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Socioeconomic attributes and traditional knowledge of artisanal fishermen communities in northeastern Brazil

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Abstract – Interactions between humans and nature are strongly mediated by traditional knowledge, which is built over time according to the laws of nature and society. This study describes the characteristics of artisanal fishing, the socioeconomic profile of the fishermen, and their knowledge regarding the environment, the biology of fish species they exploit, commercial legislation and their rights as members of a fishing community. Questionnaires were answered by 44 artisanal fishermen who perform their activities in the Paraíba River estuary, Paraíba State, in the Northeastern Brazilian Coast. The socioeconomic survey revealed substandard living conditions in the community, in which low schooling (63.64%) and low income (90.90%) prevailed. This work discusses the knowledge of these fishermen regarding the distribution, feeding habits, and morphology of fish fauna, presenting a list of scientific and common names of species. We highlight that these fishermen must be valued for their traditional knowledge transmitted hierarchically. However, the lack of familiarity with the legislation and its provisioned rights highlights the imminent need for effective strategies and measures to allow for the access of knowledge, which requires technical support for the adequate dissemination of information in traditional communities.

Keywords: Coastal zone. Environmental perception. Ethnoichthyology. Social profile.

Atributos socioeconômicos e conhecimentos tradicionais de comunidades de pescadores artesanais do Nordeste do Brasil

Resumo – As interações entre o homem e a natureza são fortemente mediadas pelo conhecimento tradicional, que é construído ao longo do tempo de acordo com as leis da natureza e da sociedade.

Este estudo descreve as características da pesca artesanal, o perfil socioeconômico dos pescadores e seus conhecimentos sobre o ambiente, a biologia das espécies de peixes alvo, a legislação relacionada ao comércio e seus direitos como membros de uma comunidade pesqueira. Questionários foram respondidos por 44 pescadores artesanais que exercem suas atividades no estuário do Rio Paraíba, Paraíba, no litoral nordeste brasileiro. O levantamento socioeconômico revelou condições de vida precárias na comunidade, em que prevaleceu baixa escolaridade (63,64%) e baixa renda (90,90%). Este trabalho discute o conhecimento desses pescadores sobre a distribuição, hábitos alimentares e morfologia da ictiofauna, apresentando uma lista de nomes científicos e comuns de espécies. Destacamos que esses pescadores devem ser valorizados por seus saberes tradicionais transmitidos hierarquicamente. No entanto, a falta de familiaridade com a legislação e seus direitos evidencia a necessidade iminente de estratégias e medidas efetivas de acesso ao conhecimento, as quais requerem suporte técnico para a adequada disseminação de informações em comunidades tradicionais.

Palavras-chave: Zona costeira. Percepção ambiental. Etnoictiologia. Perfil social.

Atributos socioeconómicos y conocimientos tradicionales de las comunidades de pescadores artesanales del nordeste de Brasil

Resumen - Las interacciones entre el hombre y la naturaleza están fuertemente mediadas por el conocimiento tradicional, que se construye a lo largo del tiempo de acuerdo con las leyes de la naturaleza y la sociedad. Este estudio describe las características de la pesca artesanal, el perfil socioeconómico de los pescadores y su conocimiento del ambiente, la biología de las especies de peces objetivo y la legislación relacionada con el comercio y sus derechos como miembros de una comunidad pesquera. Los cuestionarios fueron respondidos por 44 pescadores artesanales que desarrollan sus actividades en el estuario del río Paraíba, estado de Paraíba en la costa noreste brasileña. La encuesta socioeconómica reveló condiciones de vida precarias en la comunidad, en las que prevaleció la baja escolaridad (63,64%) y la baja renta (90,90%). Este trabajo discute el conocimiento de estos pescadores sobre la distribución, hábitos alimentarios y morfología de la ictiofauna, presentando una lista de nombres científicos y comunes de las especies. Señalamos que estos pescadores deben ser valorados por sus conocimientos tradicionales transmitidos jerárquicamente. Sin embargo, el desconocimiento de la legislación y sus derechos pone de relieve la necesidad inminente de estrategias y medidas efectivas para el acceso al conocimiento, que requieren apoyo técnico para la adecuada difusión de la información en las comunidades tradicionales.

Palabras clave: Zona costera. Percepción ambiental. Etnoictiología. Perfil social.

Introduction

Artisanal fishing is an extractive activity practiced throughout the world, especially in coastal zones of the tropics, and is a source of income and food for many communities. This activity occurs

throughout Brazil and is performed by fishermen either working alone or with family or unpaid labor to catch and land fishing resources (Dominguez et al. 2018), using different methods with the aid of gear, vessels, and a variety of fishing strategies (Silva 2014). Most fishermen in Brazil practice artisanal fishing, which has informal work relations (Alencar et al. 2019), however it is known that artisanal fishing has long occupied an important place in developing countries. As a socio-economic and subsistence activity, artisanal fishing is managed by fishermen's organizations and/or the local government, since these fisheries occur on the local or community level (Alencar and Maia 2011). Due to fluctuations in this activity related to the uncertainty of fish stocks and the costs involved in the activity, fishermen often seek other economic activities as a way to complement their income for the subsistence of their families (Ramires et al. 2012a).

Regarding the socio-economic profile, high rates of illiteracy and an incomplete primary school education predominate among Brazilian fishermen. Other concerns regard the low income obtained through artisanal fishing and the considerable participation of women in the trade, especially in post-catch work and shellfish gatherers (Alencar and Maia 2011; Alencar et al. 2019). These individuals generally reside in communities with evident social problems of unemployment and low schooling, where fishing is often the only way to have access to food and some income to sustain the family (Ramires 2012a). Thus, the lack of public policies for the fishing sector and low schooling culminates in a context of artisanal fishing and substandard living conditions (Alencar and Maia 2011).

