

## **Mollusk Gatherers in a Tropical Urban Estuary: Fishing Activities and Environmental Perceptions**

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**Abstract:** *Considering that traditional ecological knowledge (TEK) perpetuates even with urban pressures, the present study aim to investigate the social, ecological and economic aspects of the fishing activities and environmental perceptions of mollusk gatherers in the community of Brasília Teimosa, northeastern Brazil. Using semi-structured interviews and the snow-ball method, 35 mollusk gatherers were interviewed between February 2006 and May 2008, where 82.9% of whom were female. The exploited resources were the *Anomalocardia flexuosa*, *Mytella charruana*, *M. bicolor*, *Crassostrea* and *Tagelus plebeius*. With regard to environmental perceptions, the mollusk gatherers report a reduction in productivity due to recurring problems of pollution from solid waste and sewage in urban areas as well as the introduction of the a new mussel *Mytilopsis leucophaeta*. Despite experiencing the pressures and impacts inherent to urban areas, the fishing community maintains its own intrinsic characteristics, such as the transmission of traditional family knowledge.*

**Keywords** - *Artisanal fisheries, mollusk gathering, northeastern Brazil, traditional knowledge.*

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### **I. INTRODUCTION**

The coast of Brazil is densely populated, very dynamic and exhibits considerable socio-biologic complexity. Coastal areas are marked by the presence of mangroves and estuaries under the influence of the Atlantic Rainforest and constitute ecosystems classified as “hotspots” [1]. These environments play an important role in both flora and fauna biodiversity and serve to generate income and fulfill the protein needs of different populations [2] that survive on tourism activities, small-scale farming and artisanal fishing activities [3].

Estuary-mangrove complexes allow the exchange of sediments, nutrients, water and organic matter between marine and freshwater environments and act as permanent or temporary shelters for numerous species of fish, crustaceans and mollusks. Estuary systems are considered areas of free access to fishing activities [4, 5, 6] and exhibit different traditional fishing practices depending on the biological and social diversity of each location. In the state of Pernambuco (northeastern Brazil), these ecosystems offer a huge availability of food sources and accentuated primary production, making them areas with a high degree of biodiversity [7] and intensive fishing activities.

Bivalve mollusks make up part of the wealth of estuary environments and have both ecological and socioeconomic value [8]. Mollusks stand out for their high degree of diversity and numeric dominance. These organisms are a major source of income and food for coastal communities and have marked their presence in religious rites, folk medicine and the production of craftwork, jewelry and decorative items for construction purposes [9, 10, 11, 12, 13, 14, 15, 16].

Despite transformations in the landscape, society and economy in northeastern Brazil, mollusk gathering has continued through to the present day [17]. However, the increase in anthropogenic pressure on coastal resources and the growing demands for protein sources have led to a reduction in mollusk stocks over the years [18]. Thus, the management of coastal waters has become a priority in the country due to the importance of artisanal fishing activities as a source of food for the population and the large number of small-scale fishers operating along the coast [19]. The ecological basis of the human interactions of these fishers with the coastal environment has made considerable contributions to modern science, allowing the identification and assessment of the effects these communities on nature and vice versa [20].

Artisanal fishing activities constitute an important tool for the maintenance of cultural diversity. Small-scale fishers and gatherers in coastal, river, lake and reservoir environments throughout Brazil have ample knowledge regarding the biotic and abiotic components of these ecosystems [21, 22]. The use of traditional ecological knowledge has produced alternatives to current paradigms [23, 24, 25] and has proven extremely

important to the natural sciences, promoting cultural diversity as a basis for the management and recovery of ecosystems [26, 27]. Such knowledge has also contributed information for environmental management and conservation based on social realities [28, 29, 30].

Considering that traditional ecological knowledge (TEK) perpetuates even with urban pressures the aim of the present study was to characterize social, ecological and economic aspects of the fishing activities and environmental perceptions of mollusk gatherers in the traditional urban community of Brasília Teimosa in the city of Recife (northeastern Brazil), considering the importance of such knowledge to the management and conservation of coastal waters.

## II. MATERIALS AND METHODS

### 2.1 STUDY AREA

The Pina Basin (08°04'39" S and 34°52'57" W) is located on the coast of the state of Pernambuco (northeastern Brazil). This estuary-mangrove complex is situated in the interior portion of the port of Recife and measures approximately 3.60 km in length, with widths ranging from 0.26 km to 0.86 km (total area: 2.02 km<sup>2</sup>). The basin is bordered by urban constructions to the north and south, the Atlantic Ocean (with a reef system serving as a natural dike) to the east and the confluence of its rivers of origin (Tejipió, Jordão, Jiquiá, Pina and Capibaribe) to the east [31] (Fig. 1).

