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A century-old fishery in Guanabara bay, Rio de Janeiro, Brazil – The perspective of fishers on the challenges faced in the 21st century

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ABSTRACT

Guanabara Bay is an important estuary on the South American coast, both for its ecological role, still sustaining the most diverse estuarine fish fauna in Brazil, and for being inserted in the one of world's largest metropolitan areas, suffering a historic process of hypereutrophication. The fish weir (FWR), an artisanal fishing practiced for centuries, are responsible for generating income and food security for a considerable number of inhabitants. Our research focused on the Local Ecological Knowledge (LEK) as an essential tool to overcome the serious lack of data about this traditional fishery, based on semi-structured interviews with fishers identified by the local community as reliable sources on the history of environmental changes and the production of the FWR over the last 30 years. The reports produced a picture of decline in fisheries production, both in terms of landing values and the reduction in body size of the main resource associated with this fishery, the mullet *Mugil liza*, and increase costs of construction of the fishing gear. The reports were crossed with information gathered *in loco* about the construction of FWR structures to determine the extent of the use of illegal mangrove wood. The study reinforces the relevance of LEK for the development of a historical overview of fisheries and highlights the position of fishers towards local environmental management and points of conflict that need to be addressed to guarantee the successful protection of the last mangrove remnant inserted in the third largest metropolitan area in South America.

Keywords: Ethnoknowledge; Small-scale fisheries; Conservation.

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SIGNIFICANCE STATEMENT

Data-limited fisheries remains a constant challenge to the correct management of natural resources and the conservation of marine species, a scenario also present in the Guanabara bay, on the Western Atlantic coast of South America. The study focused on a traditional fishing gear and its associated fishing community as a source of reliable data capable of reconstructing the dynamics of a fishery inserted in the third largest metropolitan area in the continent over the past 30 years, covering the first decades of a local Environmental Protection Area. The data highlights fluctuations of catch rates and potential population changes within the main targeted species, consequence of declining environmental conditions and overexploitation. While the EPA successfully protected the last remains of the once predominant mangrove forests, it added costs for the fishing community in the construction and maintenance of its fishing structures.

INTRODUCTION

The occupation of the Guanabara bay estuary's surroundings dates back over 12,000 years (Soares-Gomes et al. 2016; Lopes et al. 2022). Following the beginning of Portuguese colonization in 1502, the region witnessed a growing influx of settlers. Fishing has always played a crucial role in ensuring food security for this expanding population. However, fishing pressure and environmental degradation intensified significantly across the second half of the 20th century (Soares-Gomes et al. 2016; Vianna and Mattos 2018). Unregulated coastal occupation, industrial development, and the removal of mangroves for urban expansion around the estuary were accompanied by increased naval traffic to the Port of Rio de Janeiro. Successive landfilling operations altered water circulation dynamics and the environmental quality of regions previously used as nursery for hundreds of resident or estuarine-dependent species. These changes have resulted in a continuous decline in environmental quality (Fistarol et al. 2015; Silva Jr. et al. 2016) and fish diversity in the estuary, a pattern of losses that has yet to stabilize (Teixeira-Leite et al. 2023).

Despite the ecological significance and crucial role of mangroves within the Guanabara bay estuary in fisheries production and food security, much of this dynamic remains obscured by a lack of studies on its more traditional fisheries. Fish weir (Standard FAO abbreviation: FWR – He et al. 2021), locally known as "curral de pesca", stands out as a prominent example in the upper estuary (Bernardes, 1958; Jablonski et al. 2006; Vianna and Mattos 2018). This lack of knowledge is striking considering that the region is located within Brazil's second-largest metropolitan area and the third-largest in South America, home to over 13 million inhabitants (UN 2019). The absence of official data on this fishing modality up until the early 21st century (Saback 2021), coupled with the scarcity of focused academic studies, underscores the urgent need to document the remaining knowledge of FWR fishing in the Guanabara bay. A series of multiple-use conflicts afflicts the region, involving different human activities (navigation, oil and gas infrastructures, harbour and shipyards), all aggravating the current fishing activity, which also displays frictions between fishing communities and overlapping fishing areas (fish weirs, trawling, gillnets) (Prestrelo and Vianna 2016; Prestrelo et al. 2019). Despite this scenario, recent efforts have been made towards promoting sustainable traditional fisheries, as with the case of the swimming crab fishing practiced in the upper bay area, including within the limits of a Marine Protected Area (MPA) (Garcia et al. 2022).