Despite socio-economic difficulties, fishermen are in direct contact with the environment, which provides them with knowledge relevant to scientific studies. These individuals have considerable information regarding the nature, classification, natural history, behavior, and biology of fishes and use this knowledge in their daily activities (Cordeiro et al. 2019). This knowledge is accessed through ethnobiological and ethnoichthyological studies developed in fishing communities, which furnish important data not only for the statistics of fishing in Brazil, but also biological and socio-economic information (Gumier-Costa et al. 2021). As an integral part of an eco-systemic network, traditional knowledge and interactions with the environment should be perceived as something beyond the mere use and appropriation of resources, it should also be considered within a social context (Ramires et al. 2012b; Pedrosa et al. 2018). Since these individuals have developed a certain mastery over natural resources based on their accumulated experience (Oliveira et al. 2009), such knowledge should be used in the management of fishing practices and could help guide scientific studies by providing information not yet proven scientifically (Alves et al. 2019).

As any profession, whether formal or informal, artisanal fishing is also guided by laws and decrees that aim to safeguard environmental well-being as well as guarantee the minimum rights of artisanal fishermen. For this, the Ministry of Fisheries and Aquaculture (MPA) was created on June 29, 2009 by the Law Nº 11,958 (Brasil 2009) this ministry has now been extinguished and national fisheries and aquaculture policies in accordance with Law Nº 13.266 de 05.04.2016, become the area of competence of the Ministry of Agriculture, Livestock and Supply (MAPA) (Brasil 2016). However, despite being well structured with regard to the needs of understanding the fisheries and aquaculture sector, in a practical and operational way. In this sense, national fisheries and aquaculture policies still face many difficulties to be applied in the Brazilian artisanal fisheries scenario (Moreno 2015; Torres and Carvalho 2020).

Investigating social and economic aspects as well as the knowledge acquired by fishermen over their years of experience in the estuarine environment can promote solutions and benefits that are

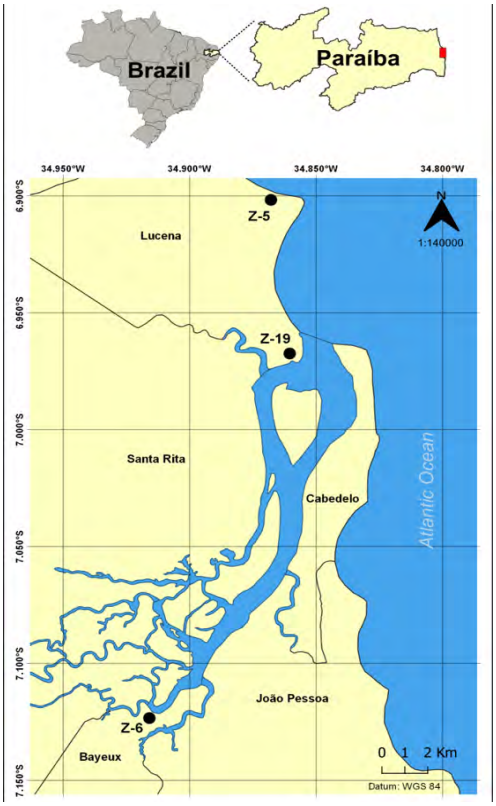
advantageous to both the species and fishing communities. Therefore, our aim here is to describe characteristics of the activity, the socio-economic profile of artisanal fishermen of the Paraíba River estuary in northeastern Brazil, and their knowledge regarding the estuarine environment, the biology of their most common target species, as well as legislation related to the trade and their rights as members of a fishing community.

Material and methods

Study area

The study was conducted in the following fishing colonies: Z-05 Benjamin Constant, Z-19 Antonio Felipe dos Santos (both in the municipality of Lucena, Paraíba, Brazil), and Z-06 Arnaldo Luz (in the municipality of Bayeux, Paraíba, Brazil). All three colonies are situated around the Paraíba River estuary (Fig. 1), which is located in the northeastern Brazil (coordinates: 34°50'00"S to 34°57'30"S and 6°55'00"W to 7°7'30"W). The estuary is formed by the Paraíba River and its tributaries (Sanhauá, Paroeira, Mandacaru, Tibiri, Tambiá, Ribeira, and Guia Rivers), encompassing an area of approximately 260 km2 (Moura et al. 2019). The estuary has typical characteristics of a river with medium discharge that enables the formation of small sandbars (Macêdo et al. 2019). Its margin is lined with a mangrove forest, but with areas where the features have been altered, and the estuary is surrounded by extensive sugarcane plantations, shrimp farms, a port (Cabedelo), and a metropolitan region comprises of five municipalities (Bayeux, Santa Rita, Cabedelo, Lucena, and João Pessoa), which together have more than one million residents (Macêdo et al. 2019).

Figure 1. Paraíba River estuary with indications of Z-5 and Z-19 fishing colonies, in the municipality of Lucena, and Z-6 community in the municipality of Bayeux, Paraíba State, northeastern Brazil.



Procedures

Among the 14 fishing colonies on the coast of the Paraíba State (Paulo Júnior et al. 2012), three of them were selected for the present study, one upstream and two downstream of Paraíba River estuary. Between January and December of 2017, questionnaires with closed-ended and open-ended questions addressing socio-economic aspects and the fishing activity (modified from Oliveira et al. 2009) were administered in interview format to fishermen of these colonies whose interest was directed at the capture of fishes in the estuarine region.