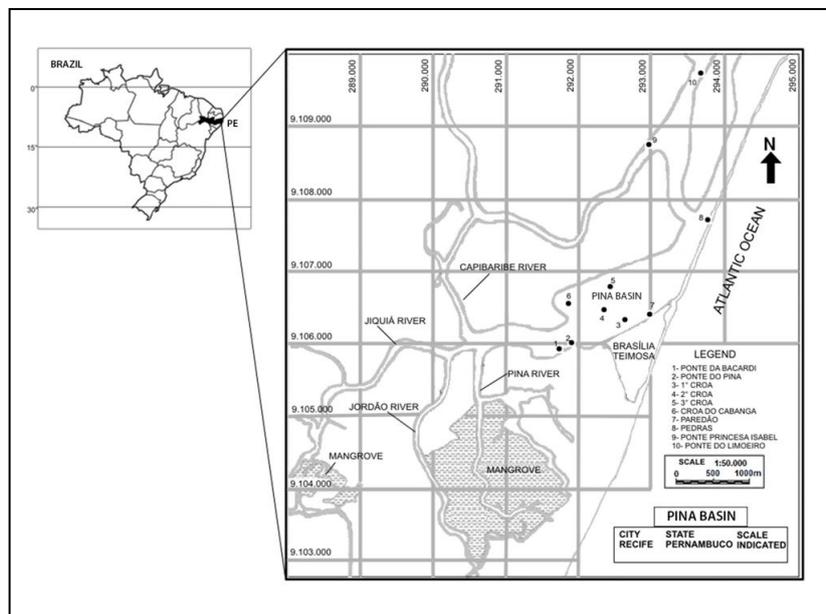


FIGURE1 – Study area showing the gathering locations in Pina Basin, Recife, Pernambuco, Brazil.

This estuary-mangrove complex serves as a tourist attraction for the city of Recife as well as feeding and resting grounds for a number of migratory birds. It has intensive fishing activities, with catches performed using nets, beach seines, line and traps, as well as the gathering of crabs and mollusks of commercial value [7, 31, 32, 33].

The community studied resides in the neighborhood of Brasília Teimosa, on a triangular peninsula parallel to the coast measuring 50 ha. This neighborhood is the oldest area of originally unregulated urban occupation (invasion) in the city of Recife [34]. It has since gained status as a Special Social Interest Zone under Brazilian law 9.785/99 [35], which regulates land use and occupation. This title is awarded to low-income communities, with low levels of schooling, little access to urban facilities and considerable exposure to violence, drugs and prostitution [35].

### 2.2 PROCEDURES

Contact was first established through rapport with an experienced local fisher [36], which facilitated communication with other fishers and the determination of fishing sites. From February 2006 to May 2008, open-ended interviews, followed by semi-structured interviews [37], were held with prior consent from the interviewees (process number: 0054.0.097.000-06, Human Research Ethics Committee, University of Pernambuco). The snow-ball method was also applied [38], in which one interviewee indicates another, thereby expanding the sample. Interviews were also held during accompaniments to the gathering sites, during guided

tours [39] and when fishers were encountered by chance gathering and processing mollusks on the margins of the Pina Basin.

The interviews addressed aspects of the mollusk gathering activities, such as extraction methods, gear, gathering sites, production and form of commercialization. Environmental perceptions were also investigated. With prior consent, photographs were taken of the gear and activities, which were duly stored at the Ethnoecology and Tropical Fish Ecology Laboratory of the University of Pernambuco (Brazil).

Answers to the questionnaires and the discourse of the interviewees were interpreted and categorized. Relative frequencies of the responses were calculated and descriptive statistics were performed (mean and standard deviation). Qualitative analysis of the data was also performed using the interpretation of interviewee discourse [40] based on the union of individual skills [41], which consists of considering all information provided by interviewees, without exception.