Local Ecological Knowledge (LEK), a tool considered complementary and pertinent in situations where official data are adequately produced and fisheries are better studied, becomes essential to rescue the minimum of knowledge still available for ecosystems or species with chronic data scarcity (Wilson et al. 2006; Sáenz-Arroyo and Revollo-Fernández 2016; Pottie et al. 2021; Nascimento et al. 2023). This tool has already proven indispensable in retrieving historical records of data-limited fisheries along the Rio de Janeiro coast (Santos et al. 2022), although meticulous evaluation is necessary to validate the accounts (Ruddle and Davis 2011; Santos et al. 2022). The fish weir, a traditional fishery developed with the assembly of a low-cost passive gear, has been employed on the Brazilian coast since colonial times, its use having extended and popularized after the 16th century with Portuguese colonization (Veríssimo 1895; Menezes 1976; Schaan 2010). The adaptation of European and indigenous fishing techniques, as well as the manufacture of more durable and efficient gear, met a growing demand from the nascent urban centers. FWR fishing in the Guanabara bay, with its practice recorded in its surroundings since the imperial period, had already been reduced to the middle and upper estuary region by the early 20th century. With the introduction and popularization of the bottom trawl fleet, it provoked the transfer of the fishing community from the port region of Cajú, in the city of Rio de Janeiro, to the region of Magé, and saw its fishing area further restricted, coming to be practiced in the limited area where it still operates today, between the municipalities of Duque de Caxias and Magé, on the northern shore of the bay, and in São Gonçalo, on

its eastern portion (Bernardes 1958). Long time series from fish landings on the production of FWR fishing is absent on official data (Saback 2021), and even when considering other sources, catch data is limited at best, ranging from few months to few years with long hiatus between them.

Our study focuses on rescuing the knowledge of local traditional FWR fishers in the Guanabara bay, seeking a more accurate history for the last few decades. Based on semi-structured interview, active and retired fishers provided descriptions and characteristics of the fish production and the gear in use, identifying technological adjustments along the time series or ecosystem changes perceived by the fishers in their local environment. A special attention was given to the traditional use of mangrove wood for the construction of the structure, a practice prohibited since the implantation of a local Marine Protected Area.

MATERIAL AND METHODS

Study Area

The Guanabara bay is situated in the Southwestern Atlantic (22º40'-23º00'S and 43º00'-43º18'W), along the southeastern coast of Brazil. It encompasses an area of over 384 km² and stretches a maximum of 28 km in the east-west axis and 30 km in the north-south axis (Figure 1). It is one of the largest Brazilian estuaries, with a drainage basin composed of 45 rivers and intense water exchange between the basin and the oceanic waters flowing through its narrow entrance (Soares-Gomes et al. 2016). In addition to the rainfall pattern with higher precipitation intensity during summer (December to February), there is also a strong influence of raw sewage and industrial effluent due to the fact that it is surrounded by one of the largest metropolitan areas in the world (Silva Jr. et al. 2016).

A conservation area, the Guapimirim Marine Protected Area (MPA), was created in 1984 by the Federal Government (Decree No. 90,225/1984), covering an area of 138.9 km² located in the part of the bay with the most pristine conditions. The MPA's mission is to preserve the largest remnant of the original mangrove cover of the Guanabara bay, the dense ombrophilous vegetation that once covered most of its margin (Baptista-Neto et al. 2017). While the sustainable use of its fishing resources is allowed, an inner core of the most preserved section of 19.4 km² is separated under full protection. This core region, the Ecological Station of Guanabara, is accessible only for research and with non-lethal methods. Nonetheless, it is strictly forbidden to remove mangrove trees and its parts from both areas. Despite being recognized as highly eutrophic and that the numerous environmental programs have not yet been sufficient to reverse or slow down the rate of the environmental degradation, the Guanabara bay still holds the greatest diversity of fish in a Brazilian estuary (Teixeira-Leite et al. 2023), a fact corroborated by the still high fishing productivity recorded by artisanal and industrial fishing in its waters (Begot and Vianna 2014; Franco et al. 2014; Vianna and Mattos 2018; Garcia et al. 2022).