Many residents in the selected communities live in substandard conditions and most perform informal fishing activity – whether for the purpose of subsistence or to sell the catch as a means of survival and to complement their variable income, investigating such facts motivated this study. Specifically, we focus on interviewing fishermen from the bordering communities upstream and downstream of the Paraíba River in the municipalities of Bayeux and Lucena, respectively. After formal contact with the presidents of the Z-6 community in Bayeux and the Z-5 and Z-19 colonies in Lucena, data collection was performed with the artisanal fishermen through scheduled visits. This study received approval from the institutional review board of *Universidade Estadual da Paraíba* (UEPB) under process number: 67238517.4.0000.5187.

Data collected through interviews

Identification charts were used to collect the following data from the fishermen: complete name, age, schooling, income, birthplace, and number of people in the nuclear family. The answers were categorized and grouped into similar expressions in order to establish a percentage representation.

Next, questionnaires were administered with items divided into two groups: A) questions on fish fauna and B) questions on environmental issues. Group A consisted of the following subgroups of questions: 1) most common fish species in the region; 2) how the fishermen learned their trade; 3) knowledge on the degree of relatedness among the known fishes; 4) closed fishing season; 5) feeding; 6) predators and prey items of fishes; 7) reproduction; 8) spatiotemporal distribution of most common species and target species (for consumption or sale); and 9) list of species with color photographs and scientific names of fishes commonly occurring in the estuary (Dolbeth et al. 2016). Group B contained the following subgroups of questions: 1) degree of pollution in the region; 2) main polluting agents; 3) how pollution affects the human population and fishes; 4) influence of abiotic factors on fishing activity; and 5) knowledge regarding legislation (laws and rights). Whenever possible, the information obtained with the questionnaires contained vernacular of the community in order to register the profile of the artisanal fishermen and their traditional knowledge regarding the fishes.

Treatment of data

The information obtained through the discourse of the interviewees was submitted to qualitative and interpretive analyses to obtain information on the socio-economic profile and environmental knowledge of the fishermen. Each category was plotted in a table divided into a socio-economic questionnaire (closed-ended questions) and questionnaire addressing fishing activity (closed-ended and open-ended questions). For the socio-economic questionnaire, categories with an affirmative answer were attributed the number 1 and those with a negative answer were attributed the number

0. These data were expressed as absolute and/or relative frequency. For the questionnaire addressing fishing activity, the answers were compiled into categories according to the perceptions of the fishermen. Whenever possible, ethnoecological knowledge was compared to scientific knowledge. A linear correlation between the catches of the most common fishes (independent variable) and the sale of target species (response variable) was applied to the data obtained from the interviews using the R statistical software.

Results

Socio-economic profile of fishermen

A total of 44 members of the three fishing colonies were interviewed, ten of whom were women. These 22.72% interviewed were fisherwomen working in all stages of the fishing chain, including family consumption or business, as well as men, without distinction of tasks between genders.

Based on the data obtained on the socio-economic profile of these men and women (Table 1), most were between 41 and 60 years of age (54.54%); artisanal fishing was performed mainly by fishermen with more than 20 years in the profession; only three of the interviewees (6.82%) had more than 50 years of experience with artisanal fishing, and a low number of individuals less than 18 years of age was found exercising the practice of fishing (2.27%). With regards to schooling, 13.64% of the interviewees were illiterate and 50.00% had schooling between the 5th and 8th grade, of these most with incomplete elementary school (Table 1). As a rule, the nuclear family was composed of a union not officialized by a church or registry office (40.91%), but with the division of the financial responsibilities related to the maintenance of the home and children of these informal unions (Table 1). The income of the fishermen was very low, as nearly all the interviewees (90.90%) reported having an income corresponding to less than the Brazilian minimum monthly wage, with a maximum ceiling of R$ 1.000,00 per month (Table 1). A large portion of the fishermen (38.64%) worked an average of five or six days per week and 27.27% went out on the ocean every day, depending on the climate (Table 1).

Table 1. Socio-economic profile of artisanal fishermen of the Paraíba River estuary, Paraíba, Brazil. RF = relative frequency.

Variables	Categories	n	RF (%)
Age classes	<18	1	2.27
	18-20	1	2.27
	21-30	5	11.36
	31-40	8	18.18
	41-50	14	31.82
	51-60	10	22.73
	>60	5	11.36

Variables	Categories	n	RF (%)
Fishing time	<10	8	18.18
	11-20	10	22.73
	21-30	9	20.45
	31-40	10	22.73
	41-50	4	9.09
	>50	3	6.82
Education	Primary school	12	27.27
	Middle school	22	50.00
	High school	4	9.09
	Undergraduate studies	0	
	Never attended	6	13.64
Marital status	Not married	12	27.27
	Married	13	29.55
	Lives together	18	40.91
	Divorced	1	2.27
	Widower	0	
Gross income from fishing	Up to R$500,00	25	56.82
	R$501,00-R$1000,00	15	34.09
	Above R$1000,00	4	9.09
Fishing days per week	1 or 2 days	1	2.27
	3 or 4 days	14	31.82
	5 or 6 days	17	38.64
	Every day	12	27.27

Fishing activities in the communities

The predominant site for fishing activities was the mangrove (43.48%), followed by the coastal area between the beach and reefs (34.78%) (Table 2), independent of whether the fishing community was located upstream or downstream in the estuary. These regions are called "fishing spots" due to the easier access of the fishermen and the greater occurrence of fishes. Regarding watercraft, 57.45% uses small boats with an outboard motor and 29.79% used rowboats, both made of wood (Table 2); these were the two main means of locomotion to perform artisanal fishing. Most of the interviewees (53.49%) own their own boats (Table 2) and therefore obtain a higher profit in comparison to those

who work on boats belonging to third parties or in partnership, where the boat owner keeps half of the production.