### III. RESULTS

Thirty-five mollusk gatherers were interviewed. All were residents of the community of Brasília Teimosa with ages between 20 and 68 years and ranging in experience from 10 to 56 years (mean: 26.9 years). A total of 82.9% were female and 17.1% were male; 46.4% were married, 42.9% were single and 10.7% were widowed. A number of the single individuals had partners, but without a legal union. The number of children per fisher ranged from 0 to 13 (mean: 2.8; SD: 2.8), who commonly assisted in the gathering and/or processing of the mollusks. Family participation occurred in 82.9% of the gathering activities, with the father in charge of the transmission of fishing knowledge (62.5%). The remaining 37.5% learned the trade from older fishers in the community.

The gathering sites most often cited by the fishers were First *Croa* [denomination for land elevation in a body of water] (19.3%), Third *Croa* (16.8%), Second *Croa* (16.1%), Cabanga *Croa* (12.4%) and Pedras *Croa* (10.6%) (Fig. 2). Regarding the site of preference, 30.2% reported First *Croa* and 23.3% reported Cabanga *Croa* due to the proximity to their homes as well as the abundance and size of the mollusks.

*Wherever it's good, I like it, but First Croa is the best, because it's closest and has good mud,*” R. P. S., 42 years as a fisherwoman.

*“CabangaCroa is the best, because it has more mud and therefore more mollusks,”* E. S. P., 10 years as a fisherman.

*“GarçasCroa, because it's big and the shellfish are large,”* R. B. R., 20 years as a fisherwoman.

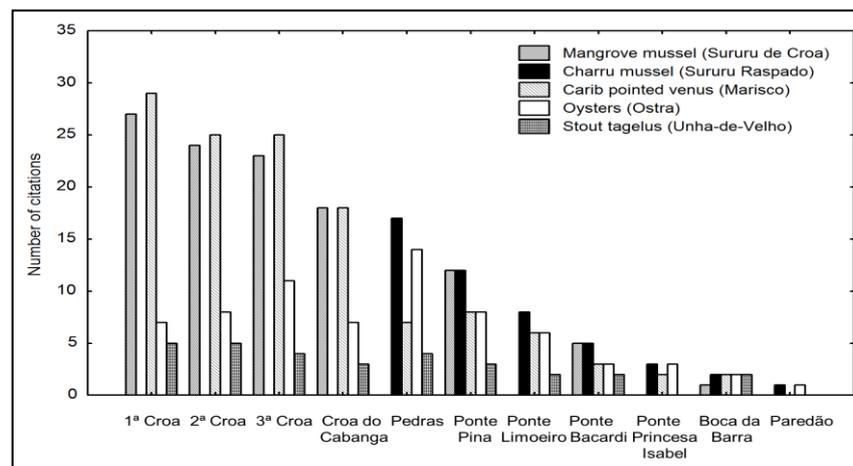


FIGURE2 – Relative contribution of mollusks at extraction sites caught by fishers of Brasília Teimosa in Pina Basin, Recife, Pernambuco, Brazil.

To arrive at the gathering sites, 54.7% of the fishers used a small, wooden boat powered by oars (Fig. 3) or, in some cases, a motor; 37.7% arrived at the sites on foot, 5.7% by swimming and 1.9% took public transportation (bus). The small boat was used to arrive at most sites, except *Paredão*, to which access is only gained on foot, as this site is located on the margin of the community. *Boca da Barra* was the site that required the longest time to arrive at by foot (mean: 67 min) and *Paredão* required the least time (mean: 5 min). Arrival by bus was only mentioned for the extraction of mollusks at *Ponte do Limoeiro* (mean: 20 min).



FIGURE3 – Wooden boat powered by oars.

The species of mollusk exploited by the fishers were the clam *Carib pointed venus* *Anomalocardia flexuosa*, (Linnaeus, 1767), the charru mussel *Mytella charruana*, (d'Orbigny, 1842), the mangrove mussel *Mytella bicolor* (Bruguère, 1792), the oyster *Crassostrea rhizophorae*, (Guilding, 1828) and the stout tagelus *Tagelus plebeius*, (Lightfoot, 1786). Mussels were considered a single category, as there was no separation of species for sales. Thus, this category accounted for the greatest captures (34.4%), followed by the *Carib pointed venus* (32.3%), oysters (22.2%) and stout tagelus (11.1%). Activities always targeted more than one species: 28.6% gathered the mangrove mussel, charru mussel, *Carib pointed venus* and oysters; 17.1% gathered the charru mussel, mangrove mussel and *Carib pointed venus*; 14.3% gathered the charru mussel and *Carib pointed venus*; 11.4% gathered the mangrove mussel, charru mussel, *Carib pointed venus*, oysters and stout tagelus; and 11.4% gathered the charru mussel, *Carib pointed venus*, oysters and stout tagelus.