Structure of the local fish weir (FWR) and Wood Origin

The structure is of particular importance given the original reliance on wood from the once abundant mangrove forests, where the red mangrove *Rhizophora mangle*, the white mangrove *Laguncularia racemosa*, and the black mangrove *Avicennia schaueriana* predominate, which led to the creation of a MPA in the region aimed at preserving this vegetation. A preliminary survey was carried out using images made available by Google Earth software, where FWR structures were identified based on the typical pattern of the structure in the region, facilitating their identification by aerial and satellite images. However, this approach is inconclusive as it is not possible to accurately distinguish active from inactive fish weirs. The field survey was carried out in partnership with local fishers who assisted in locating the structures within the fishing area included in the Guapimirim MPA. The structures were geolocated, the wood used in the construction identified, and their coordinates were analyzed using the QGIS 3.28.1 geoprocessing software.

Identification of Expert Fishers and Interview Methodology

The snowball method, already widely used in sociological surveys, has also been shown to be effective in hard-to-reach communities (Goodman 2011; Valerio et al. 2016), which is a common reality in artisanal fishing. The study restricted the list of interviewees to fishers over 60 years old and with 30 years of experience in FWR fishing, in order to reduce the effects of the intergenerational paradigm shift for the studied region (Pauly 1995; Soga and Gaston 2018; Santos et al. 2022). The research followed the guidelines of the Declaration of Helsinki and Tokyo for humans. The questionnaires applied were evaluated by the Research Ethics Committee (CEP) of the Federal University of Rio de Janeiro (UFRJ), and were approved under opinion number 5.111.289 (National Health Council, "*Plataforma Brasil*"). FWR fishers from the localities of the upper estuary were interviewed in person and individually, without the presence of third parties. All interviewees declared or signed their consent prior to the interview. These communities are located within

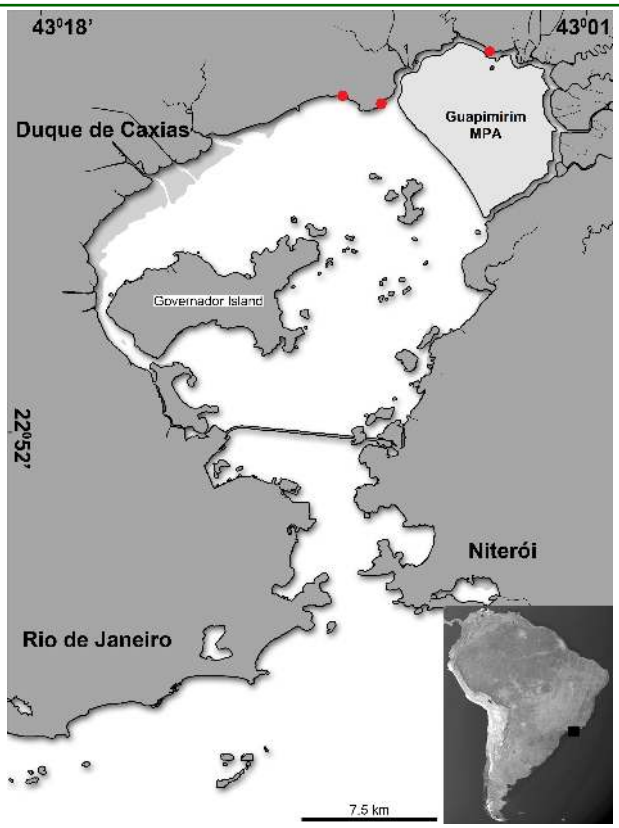

Figure 1. Map of Guanabara Bay, coast of Rio de Janeiro State (Brazil), with the bathymetry of the region. Highlight for the Guapimirim MPA. Visited fishing communities in red.

the municipality of Magé, partially located within the limits of the Guapimirim MPA. Their role in FWR fisheries was assessed, and for those still active, the number of FWR where they operate was identified. The destination of the production over the past 30 years was recorded, with the fishers determining the percentage of their catch sold to middlemen, local markets or directly to consumers. To better characterize the traditional aspect of the fishery, information was collected on how many generations of the fisher's family are or were involved in FWR fishing, as well as whether their descendants were also active in this fishery. Technological aspects were evaluated for both the boat used (size and engine power) and the source of wood used for the FWR structure. Fishing production was evaluated in detail in the rest of the interview, with fishers providing data on production per species/category, their personal perception of how fish categories have fluctuated over the past 30 years (increase or decrease in landings), and the record catches (category, weight, size, and year) that they could mention or provide supporting documentation. Each interviewee could mention as many species/category as they considered necessary.