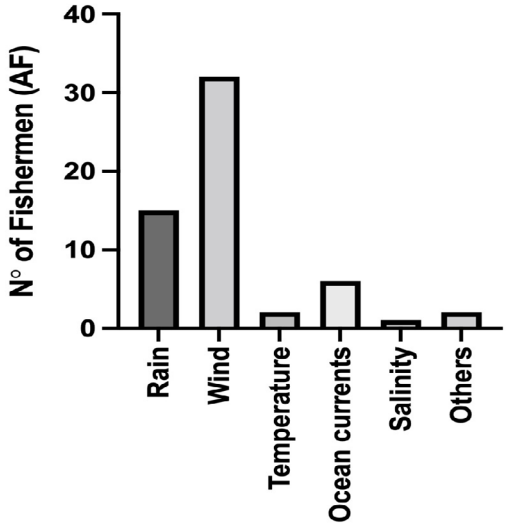
The gear most frequently used involve various types of nets with singular uses, especially gill nets, which are generally deployed by a team of two fishermen per boat. There were also records of the use of traps, such as the *tomada*, which is deployed only a few days per month, consisting of a trap made with nets, often from several fishermen through a previous agreement, which are deployed at low tide and raised on stakes removed from the mangrove, and product of the catch is usually shared among the fishermen who participated in the fishery. This practice is performed in such a way that the owners of larger nets are the first to harvest fishes and those who do not own a net only have access to the remaining fishes, receiving what is locally called the *mistura*, which has no commercial value and is used for family consumption.

Table 2. Characteristics of activity of artisanal fishermen of Paraíba River estuary, Paraíba, Brazil. RF = relative frequency.

Variables	Categories	n	RF (%)
Fishing location	In the mangroves	20	43.48
	Between reefs and beaches	16	34.78
	After the reefs	1	2.17
	At sea	9	19.57
Type of vessel	Motor	27	57.45
	Candle	5	10.64
	Rowing	14	29.78
	Baitera	1	2.13
Boat	Own	23	53.49
	Partnership	7	16.28
	Third parties	13	30.23

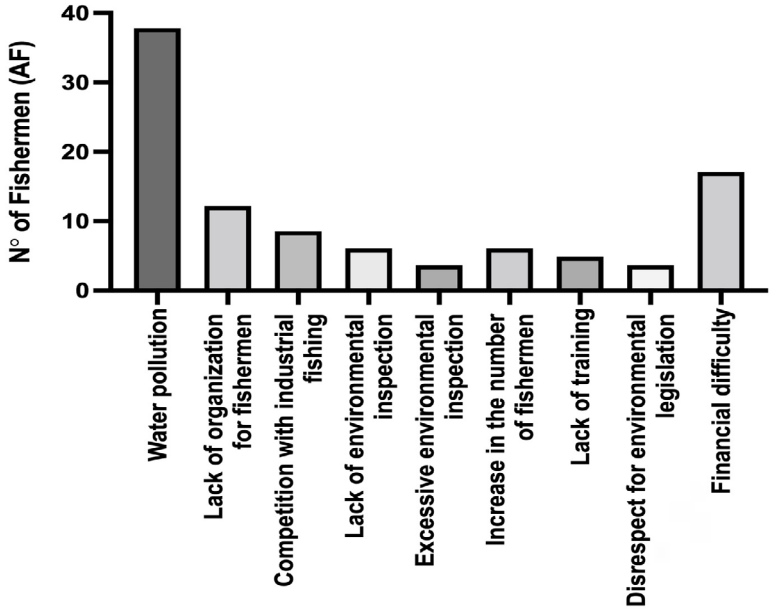
According to the interviewees, fishing is more favorable in the dry season. When asked about what environmental aspects exert a negative impact on the quantity of fish caught, the wind was the most recurrent answer, mainly affecting small boats, as the sea becomes "more agitated". Rain and ocean currents were also mentioned (Fig. 2) and when asked how water temperature affects the quantity of the catch, the majority (n = 27; 61.36%) of the fishermen reported that "it is harder to find fish" when the water is still cold, whereas fishes appear with greater frequency and, therefore, the catch is larger on days when the water is warmer.

Figure 2. Abiotic factors that exert the greatest negative impact on fisheries in the perception of fishermen (n=44) of the Paraíba River estuary, Paraíba, Brazil. AF = Absolute frequency.



Regarding the pollution in the estuary and adjacent marine water, twenty-eight fishermen (63.64%) reported finding solid waste of the most varied types in their nets. Plastic bottles, plastic bags, a refrigerator door, tires, and even a wheelbarrow were cited as examples. In addition to water pollution, there are other difficulties associated with fishing activity, but the interviewees also highlighted the lack of organization and union on the part of the fishermen and the lack of financial resources to invest in improving nets and boats (Fig. 3).

Figure 3. Main difficulties for fishing according to artisanal fishermen (n=44) of Paraíba River estuary, Paraíba, Brazil. AF = Absolute frequency.



Knowledge about taxonomy, feeding behavior, and reproductive behavior of fishes

As a contribution to folk taxonomy, we recorded the common names of the fishes caught by the interviewees (Table 3), the identification of which was confirmed visually during the interviews through spreadsheets prepared with pictures of the fish.

Table 3. Fish species and their local names used by artisanal fishermen from the Paraíba River estuary, Paraíba, Brazil.