The following gear were reported: sickle, hoe and trowel used to gather oysters and mangrove mussels, which are generally attached to rocks or hard substrates; spoons and forks for gathering the *Carib pointed venus*; *galeia*, which is an empty plastic box to dig out the *Carib pointed venus* and also serves to transport other mollusks; and the *bicheiro*, which is formed by wooden pole with a curve iron rod at one end and used to capture the stout tagelus. The following equipment was also cited: bags, buckets, iron utensils, gloves and sneakers to protect the hands and feet and a hand cart for transportation.

The mention of species per gathering site was used to determine distribution, with a predominance of the *Carib pointed venus* and charru mussel, especially on sand banks of the First *Croa* (42.0% and 39.1%, respectively), Second *Croa* (40.3% and 38.7%), Third *Croa* (39.7% and 36.5%) and Cabanga *Croa* (39.1% and 39.1%). The mangrove mussel and oysters predominated at *Pedras* (40.5% and 33.3%, respectively) and *Paredão* (50.0% and 50.0%). The stout tagelus was not cited for *Paredão* and cited little for the other sites (Fig. 2). It was reported that considerable practice and skill are needed in the use of the *bicheiro*, which may be related to the lesser capture rate for the stout tagelus.

*"I don't go after the tagelus because it requires lots of practice and patience," T. M. T. N., 18 years as a fisherwoman.*

When asked about the best weather conditions for fishing, 85.3% reported that the dry season was the best period, as the rainy season poses greater health risks, hinders the processing of the catch (especially the cooking of the mollusks, which generally occurs outside the homes) and causes the death of the organisms through the change in the water composition of the estuary due to the sediment load carried by the rainwater.

*"It's better in the dry season, summer. When it rains, it's very risky," R. M. L., 24 years as a fisherwoman.*

*"In the summer, it's better. The rain makes things difficult, because I don't have enough space to cook and the wood fire keeps going out," M. P. S., 40 years as a fisherwoman.*

*"In the summer, it's better, because when it's rainy, nobody earns anything; the fresh water kills the mussels," M. M., 12 years as a fisherwoman.*

Catches occur at low tide, when the mollusks are more exposed. According to 84.8% of the interviewees, the full and new moons, locally denominated large tides or moon tides (result of the sun and moon in syzygy), are the best times for gathering, as rocks and sediment banks are uncovered and the mollusks are "meatier", which, in the conception of the fishers, means that the organisms have greater biomass. The neap tide (result of the sun and moon at quadrature), which is the period of the crescent moon and quarter moon that causes less variation in the water levels, was cited by 6.1% of the fishers. The periods between the new and quarter moons and between the crescent and full moons were cited by 3.0%. The neap tide in which the tide variation is minimal was cited by 3.0% and another 3.0% reported that the moon had no influence over fishing activities.

“The low tide is the best, because the rocks are exposed,” T. M. T. N., 18 years as a fisherwoman.

“The full moon is better; the mollusks have more meat,” G. J. S., 43 years as a fisherwoman.

Although gathering activities are related to changes in the tide and climate, 42.3% of the fishers exercise their activities on a daily basis, 23.1% fish four times a week, 15.4% only fish during the spring tide, 11.5% fish three times a week and 7.7% fish six times a week. The fishers remain at the extraction site for 1 h 30 min to 5 h 30 min (mean: 3 h 48 min).

The processing procedures for the sale of mollusks caught in the Pina Basin are similar for the different species. After collection, the mollusks are washed for the removal of sediments and cooked over a wood fire in individual cans (Fig. 4. A). For mussels, the byssus is removed, followed by a second washing prior to cooking. After cooking, shelling occurs, in which the soft parts of the mollusks are removed from their shells (Fig. 4. B). Mollusk processing is commonly practiced by the fishers themselves (94.7%), 44.5% of whom perform the procedures alone, 33.3% count on the help of family members and 22.2% count on the help of neighbors. This procedure is carried out in front of or near the homes or places in the community in which it is common for fishers to meet to shell the mollusks, which can take between 30 min to 8 h (mean: 4.5 h), depending on the number of assistants and the amount of mollusks.



FIGURE4 – Processing procedures for cooking (A) and shelling (B).