RESULTS

Structure of fish weir (FWR) and wood origin

A fish weir is a stationary trap designed to catch demersal fish, mainly mullet (*Mugil* spp.), catfish (*Genidens* spp.), whitemouth croaker (*Micropogonias furnieri*), and other Sciaenidae, and snook (*Centropomus* spp.). Fish weirs are typically 37 to 48 meters long and are built in shallow areas, predominantly less than 5 meters deep. They are mainly accessed by motorized wooden boats, although rowboats are also part of the local fleet. FWR are constructed with a palisade made of bamboo mats (40 mm spacing) and eucalyptus logs arranged in parallel rows. A walkway is built on the emerged portion to allow fishers to access the structure for fishing and routine maintenance. FWR are typically divided into four compartments (espia - spy, gancho - hook, casa do meio - middle house, and viveiro - nursery), with fishing taking place in the latter and carried out by one to three fishers (Figure 2).

A total of 132 fishing weirs were inspected. Of these, 81.8% are active, while 14.4% are abandoned and 3.8% are under renovation (Figure 3). Of the active FWR, 31.5% do not use mangrove wood, while

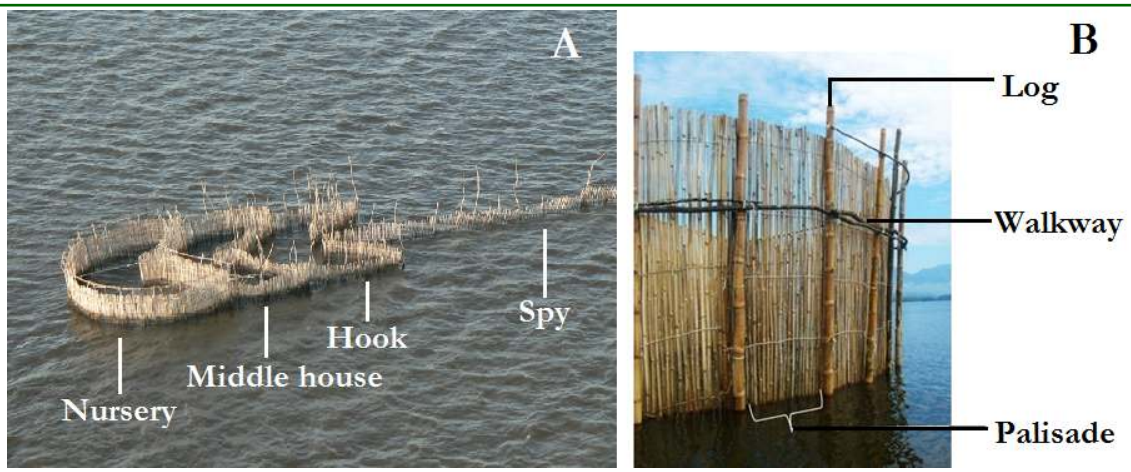

Figure 2. Fish weir (FWR), a fixed trap used in Guanabara Bay, Rio de Janeiro, Brazil. A) Compartments of a typical FWR; B) Structure of the FWR.

50.9% use it only for the walkway, 16.7% use it for both the walkway and the logs, and 0.9% use it only for the logs. Among the FWR that used mangrove wood in their construction, it was identified that the vast majority (97.30%) use white mangrove, *Laguncularia racemosa* (L.) C. F. Gaertn, while red mangrove, *Rhizophora mangle* L., was present in 2.70%. The FWR that do not have mangrove wood are made solely of bamboo, or with mats and walkways made of bamboo, with eucalyptus logs.

Regarding regulation, three documents are in effect and refer to fish weirs (Table 1). The most important for Guanabara Bay is the Normative Instruction (NI) 14/2005, from the federal environmental ministry, which has a state-wide scope but is, in practice, more closely linked to regulating the use of fish weirs inside this bay.