Family	Species	Local name
Atherinopsidae	*Atherinella brasiliensis* (Quoy & Gaimard, 1825)	Manjuba verde / Peixe rei
Belonidae	*Strongylura marina* (Walbaum, 1792)	Agulha preta / Lambaio / Agulhão
Hemiramphidae	*Hyporhamphus roberti* (Valenciennes, 1847)	Agulha / Agulhinha
Clupeidae	*Opisthonema oglinum* (Lesueur, 1818)	Sardinha azul
Engraulidae	*Anchovia clupeoides* (Swainson, 1839)	Sardinha branca / Sauna
Mugilidae	*Mugil curema* Valenciennes, 1836	Tainha
	Mugil liza Valenciennes, 1836	Tainha
Carangidae	*Caranx latus* Agassiz, 1831	Xarel
	Oligoplites palometa (Cuvier, 1832)	Tibiro
	Selene vomer (Linnaeus, 1758)	Galo
Centropomidae	*Centropomus undecimalis* (Bloch, 1792)	Camurim
Ephippidae	*Chaetodipterus faber* (Broussonet, 1782)	Parú
Gerreidae	*Diapterus rhombeus* (Cuvier, 1829)	Carapeba / Carapicu
	Eugerres brasilianus (Cuvier, 1830)	Carapeba / Carapicu
Gobiidae	*Bathygobius soporator* (Valenciennes, 1837)	Amoré
	Gobionellus oceanicus (Pallas, 1770)	Taissica
Lutjanidae	*Lutjanus jocu* (Bloch & Schneider, 1801)	Vermelho / Ariacó / Dentão
Sciaenidae	*Micropogonias furnieri* (Desmarest, 1823)	Boca mole
Achiridae	*Achirus lineatus* (Linnaeus, 1758)	Tapa
	Trinectes paulistanus (Miranda Ribeiro, 1915)	Soia
Ariidae	*Cathorops spixii* (Agassiz, 1829)	Bagre amarelo/ Bagre de fita
	Sciades herzbergii (Bloch, 1794)	Bagre branco / Bagre camboeiro
Diodontidae	*Chilomycterus spinosus spinosus* (Linnaeus, 1758)	Baiacu de espinhos / Espeto
Tetraodontidae	*Colomesus psittacus* (Bloch & Schneider, 1801)	Camisa de meia
	Lagocephalus laevigatus (Linnaeus, 1766)	Camisa de meia
	Sphoeroides greeleyi Gilbert, 1900	Baiacu pintado / Pintadinho
	Sphoeroides spengleri (Bloch, 1785)	Baiacu caixão
	Sphoeroides testudineus (Linnaeus, 1758)	Baiacu pintado / Pintadinho

The answers given by fishermen about the degree of relatedness among the fishes enabled grouping the species listed by the fishermen in 11 different families, which was confirmed by the taxonomic classification of the fish listed below (Table 4).

Table 4. Ethno-families: Morphological association of fishes made by artisanal fishermen of Paraíba River estuary, Paraíba, Brazil.

Family	Cited fish (local name)	Relatedness among the fishes*
Mugilidae	Tainha, Tainhota, Tamatarana, Sauna and Curimã	Positive
Carangidae	Xaréu and Garacimbora	Positive
Ginglymostomatidae	Lixa and Cação	Positive
Gerreidae	Carapicu and Carapeba	Positive
Belonidae/Hemiramphidae	Agulhão and Agulha	Negative
Clupeidae	Sardinha azul and Sardinha rabo de fogo**	Positive
Sciaenidae	Pescada branca, Pescada de dente, Pescada amarela, Corvina and Focinhuda	Positive
Centropomidae	Camurim and Camurupim	Negative
Tetraodontidae	Baiacu pintado, Baiacu de caixão and Baiacu de espinho	Positive
Gobiidae	Taissica and Mororó**	Positive
Ariidae	Bagre branco and Bagre amarelo	Positive

*Froesy and Pauly (2020). ** Local name of species belonging to the family that were associated during interviews.

The interviewees also recognized important behavior regarding the feeding habits of the fishes (Table 5).

Table 5. Feeding habits of fishes according to the perception of artisanal fishermen of Paraíba River estuary, Paraíba, Brazil.

Main answers	Emic categories	Most cited fish (Local name)	Scientific correspondence*
Fish that feed on shrimp	Carnivorous	Cavala, Serra, Dorminhoco, Parú, Baiacú, Ariacó, Chicharro	Yes
Fish that eat silt	Iliophagous	Tainha, Curimã	Yes
Fish that eat everything	Opportunist	Sardinha, Bagre	Yes
Fish that feed on other fish	Piscivorous	Camurim, Camurupim	Yes

*Froesy and Pauly (2020).

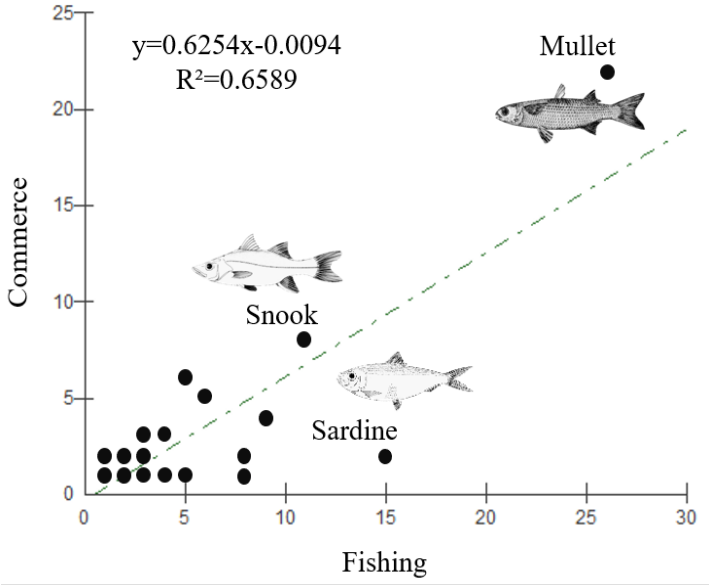
Regarding reproductive behavior, the fishermen were less emphatic in comparison to their reports of feeding habits, revealing less mastery over this aspect. In terms of the reproduction sites of the target fishes, 40.91% of the interviewees were unable to answer and the others gave non-specific answers, such as "in the headwaters of the river", "in the open sea", "under rocks", and "in tidal creeks". When asked about their knowledge of the parental care of the species, the catfish was the most cited: "The catfish holds its eggs in the mouth".