To finalize the process, the meat is weighed, packaged and sold directly to consumers (53.1%), middlemen (25.0%) or both (21.9%). Sales generally occur after processing. When this is not possible, the mollusks are stored in a refrigerator (88.9%) or freezer (11.1%) for one to four days until being sold or eaten. The shells are generally discarded on the margin of the Pina Basin or in trash receptacles.

With regard to subsistence, mollusk fishing is the only source of income for 31.4% of the interviewees, whereas 68.6% have other sources of income, such as informal (“under the table”) work, housecleaning, craftwork and government assistance (family assistance program). Monthly income from fishing activities consists of less than US\$ 177 per month for 50.0% of the fishers, approximately US\$ 177 for 25.0%, more than US\$ 354 for 20.0% and approximately US\$ 708 for 5.0%, which explains why the majority of fishers also practice other activities to supplement their income.

Daily production and prices varied among the interviewees due to different fishing efforts, different forms of commercialization and the criteria of the “law of supply and demand”. Based on the information obtained, mussels were the most captured, with a mean daily volume of 4.7 Kg/person (range: 1 to 14 Kg) and oysters were caught at the lowest frequency, with mean volume of 2.3 Kg/persons (range: 0.5 to 10 Kg). However, oysters had the highest commercial value both in terms of direct sales to consumers (US\$ 5.30/Kg) and sales to middlemen (US\$ 3.60/Kg) (Table 1).

Regarding environmental issues, the presence of the brackish water fouling mussel (*Mytilopsis leucophaeta*) was reported, which is an exotic bivalve from North America. A total of 40.6% of the interviewees noted the presence of this mussel, among whom 50.0% report that it first appeared in the Pina Basin in 2005, relating its introduction to the rain and ships anchored at the Port of Recife. Among the fishers having observed the presence of this bivalve, 85.7% considered the introduction of the brackish water fouling mussel harmful, as it does not have any commercial value and has resulted in the reduction of native commercialized mussels. Knowledge on the introduction of the brackish water fouling mussel may be related to the extraction site, as the fishers with the greatest knowledge on this bivalve generally fished at *Pedras*, which is near the mooring site for ships and is not often frequented by fishers who were unaware of the exotic mollusk (Fig. 5).

TABLE 1 - Mean daily mollusk production (Kg) per fisher and mean sales price.

Species	Gear	Mean daily production and standard deviation	Mean sales price (US\$) and standard deviation		
		Kg/day/person (min-max)	Direct sales to consumer (min-max)	Middlemen (min-max)	
Mussels	<i>Mytella charruana</i> (Charru mussel)	<i>Galeia</i> (type of box)	4.7; 3.1 (1-14 Kg)	3.3; 0.7 (1.87- 4.38)	2.7; 0.7 (1.56 - 3.75)
	<i>Mytella bicolor</i> (Mangrove mussel)	Sickle, hoe, trowel			
Carib pointed venus	<i>Anomalocardia flexuosa</i>	Spoons/forks; <i>Galeia</i>	3.2; 1.9 (1-10 Kg)	3.0; 0.7 (1.25 - 3.75)	2.6; 0.9 (1.56 - 4.38)
Stout tagelus	<i>Tagelus plebeius</i>	<i>Bicheiro</i> (wooden pole with iron rod)	3.1; 1.5 (1- 5 Kg)	3.3; 0.9 (2.50 - 5.00)	2.3; 0.3 (1.88 - 2.50)
Oysters	<i>Crassostrea rhizophorae</i>	Sickle, hoe, trowel	2.3; 2.3 (0.5-10 Kg)	5.6; 1.1 (3.13 - 6.25)	3.6; 1.7 (1.88 - 6.25)