Interviews with Expert Fishers

Twenty fishers identified as key references in the fishing of the studied region were interviewed, with ages between 60 and 81 years (mean of 68.8 years ±5.7) and time dedicated to FWR fishing between 30 and 72 years (mean of 53.9 years ±10.5). Most of the fishers remain active in fishing (75%), with 14 of the 15 active fishers registered as part of two established colonies (Z-09 and Z-11). Of those interviewed, 40% own at least one FWR structure, varying between 2 and 12 weirs (mean of 7.1 weirs ±3.3), being responsible for a total of 57 FWRs. The marketing of the landed fish is shown to largely rely on the figure of the middleman (71.0 to 81.7%), being the preferential destination of the production in the last 30 years. Local trade has a minority share, receiving 17.5 to 28.4% of the production. Direct sales to the consumer were not considered relevant for the fishers, not exceeding 2% of the first sale made by those interviewed (Table 2).

As part of a traditional community, working on a historical fishery in this region, 36% of expert fishers are grandchildren or great-grandchildren of FWR fishers, while 50% of those interviewed are their direct descendants (children). There is also a considerable insertion of new fishers to this particular fishery, with 14% of those interviewed joining the community without prior fishing history (Figure 4). The economic dependence on the activity is also exposed by the identification that while 75% of those interviewed remain active in FWR fishing, 45% (9 fishers) receive a pension from Social Security, provided by the Federal Government, but need to supplement their income by maintaining the fishing activity.

Most fishers (65%) have their own boat, mostly made of wood and with an inboard engine, but some fishers also routinely use rowboats. The structure of the FWR deserved special attention due to the traditional use of plant material, especially extracted from mangroves, for its construction and maintenance. While 85% of fishers reported the use of mangrove wood at some point in their professional activity, only 14.3% said they still utilize mangrove wood in some FWR structure, with only eucalyptus and bamboo currently being used. When asked about when they replaced the use of mangrove wood, the reported exchange process extended between 1980 and 2019, with a median around 2002. It is important to note that two fishers admitted to still work with mangrove wood today.

The fishers's perception of fish production indicates a generalized decline in production, predominantly associated with two species: the mullet *Mugil liza* Valenciennes, 1836 and the whitemouth croaker *Micropogonias furnieri* (Desmarest, 1823). All 20 fishers interviewed reported a reduction in fish production