Fishes: catch, consume and sales

When asked about what individuals are easiest to catch, the fishermen reported fishes with gregarious habits that occur in large schools, which, despite the lower commercial value, ensure profits due to the quantity and constancy of the catches, catches such as mullet and sardine. Likewise, the catches that were easiest to sell were those with greater aggregate value and abundance such as the mullets and snooks in estuaries.

The regression between the species caught and those sold was moderate (66%) and positive, such that an increase in sales is expected when there is an increase in the mullet and snook caught. A cluster of fishes with low commercial values was found near the origin of the axes, highlighting the sardines, with many fishermen catching these species and selling them locally or using them for their own consumption (Fig. 4), as informed in the interviews.

Figure 4. Regression between target species caught and those sold according to artisanal fishermen of Paraíba River estuary, Paraíba, Brazil.



Another aspect that stands out is the considerable capture of catfishes but with no sales and even no consumption of this fish by the local community, as it is reported to be a "loaded fish". This taboo is fueled by the popular belief that scaleless fish have a strong flavor, are fatty, and provoke inflammation in individuals with injuries or debilitated health and the fact that catfishes also have generalist habits, feeding on mud and hunting in a non-selective manner.

A large part of the interviewees fish for the purpose of selling the catch. However, due to a lack of freezers, they either sell the catch to intermediates, known as "middlemen", or sell the specimens at street markets, near their places of residence due to the lack of an adequate storage place for the product. The fishing colonies of which these individuals are members could do actions such as the acquisition of freezers and accords with restaurant owners and fish markets to obtain a cooperation favorable to both parties.

Laws and rights

When asked about their knowledge regarding their rights as fishermen and members of the fishing community, only 20.45% reported being unaware of any type of right that they might have through their profession and as members of the fishing community (Table 6).

Regarding laws related to fishing activity and environmental protection, only half (50.00%) of the interviewees reported having some knowledge about legislation and laws on environmental preservation (Table 6). Examples cited by the fishermen were defense periods, mesh sizes of the nets, the prohibition of blocking the channels of rivers with fishing nets, the ban on hunting whales, and prohibition of contact with manatees.

Table 6. Knowledge of fishermen (n=44) regarding laws that affect the profession and their rights as artisanal fishermen and members of fishing colonies of Paraíba River estuary, Paraíba, Brazil.

Variables	Answers				Main answers
	No		Yes		
	(n)	(%)	(n)	(%)	
Knowledge about the laws that involve fishing	22	50.00	22	50.00	Environmental preservation laws, ban on whale hunting, closed season, network mesh size, ban on interruption of river channels, regularized fishing license
Knowledge about rights as an artisanal fisherman	9	20.45	35	79.55	SEAPE portfolio, pension, loan, courses, health assistance

Discussion

Socio-economic conditions among the artisanal fishermen

Artisanal fishermen communities are often inserted in scenarios with multiple socio-economic problems that affect fishermen and their families. The current context of artisanal fishing forces the entire family to participate in the activity, either directly or indirectly. This is reflected in the fact that more than 20% of those interviewed here were women, she works in the entire fishing production chain. The predominance of male fishing, reflects a model of social organization and sexual division of labor, continually reproduced in society as a whole (Maruyama et al. 2018; Araújo and Parente 2016; Zacardi et al. 2017). Even though most fishermen were men, our results point to a growth in female participation in this scenario and the important role of women in it. The fact that 10 of the 44

interviewees are women points to the pursuit of the activity as a source of income also by women. In any case, they practice fishing regularly and, like men, they work in the entire fishing trade chain, in the artisanal case. In turn, men describe that their children and wives also indirectly help in making and repairing nets, as well as cleaning and selling fish, the same was reported by Araújo and Parente (2016) in Tocantins, TO and Alencar et al. (2015) in the Amazon. But here, women effectively lead the process of fishing in the estuary in search of family support.

According to Carvalho et al. (2020), the diversity of catches exploited by women – whether for sales or personal consumption – demonstrates the importance of these resources to the subsistence of these women and their families. Thus, records such as the present study are of considerable importance, confirming that the female element of fishing represents a source of income and food in these communities.

Studies like those of Vasconcelos et al. (2003) in the Rio Grande do Norte State and Soares and Marques (2017) in the Piauí State, both in northeastern Brazil, offer data that are compatible with the artisanal fishing situation found in the Paraíba River estuary. The activity is transmitted to younger individuals, who see fishing as a financial complement to their work activities and/or assistance to the subsistence of the family. Fishermen more than 40 years of age often give up the trade only with the advance of age, when they are less physically capable of exercising the profession, which requires considerable effort.

The low schooling observed in this study reflects the lack of opportunities in childhood to dedicate themselves to their studies. This lack of governmental incentives to keep studying and the need to work early in life to contribute to the family income are the main factors associated with abandoning the classroom on the part of artisanal fishermen (Alencar and Maia 2011), as recorded in the present investigation. The high rate of incomplete primary school education reflects a national pattern in this category of fishermen, ranging from 71.5% in the southeastern region of the country to 82.8% in the northeastern region (Alencar and Maia 2011).

In contrast, only one fisherman under 18 years of age was interviewed, leading us to believe that this scenario tends to change, and future fishermen may have a higher degree of schooling. This may be attributed to the increase in the number of public schools over the years, which has facilitated access to an education and information among young people today compared to the past (Vasconcelos et al. 2003). There may have been a growing awareness on the part of fishermen regarding the education of their children and the need to keep them away from child labor by encouraging them to attend school or yet to have been a concern for the younger generation to conclude their studies and become qualified for the job market, as the fishermen do not see fishing work as promising, especially due to the difficulties inherent to the trade and the low pay involved.