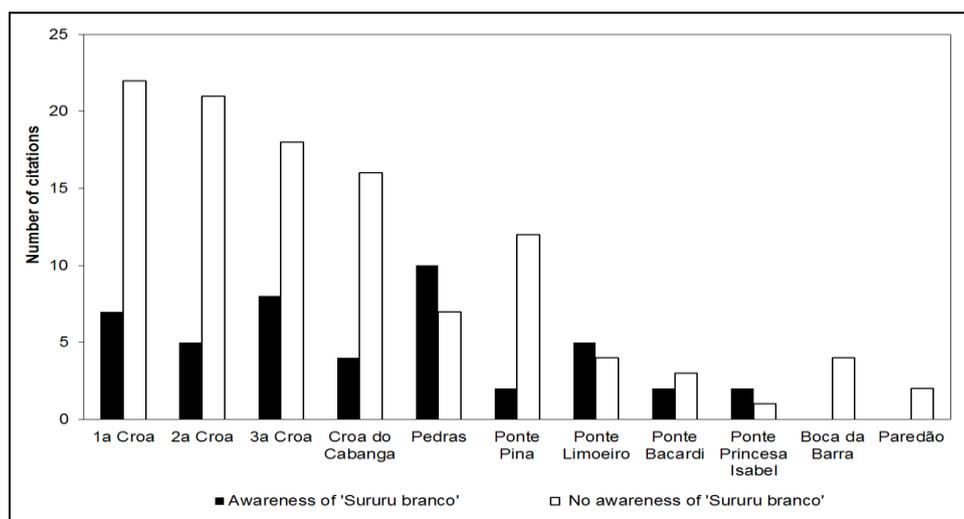


FIGURE5 – Comparison of mollusk extraction sites regarding perception of brackish water fouling mussel by fishers of Brasília Teimosa in Pina Basin, Recife, Pernambuco, Brazil

When asked about mollusk fishing over time, 74.3% reported better conditions in the past, with the depletion of current resources. Among these interviewees, 64.0% attributed the increase in fishing efforts as the main reason for the reduction in the number of organisms, whereas 36.0% cited pollution caused by trash discarded in the estuary.

*“It was better in the old days, because there was still something to fish. Now there are too many people and the pollution is finishing off everything,” M. P. S., 40 years as a fisherwoman.*

*“It was better in the old days. Times change; things get more expensive and many people are unemployed. The only way to do it is to work the tides. The catches are getting scarce because there are many people fishing. Before, there were four or five ‘baiteras’ [implement used for catches]; today, they take a lot of ‘galeias’ [implement used for catches], and wherever you take and don’t put back, the stock runs out,” G. B. L., 35 years as a fisherman.*

A total of 57.1% of the fishers considered the mangrove important to mollusk fishing, but did not know how to explain exactly its degree of contribution, despite recognizing the worth of this ecosystem for the plurality of the local biota and even describing data on the bio-ecological cycle. The fishers also reported environmental problems that affect the mangrove, such as the discarding of solid waste (54.5%) and the dumping of industrial effluents (36.4%) and domestic sewage (9.1%).

“The mangroves are important because they are part of nature and, if you get rid of them, it will hurt nature,” I. M. C., 15 years as a fisherwoman.

“The mangrove is important because it protects the creatures,” N. M. S., 40 years as a fisherwoman.

Fishing activities were unanimously considered a gratifying practice for the fishers of Brasília Teimosa, who can achieve their sustenance without having the obligations or annoyances common to other activities. When asked about changes desired for the fishing activity, the fishers mentioned cleaning up the Pina Basin, raising awareness on the part of the population regarding not dumping trash in rivers and better working conditions. The fishers of Brasília Teimosa also desire a type of financial assistance during the winter months due to the reduction in mollusk productivity in this period.

#### IV. DISCUSSION

Heredity is an intrinsic characteristic of traditional knowledge, but does not impede the evolution or changes in knowledge [42]. This was evidenced in the community of Brasília Teimosa, where the majority of fishers learned the trade from a relative, demonstrating the force of family tradition in this community. The same was not observed in the community of Vila Velha (also in the state of Pernambuco), where more experienced fishers are responsible for passing down knowledge regardless of kinship [43]. Vila Velha is a rural community, whereas Brasília Teimosa is an urban community, indicating that each community has its own characteristics regarding the transmission of knowledge.

Despite the form of transmission of knowledge be specific to each community (rural or urban), the resource management at the local level, can also be affected by the erosion of traditional knowledge and practice. According to [44], change and erosion in TEK is complex, and the adaptation of social, environmental and ecological knowledge systems have different impacts on different domains and dimensions of TEK, as noted by [45] who reported an intergenerational erosion of skills in making canoes in Pohnpei, Micronesia. In Brasília Teimosa all types of gears were observed, including the *bicheiro* that takes practice and skill in its use and, therefore, is only used by the older fishermen. However, there are indications of adapting knowledge, in particular to optimize the fishing effort, as the inclusion of the use of *galeia* in *Tagelusplebeius* fishing.

