of educational programs and community information sharing programs on sardine conservation is essential to establish and improve these attitudes in this fishing village in practice. This recommendation is reinforced further in Arraial do Cabo, where attitudes about the conservation of sardines were moderate.

Already in six villages and protected areas in the Western Serengeti, in Tanzania, the level of education was an important predictor of attitudes (Kideghesho et al., 2007). Members of these local communities with a higher level of education supported the conservation of these protected areas (Kideghesho et al., 2007). The attitudes of local residents about the conservation and management of natural resources in one of the largest protected areas of the Ecuadorian coast in Latin America also tended to increase with the level of schooling of the interviewees (Fiallo and Jacobson, 1995).

Notwithstanding, in villages around Nouabalé-Ndoki National Park (NNNP) in northern Congo, researchers found little evidence of the impact of education on residents' attitudes toward elephants conservation (Nsonsi et al., 2017). It is observed in this case that the positive attitudes came from villages where there was an existing conservation project. In an attitude survey in Mozambique, rural owners with higher levels of education were not associated with a predisposition to conserve the Renosterveld Coastal Overberg (OCR) in South Africa (Winter et al., 2005). In a study of ethnoprimateology in Fanjingshan National Nature (FNNR), southwest China's Guizhou Province there was no correlation between the scores of conservation attitudes and the level of education of the local people (Ellwanger et al., 2015). However, in this local community, the residents had predominantly positive attitudes towards monkeys (Ellwanger et al., 2015).

Regarding the association of the interviewees to Z-5 fishing association of Arraial do Cabo, we can only point out that there was a difference of ethnoecological knowledge about sardines between members and non-members of the fishing colony (Fig. 4c). The LEK, in this case, may be linked to other variables and not to the simple fact that fishers are associated or not with the local fishing colony/association. The fact that there are other fishing associations in Arraial do Cabo may also have influenced this finding.

Nonetheless, when comparing the attitudes between these two groups, it was noticed that the associates tended to have more positive attitudes regarding the conservation of sardines than those not associated with the fishing colony (Fig. 4d). Some actions of this association of fishermen made these associated residents more favorable towards conservation of sardines than non-members. The information provided by the fishing colony on the closure of sardine fishing through the laws imposed by the Brazilian Institute for the Environment and Renewable Natural Resources (Ibama, Normative Instruction No. 15, of May 21, 2009) probably contributed to fishermen propensity to conserve this biological resource. The fear of breaking government involving punishment may have provided a preventive factor for attitudes to be favorable in this case.

The conservationist attitude and LEK about sardines varied between boat owners and non-boat owners. Boat owners tended to have a greater ethnoecological knowledge about sardines. This finding reinforces the positive and significant correlation between income and LEK that was observed. This is because fishermen who own boats usually receive more income than non-owners. This was also expected because generally those who command the fishing activity (priority areas for fishing, fishing effort and catch of sardines) are boat owners, who are also usually the boat-master. Therefore, they had a greater propensity to acquire knowledge about sardines ecology, as mentioned previously.

It was clear that fishermen restricted to fishing have higher LEK and tended to range their attitudes towards conservation of sardines (Fig. 5d). Ferreira et al. (2014) argue that fishermen restricted to fishing gain more experience in fishing methods and conservation strategies. This may help to explain the tendency of restricted fishermen to have

greater local knowledge of sardines than fishermen with other sources of income. Through better knowledge of fishing gear, fishermen can better understand the ecology and biology of target species over time and to improve fishing effort. These fishermen restricted to fishing may also have this LEK trend because they have a greater availability of time directed to the fishing activity. With this, they gain more experience and knowledge about the species due to a greater coexistence with the ecosystem and the temporal changes of the biological resources.

Normally, the most active fishermen in the fishery have more contact with boat masters, older fishermen, and other fishermen. Through informal conversations, various discussions about fishing strategies, occasional events during a fishing trip, and some experiences of former fishing professionals can be generated. The mere fact of being more present at these meeting places and the imminence of exchanges of information on these occasions may also have contributed much to our finding.

4.4. Implications for conservation of sardines and conclusion

Social-ecological studies on traditional fishing communities represent a valuable source of information on the current state of fisheries and may show their predisposition to work with conservationists in consensus around a marine biological resources (O'Bryhim et al., 2016). It is known that incorporation of both technical knowledge and local knowledge can increase accuracy in environmental monitoring (Giordano et al., 2010). However, even with some gaps in our traditional scientific knowledge, there is still resistance on the part of scientists to include local knowledge to aid scientific research, even with the imminent possibility of such knowledge to generate diversified and practical information (Mackinson, 2001).