In turn, the fact that these men and women work almost every day and have lower incomes than the monthly minimum wage reveals a scenario of poverty and substandard living conditions among families along the coast of the Paraíba State involved in subsistence artisanal fishing.

Impacts on the fishing activity

The sites where the fishermen reported performing their activities were areas of the mangrove with favorable environmental conditions and greater occurrence of fishes – whether residents or species that regularly make use of this ecosystem during migrations through the estuarine environment for

the purposes of feeding and reproduction (Potter et al. 2015). Another site was the area between the beach and reefs, which is favorable due to the concentration of species of greater commercial value (Silva et al. 2013), which are often aggregated in schools.

Regarding the materials used in fishing in the Paraíba River estuary, boats are extremely important to the fishing activity not only for locomotion but also in the execution of the activity, along with the gear and techniques employed by the fishermen. The equipment, especially the nets and the techniques used when fishing are based on the knowledge of the ecology of the environment that fishermen have empirically accumulated over generations. The knowledge about the "fishing spots" added to the various ways of using the net, whether for trawling or setting traps, leads to a system for catching a large amount of fish.

Historically, the product of the *tomada* practice, the fish selection of which is based only on local physiography knowledge and mesh size, as described by Martins and Vendel (2014) is shared among the fishermen in the estuary, which reveals the hierarchy between the most experienced and their apprentices. Such traps have local variations, such as *tapagem* in the Maranhão State, Brazil (Diniz et al. 2020) and chicocota in Mozambique (Darkey and Turatsinze 2014), but share a non-selective characteristic that leads to the capture of juveniles, which constitutes a threat to the health of the estuarine ecosystem.

Regarding climatic conditions that affect fishing, temperature, wind, and rain certainly exert an influence. Rain makes the water more turbid, which hinders the sighting of fishes and ocean currents tend to change the position of both the fishes and deployed gear. Indeed, the fishermen correctly describe weather conditions, classifying them as favorable or unfavorable to their activity. They state that fishing is better in the dry season, when there is less rainfall, the winds are calmer, and the ocean currents are milder. Saldanha et al. (2020) report that weather conditions exert a considerable influence on fishing activity, especially artisanal fishing, and can, at times, impede the execution of the activity.

Among the different factors cited as harmful to fishing, the pollution reported by the fishermen reveals the local impacts on the mangroves, sandbanks, and beaches. The destruction of these habitats affects the quantity of fishes available as well as the quality of the product that is caught and sold. Pollution in the form of solid waste and chemical products has severe impacts (Rajmohan et al. 2019).

Degraded habitats can lose their key roles in the maintenance of populations of aquatic organisms. Fishes use mangroves and reefs as nurseries due to the abundant food sources and shelter offered for growth and reproduction. These ecosystems are also fundamental to maintaining connectivity with adjacent habitats (Hillman et al. 2018).

Pollution exerts a negative impact on the natural capacity of ecosystems to remain productive. The strong human impact on the coastal region of the Paraíba State is associated with factors such as the discard of domestic and industrial contaminants without prior treatment, shrimp farming, and large sugarcane plantations (Macêdo et al. 2019). Vendel et al. (2017) attribute the high impact on this estuary to the considerable pressure from local urbanization as well as pollution stemming from the plantation and processing of sugarcane and shrimp farming, which are human activities that are known to have a huge impact in the region. After interviewing artisanal fishermen in the same estuary, Silva et al. (2011) described urban trash, the lack of basic sanitation, and the indiscriminate use of pesticides and chemical products on sugarcane plantations and in the control of predation in shrimp farm tanks as major contributors to the degradation of local environmental quality and the reduction in the productivity of crab and mollusk collectors in the Paraíba River estuary.

Broad ethnoichthyology knowledge of artisanal fishermen

Social perceptions are organized hierarchical sets of judgments, attitudes, and information that a given social group has about a particular topic (Mathé and Rey-Valette 2015). Increasing value has been placed on information from popular classification together with the biological classification, as the combination of this knowledge broadens our understanding about species (Oliveira et al. 2009). The names fish species used by the fishermen are monomial generic terms. When the fishermen give more than one name to a species, the second name generally refers to an apparent morphological trait of the fish, such a coloration or spot patterns for example: "Baiacu pintado" (spotted pufferfish), revealing the detailed knowledge the fishermen have on the resources they use and a distinctive cataloging of these resources, which is important to communication among them.

The main criteria that fishermen use to justify the grouping of species were aspects such as morphology, diet, and habitat. In the comparison of folk taxonomy and the scientific taxonomic classification made here, a positive correspondence was found in terms of family, genus, and species, such as in the case of *tainha* (Mugil spp.), which the fishermen described as being related to the *curimã*, both of which are representatives of the family Mugilidae. Other species also reported as being "related" were the *tainha* (mullet) and *saúna*, the latter of which is actually a smaller stage of mullet, which demonstrates ethological differentiation in the ontogeny of the fish. In contrast, other species indicated as "related", such as the *agulhão* (needlefish, *Strongylura timucu*) and the *agulhinha* or *agulha* (slender halfbeak, *Hyporhamphus roberti*) do not belong to the same family. *S. timucu* belongs to the family Belonidae and *H. roberti* belongs to the family Hemiramphidae, although the two species have very similar habits and morphology, which the fishermen recognize and considered when giving them similar names (see Table 4, where the species are maintained together).