Despite the male dominance in fishing activities [46], mollusk fishing has historically been a female occupation in some regions, such as the community of Brasília Teimosa, where the female presence prevails in both the collection and processing activities. According to [47], female dominance stems from the fact that mollusk fishing requires a relatively small amount of time, is generally carried out in areas near the home, is less dynamic and less taxing than activities targeting fish and allows processing the product in the mollusk fisher's own home.

The proximity of the collection site to the home was also prized, as the fishers preferred the First, Third and Cabangas *Croas*, which are the closest to the community of Brasília Teimosa, but were not against traveling to other extraction areas. This aspect has also been reported by [11], in the estuaries of the rivers Paraíba do Norte and Mamanguape, where fishers prioritize close areas, but do not forego more distant areas when such locations offer adequate productivity. Considering the optimal foraging theory (OFT) based on the “Model of Diet Breadth in Foragers” proposed by [48], it is possible to attempt to decipher decisions in terms of costs and benefits measured in the time and energy spent by mollusk fishers related to selective pressure at preferential sites and movements to distant sites that offer a greater individual return. Focusing on contemporary shellfish exploitation, in Kiribati, Micronesia, [49,50] has shown that shellfish gatherers foraging in a manner that matches the predictions of optimal foraging theory by maximizing their net energy return rates. As observed, the fishers of Brasília Teimosa apply the OFT therefore prefer to spend an average of 67 min to arrive at *Boca da Barra*, which is the most distant collection site from the community, to obtain a better yield in catch weight. According [49, 50] decisions based on OFT together with high human population growth, urban crowding and social structure has undermined recent attempts to help conserve resources.

The catches by the mollusk gatherers of Brasília Teimosa in the Pina Basin were similar to those reported by [51] for the estuary of the Formoso River (state of Pernambuco): stout tagelus (*Tagelusplebeius*), mussels (*Mytella charruana*) and oysters (*Crassostrea rhizophorae*). In the Ponta do Tubarão Ecological Reserve in the state of Rio Grande do Norte (northeastern Brazil), the Carib pointed venus (*Anomalocardia flexuosa*), the clam ‘thick lucine’ (*Lucina pectinata*) and the mangrove mussel (*Mytella bicolor*) are reported to be the main resources [47]. Mussels and the clam ‘Carib pointed venus’ are the main resources exploited in northeastern Brazil due to the ease by which these species settle and colonize intertidal zones in estuary-mangrove complexes. Participation in the direct use of the mangrove ecosystem allows gatherers to develop techniques to maximize the catches [52]. Specific gear is used for extraction activities in the Pina Basin: the *bicheiro* (wooden pole with iron rod) for the stout tagelus; hoes, sickles and trowels for mussels and oysters; and *galeias* (type of box) and forks/spoons for the Carib pointed venus. In the state of Paraíba (northeastern Brazil), [53] report a variety of mollusk gathering techniques that exert a direct influence over the efficiency of the catch. This

explains the lower production of the stout tagelus in comparison to other mollusks caught by fishers of the community of Brasília Teimosa, as handling the *bicheiro* requires greater skill and is therefore used by a smaller number of fishers. Tidal dynamics is a determinant factor regarding fishing times and periods in estuaries. Indeed, the mollusk gatherers of Brasília Teimosa cited the influence of tidal variations and phases of the moon. The same was reported by [54] for mollusk gatherers on the coast of the state of Paraíba, which allowed characterizing the distribution of mollusks in the estuary of the Mamanguape River and was considered an important factor for the optimization of fishing activities. While the fishers use their own techniques and resources aimed at greater efficiency and optimizing the catches, this is not reflected in the yields in Brasília Teimosa, where 50.0% of the fishers receive less than US\$ 177/month. Similar findings are reported for fishers targeting the Carib pointed venus in the Formoso River (state of Pernambuco), 80.0% of whom receive less than this amount [51]. The low yield does not reflect the fishing efforts/techniques employed and demonstrates the precarious financial conditions of fishers in the state of Pernambuco, which may also be related to the forms of commercialization. According to [55], the main economic articulation between artisanal fishing and the market is performed indirectly through middlemen. In this type of economic transaction, the individual value of the mollusks is lower in comparison to direct sales to the consumer, allowing fishers only a portion of the total wealth generated by the fishing activity. On the other hand, indirect sales allow a stable unit of trade. Nonetheless, economic gains can be greater through the organization of the community in the form of cooperative. Governmental and/or non-governmental initiatives need to recognize mollusk gatherers as having productive and lucrative potential and capable of becoming organized and exercising a professional role.