In the Southern Atlantic, the commercial catches of Brazilian sardinella have shown intense oscillations in recent decades due to their own life history, intense fishing effort and direct environmental variations (Cergole and Dias-Neto, 2011). With the great vulnerability of fish stocks worldwide, here with an emphasis on *Sardinella brasiliensis*, we seek to combine scientific information with local knowledge. Mackinson and Nottestad (1998) suggested that this type of research can provide a more adaptive management and a mutual respect between all actors involved with the resource in question. In Latin America, for example where small and medium-scale fisheries have negative impacts on the marine ecosystem and are of great commercial and social importance to the population, the use of LEK can also contribute to increasing the success of legislation in the area of conservation (O'Bryhim et al., 2016).

Thus, incentives for the viability of ecological knowledge to be used in governance is needed, pertinent and timely (Adger et al., 2005). In this sense, local ecological knowledge emerges to provide high value and low cost information, especially when traditional sampling patterns are expensive or difficult to implement (Anadón et al., 2009), which can be extremely useful for conservation biology efforts (Huntington, 2000). However, it is known that this information derived from this knowledge depends on the methodology used, reliability and accuracy of the information collected to provide consistent data (Hamilton et al., 2012a,b). It also advises in this type of social research, approaches of detailed systematic methodologies with critical and refined treatments so that this local knowledge incorporates in reality what it says to represent in fact (Davis and Wagner, 2003).

In the present study, fishers showed moderate informal knowledge of the ecology and biology of Brazilian sardinella when compared to scientific literature. The data in this analysis on the ethnobiology of *S. brasiliensis* that did not correspond to the scientific knowledge should not be totally discarded, but rather analyzed to see the possibility in the contribution of the formulation of new hypotheses for future ecological studies (Drew, 2005; Silva et al., 2014). The behavior observed between the fishermen's variables and the LEK in our study is suggested as a source of additional information on the fishing resource in question for

fishery managers within of the Marine Extractive Reserve of Arraial do Cabo for a better understanding the fisheries planning for sardine.

Attitudes towards conservation in this context can also be an important predictor of interests in the use of natural resources by local communities (Arjunan et al., 2006), and can be critical to their long-term sustainable management (Garekae et al., 2016). In addition to the purpose of the environmental attitude of expressing how certain information and informative quality are expressed by individuals in practice, this variable can also be influenced by institutional and social factors, which can direct and shape individuals' responsiveness (Lo et al., 2012).

In this context, it is known that the educational level is recognized as one of the most important variables to explain ecological concerns, everyday lifestyle, and behavior (Zsóka et al., 2013). But it is also known that the level of education does not always influence the variation of conservation attitudes (Baral and Heinen, 2007; de Boer and Baquete, 1998). Nevertheless, in a society with a greater contingency of people with high level of education, the level of consciousness also tends to follow a higher standard, which may induce more positive attitudes (Shibia, 2010). In addition to the educational level, significant conservation support can be a function of many variables, such as people's sincerity and expectations (Kideghesho et al., 2007).

As a way to promote awareness and positive attitudes in practice regarding sardine conservation, it is indicated that medium-long-term multilateral efforts should be made between the Brazilian federal environmental government, managers of marine reserve, local fishermen's institutions (registered) and autonomous fishermen. Greater attention to the representativeness of boat owners is indicated in the involvement of possible assistance in changing the attitudes of fishermen in general. This is indicated because fishermen who were boat owners tended to have an ethnoecological knowledge about the natural resource in question greater than the fishermen have no boats. It should also be noted that boat-owners had more positive attitudes than non-owners. This fishermen's profile (boat owners) should still be evidenced as important because they generally lead local fisheries management in practice.

Extension of studies among teenage fisherman and adults is also advisable in this regard. According to Kideghesho et al. (2007), the education factor can be seen as one of the ways of changing attitudes as well as bringing individuals to other financial niches, which may lead to less pressure on biological resources. However, to foster proenvironment changes in residents' behavior, it is not only a question of changing their way of thinking, but rather of clarifying and improving the assimilation of these local members about the environment in which they live and the problems they confront (Smith, 1995).

In this sense, support from the local community is essential for widespread acceptance of biodiversity management efforts and institutionalized marine policies (Tonin and Lucaroni, 2017). Data provided by the fishermen of Arraial do Cabo on the informal knowledge and the attitudes regarding the conservation of the sardine and its variations according to sociodemographic variables were duly explored in this study. Through these differences, it was possible to predict how informants tend to behave through their perceptions and motivations in favor of this marine resource. Finally, fishers provided additional information that could assist in the management of small-scale sardine fishing in this prominent community in the tropical Southwestern Atlantic.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.fishres.2018.03.019>.

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