In general, species with similar morphological features but characteristics that separate them from other species were classified on the same taxonomic level as "related". In scientific taxonomy, morphological traits, such as coloration, body shape, head shape, and size of the individual, are used in identification of species. In a similar way, ethno-taxonomic investigations using morphology as a criterion of folk taxonomy, are explained by Mourão and Nordi (2002) in the estuary of the Mamanguape River (Paraíba, Brazil) and Ramires et al. (2012a) on Ilhabela (São Paulo, Brazil), and demonstrate the importance of morphological details, such as coloration, body shape, size of the individual, and type of fins, to identify, name, and classify fishes, placing them into a particular category.

Regarding the feeding habits of the fishes used for the grouping of species in each emic category, the mullet (common name that encompasses a species complex of the family Mugilidae) was cited as having iliophagous habit, translated into the words of the fishermen as "mullets eat silt and mud". Other observations on feeding habits were recorded: "snooks eat mullet bait", reporting the carnivorous habit of this fish when preying on the offspring of the herbivore: "sardines eat godoia", term that in the popular jargon means "everything that is no good", reporting on the generalist habit of the species; this description was also used for catfishes.

Therefore, our results demonstrate that artisanal fishermen have broad knowledge on the environment and the target species. This knowledge can be used as an important tool for the formulation and application of environmental policies, as well as in the management of priority conservation areas. In addition, these data can improve communication between researchers, government and the fishing community by helping to understand the language used by fishermen. A good understanding between these agents can culminate in the appropriate execution of conservation strategies, such as the closed season for

species. Therefore, these applicability of the traditional knowledge of fishermen reveal its potential and importance for multiple socio-environmental segments.

The features of catching and selling fish

The mullet stands out in the regression between the species the fishermen report catching and those they state are best for selling. This is wholly justified, as mullets constitute a traditional resource widely sold along the coast of Brazil and account for a large portion of coastal production in the states of Pará, Paraíba, Santa Catarina, and Rio Grande do Sul (MPA-MMA 2015). Curiously, there were no reports of local fishing for some target species that are defined due to their high commercial demand, such cartilaginous fishes (rays and sharks) and ray-finned fishes (as Carangidae for example). This seems to be due to the fact that we prioritized fishermen who work in the estuary and these fishes occur in the coastal region.

The ineffective understanding of laws and rights

Most fishermen interviewed reported having knowledge of some rights related to the craft of artisanal fishing. Rights such as social security, health assistance, greater ease in obtaining bank loans and, especially, insurance offered for the defense of crabs and lobsters for those whose registration with the Special Secretary of Aquaculture and Fishing is up to date, were commonly cited. The latter occurs during the closed season, which is supported by Law No. 10.779, of November 25, 2003 and regulated by Decree No. 8424, of March 31, 2015, where it offers a monetary value to ensure the well-being and survival of fishermen during closed season, when occurs the breeding periods of crabs and lobsters.

Regarding the laws that deal with the environment, fishermen know that there are guidelines aimed at environmental preservation, which involve network mesh, prohibition of interruption of river channels, etc., but they do not know that these and many other issues are described in law No. 9,605/1998, which provides for forms of predatory fishing that constitute a crime, the fishing of specimens with sizes smaller than those allowed, in a quantity greater than that allowed or through the use of equipment, gear, techniques and methods that are not allowed. That may pose risks to the permanence and maintenance of species in the environment.

Although the fishermen had some knowledge about issues related to the rights and duties linked to artisanal fishing, and about the biological and environmental interactions related to fishing, what is noticeable is that many of them has intuitive knowledge or based on information explained by the colony leaders and passed on by word of mouth, but with no real basis on the laws and what is contained in each of them, and that there is little knowledge about their rights legal as artisanal fishermen.

This underscores the importance of studies like this, that seek to hear the fishing community, determine their knowledge and needs, counsel those involved, and clarify the social, environmental, economic, territorial, political, and cultural rights that they can exercise as artisanal fishermen. In a practical manner, Darkey and Turatsinze (2014) suggest that interested parties – such as the fishing colonies in the present study – make use of locally available instruments, such as radio programs and other mass communication resources directed at sensitizing the general population and, particularly, the fishing community regarding the need to know and comply with the laws and regulations that govern the fishing sector for the benefit of everyone. After all, local knowledge is a dynamic, adaptive

process that can easily change according to different needs and situations and the community of artisanal fishermen plays a role in which it runs the risk – whether aware of it or not – of violating several laws.

Conclusion

Artisanal fishing is an important economic activity for the population around the Paraíba River estuary, which fish in a coastal zone. In fishing colonies Z-5, Z-19 (downstream), and Z-6 (upstream), there is a predominance of fishermen over 40 years of age with more than 20 years of fishing experience; the majority work five to six days per weeks, depending on the climatic conditions, and have an average income lower than the Brazilian monthly minimum wage. This is a socio-economically worrisome scenario that reflects the low quality of living of these communities. Knowledge on the feeding habits of fish species and the effect of abiotic factors, such as the wind, temperature, tide, and lunar phase, assists in gaining a better understanding of fishing dynamics and provides information that can be tested scientifically. The fishermen are aware that local pollution has contributed to a reduction in catches and that many target species of the informal trade have not been accessed as a consequence of this pollution. Half of the fishermen interviewed revealed having some knowledge of the laws and rights that the fishing trade ensures, but do not effectively understand their rights or put them into practice with the administration of the fishing colonies of which they are members. Thus, there is a clear need for educational efforts on the part of the government regarding the preservation of resources as well as the valuing of the rights that fishermen have as members of fishing colonies, with periodic qualification offered to the community. Such encounters – mediated by fishing colonies – should ensure adequate reception, instruction, the exchange of experiences, and union, as there is a general lack of access to information in these communities. Evaluating the traditional knowledge of artisanal fishermen, who suffer directly from human impacts, should be regularly considered in environmental education actions and measures. It is necessary to offer support to these communities with the implementation of qualification measures, the acquisition of resources, and, especially, the maintenance of their traditional knowledge.

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