The environmental factors addressed in the interviews were determinants for the identification of the cause of economic losses on the part of the fishers of Brasília Teimosa. The fishers cited the introduction of the brackish water fouling mussel (*Mytilopsis leucophaeta*) as responsible for the reduction in the productivity of native mussels, which are the main resource exploited. The brackish water fouling mussel was first recorded by [56] through information gathered from local fishers, with reports that the presence of *M. leucophaeta* in the area around the Port of Recife was first noted in January 2004, introduced mainly by ships passing through the region. According to [57], areas surrounding the ports of large coastal cities are subject to the introduction of exotic species as a consequence of the constant mooring of ships from other regions of the country and the world. As the Port of Recife undergoes the constant movement of ocean-going vessels, with an average of 491 moorings of ships annually [58], the introduction of the brackish water fouling mussel in the Pina Basin was evidently through the port.

Human actions in the form of the improper use of natural resources and a lack of ecological awareness lead to degradation and waste. Fishers in the community reported the discarding of solid waste, domestic sewage and industrial effluents in the mangrove. [51] report similar perceptions on the part of fishers of the Formoso River (state of Pernambuco), who report domestic sewage as having the greatest impact on the mangrove. According to [47], shellfish gatherers as Ponta do Tubarão (state of Rio Grande do Norte) report the discarding of trash and pollution from oil from vessels as the most harmful aspects for mangroves. The awareness of traditional communities regarding their dependence on natural resources creates a certain degree of responsibility and greater awareness [43]. This process can be seen in the community of Brasília Teimosa, where fishers demonstrate knowledge on the importance of the mangrove for fishing activities. According to [22, 59, 60], the relationship between fishers and the environment reflects the cultural baggage and degree of dependence and practical learning that these traditional communities have with regard to the environment in which they live. However, the fishers of Brasília Teimosa are also responsible for discarding waste in improper locations, thereby contributing to environmental degradation and demonstrating that urbanization also exerts an influence over the practices of the community.

The enormous pressure that coastal ecosystems undergo stems from the fact that 80% of the population of Brazil live in cities, most of which are within 60 Km from the ocean [61]. This situation goes back to the early colonial period and is marked by the intensification of the use of lake and estuarine ecosystems [6]. Inadequate urban planning and the scarcity of basic sanitation have direct implications on living conditions in river communities.

Due to the numerous sources of pressure placed on marine ecosystems and considering these environments as fundamental to the survival of traditional coastal communities, shellfish cultivation may be a viable alternative to avoid the depletion of existing stocks. Mollusk farming could contribute toward the development and maintenance of traditional fishing communities in their respective areas of origin along the coast, providing increased income and a significant improvement in the quality of life of artisanal fishers [62]. This has been observed in the Gulf of San Matias in Patagonia, where artisanal fishers began to farm endemic mollusks as a way to increase productivity [63]. However, one must not overlook the risks and negative impact on the environment. Therefore, further studies are needed to investigate the relationship between humans and the environment and contribute toward the drafting of public policies directed at the sustainable use of coastal resources while respecting natural areas.

Another alternative would be the participation of fishers in management processes that prize local knowledge and offer compensatory mechanisms, as in the case of the ‘payments for environmental services’ [64] employed as a form of monitoring in protected areas and in periods in which fishing practices are prohibited to protect local stocks. Such mechanisms could be used in the post-winter period and some fishing sites could be closed temporarily for the recovery of mollusk stocks.

## V. CONCLUSIONS

Mollusk gatherers in the community of Brasília Teimosa have a large body of knowledge regarding bivalves, which is applied in different fishing gear and the choice of extraction sites and such knowledge comes mainly from family relations.

The socio-environmental situation of the fishing community of Brasília Teimosa portrays urban phenomena in the city of Recife, such as an inadequate sewage system and the generation of solid waste. However, these fishers still constitute a true “mangrove civilization”, maintaining their socio-cultural and economic traditions linked with the estuary-mangrove environment.

The environmental fragility of the estuarine complex of the Pina Basin and the precarious income of mollusk fishers have led to a needy fishing community that intensively exploits these resources as a source of income and subsistence.

Information on mollusks as well as the perceptions and way of life of the fishing community of Brasília Teimosa constitute traditional knowledge that persists among the pressures of the city. This knowledge should be prized and incorporated in urban planning policies and management/conservation projects in coastal areas.

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