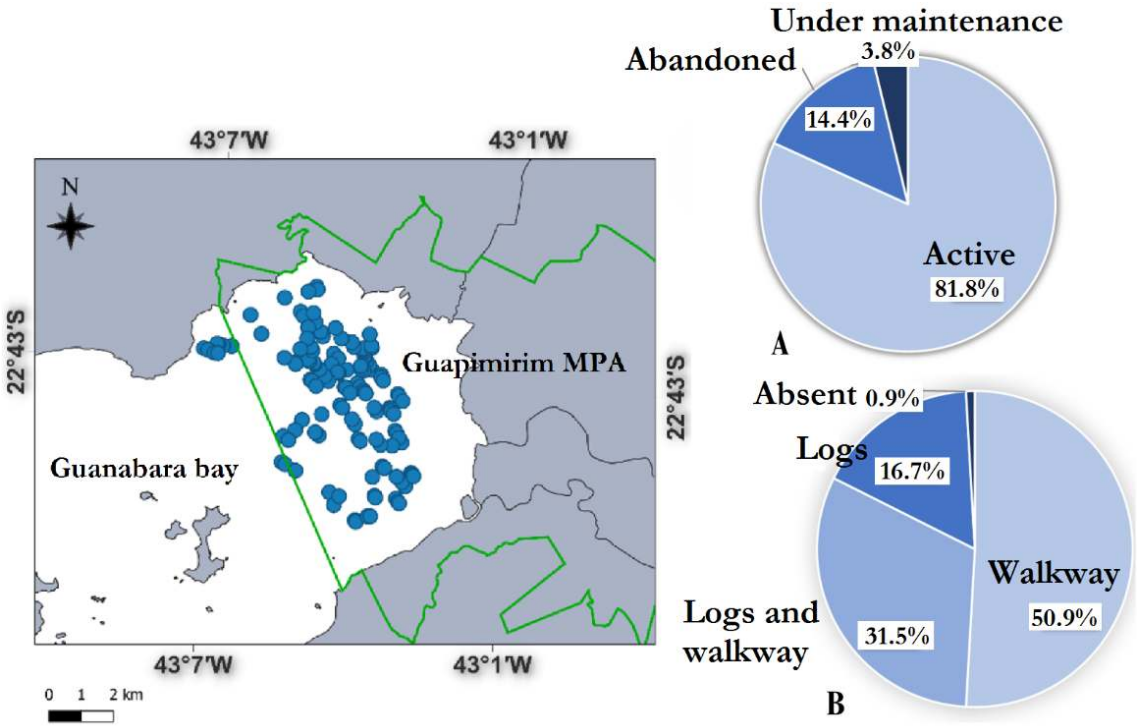

Figure 3: Proportion of active and inactive weirs within the Guapimirim MPA, Rio de Janeiro, Brazil. Detail of the current status of FWR structures (active, abandoned and under renovation/maintenance) (A), and the use of mangrove wood (logs, walkway, and logs/walkway) in its construction (B).

Table 1. Current legislation on fish weirs in Guanabara Bay, ordered by date, from the most recent.

Data	Regulation	Document N°	Agency*	Scope	Subject
14/06/05	Normative Instruction	14	MMA	State	Establishes criteria for the use of fish weirs in the State of Rio de Janeiro.
20/02/97	Ordinance	8	IBAMA	Local	Prohibits fishing with nets and the installation of new fish weirs (=relocation) in the Guapimirim MPA.
25/09/84	Federal Decree	90225	PR	Local	Creates the Guapimirim MPA.
13/12/73	Ordinance	602	SUDEPE	Local	Regulates trawl fishing in Guanabara Bay and prohibits its presence in areas intended for fish weirs.

* Agencies from the Federal sphere: IBAMA = Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, MMA = Ministério do Meio Ambiente, PR = Presidency of the Federative Republic of Brazil, SUDEPE = Superintendência do Desenvolvimento da Pesca.

in several categories, totaling 72 mentions of species reduction between the beginning of their professional activity and the present day. Fishers related 15 fishing categories, with mullet (20.8% of reports) and white-mouth croaker (18.1% of reports) representing 39% of the total (Table 3). The most valued fish produced in the region, the snook *Centropomus* spp., was marked by a reduction reported in 9.7% of the reports. Even a less attractive fish for the fishers and considered of little value by the consumer, the catfish *Genidens* spp.

Table 2. Destination of fish caught by fish weir (FWR) informed by expert fishers, from Guanabara Bay, Rio de Janeiro, Brazil.

Destination (%)	Present	- 10 Yrs	- 20 Yrs	- 30 Yrs
Middlemen	81.7	71.0	77.9	79.0
Commerce	17.5	28.4	20.5	20.5
Consumer	0.8	0.6	1.6	0.5

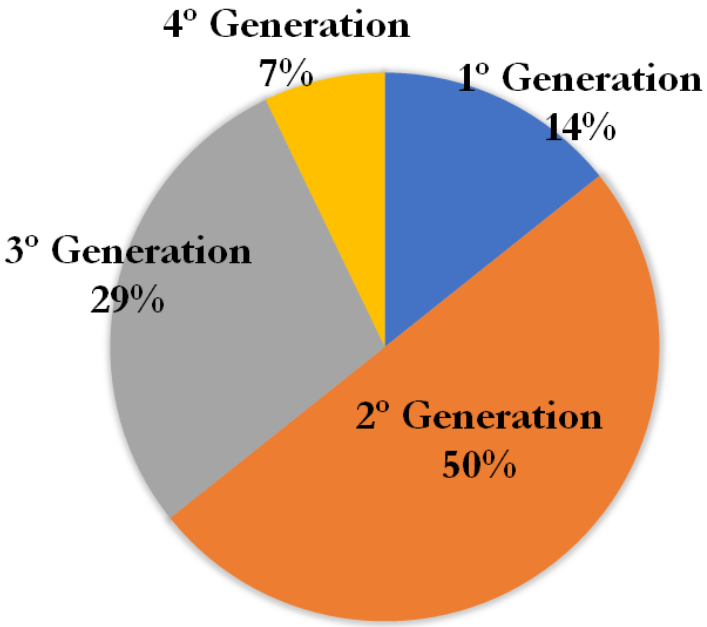

Figure 4: Traditional fishery: Generation to which the interviewed expert fishers belong, regarding fish weirs (FWR) in Guanabara Bay, Rio de Janeiro, Brazil.

had its reduction mentioned in 16.7% of the reports. Changes in fish size were less perceived by fishers, with 24 changes reported for nine fish categories, by 16 professionals. Of the result obtained, the most expressive is the indication of the reduction in the size of the mullet, representing 25% of the reports. Agreeing with the decline scenario, only two fishers reported an increase in the production of two categories, the African catfish *Clarias gariepinus* (Burchell, 1822), a species introduced in the region by fish farming but which is already established in the rivers of the study area, and the corvinota. This is a variation in the common name of the whitemouth croaker *M. furnieri* associated with individuals of smaller sizes than the specimens marketed as whitemouth croaker ("corvina"), including immatures.

Finally, the combined analysis of the answers on the causes of the decline in production and the reduction in fish size allowed us to analyze who the fishers attribute the changes they observed to. Grouped by themes, pollution in general was the main cause in 23.3% of the answers, while 16.7% directly pointed to oil spills as the cause. Combined, environmental and oil pollution were mentioned in 40% of the responses. Environmental degradation, the second most common cause (33.3%), includes river silting and the loss of mangrove areas, however one fisherman drew attention to human interventions and highlighted the construction of the President Costa e Silva Bridge itself, a 13.3 kilometers structure inaugurated in 1974. Overfishing appeared in only five answers, with industrial fishing and gillnetting being directly blamed (Figure 5).

DISCUSSION

Structure of the fish weir (FWR) and Origin of the Wood

The FWR fishery in Guanabara Bay was classified by Prestrelo et al. (2019) as a fishery with low techno-

Table 3. Perception of changes in landed volume and fish size by expert fish weir (FWR) fishers (n=20) across their period of activity in Guanabara Bay, Rio de Janeiro, Brazil.

		Reduction in volume		Reduction in size
Category	**Taxonomic group**	**Mentions**	**%**	**Mentions**
corvina	*Micropogonias furnieri*	13	**18.1**	3
pescada	Cynoscion spp.	2	**2.8**	2
pescada-amarela	*Cynoscion acoupa*	1	**1.4**	2
pescadinha	Sciaenidae	2	**2.8**	
piraúna	*Pogonias courbina*	8	**11.1**	3
SCIAENIDAE			**36.2**	
tainha	*Mugil liza*	15	**20.8**	6
parati	*Mugil curema*	1	**1.4**	
MUGILIDAE			**22.2**	
bagre	Ariidae	7	**9.7**	2
bagre-amarelo	*Aspistor luniscutis*	1	**1.4**	
bagre-guri	*Genidens genidens*	2	**2.8**	
bagre-papai	*Genidens barbus*	2	**2.8**	
ARIIDAE			**16.7**	
robalo	Centropomus spp.	7	**9.7**	3
CENTROPOMIDAE			**9.7**	
caianha	*Archosargus rhomboidalis*	1	1.4	
enxada	*Chaetodipterus faber*	1	1.4	2
sardinha	Clupeidae	1	1.4	
tilápia	Cichlidae	1	1.4	
TELEOSTEI			**5.6**	
siri	Portunidae	1	1.4	
camarão	Penaeidae	3	4.2	
CRUSTACEA			**5.6**	
raia	Myliobatiformes	3	4.2	1
CHONDRICHTHYES			**4.2**	

logical cost, not requiring the use of large-scale vessels with greater autonomy. Thus, the cost of construction and maintenance of the fishing gear itself becomes central to the operational costs. The interviews allowed us to identify that the change in environmental legislation, especially in the 1990s and 2000s, and the incorporation of large areas used by the FWR fishing community into the Guapimirim MPA, resulted in a change in the material for structuring the fish weirs, with the need to use eucalyptus and bamboo wood, and to a lesser extent, the wood from the surrounding forests themselves, replacing mangrove wood. The ban on the extraction of wood for the construction of FWR was instituted in 2005 (MMA 2005, Table 1), close to the median replacement year found for the change reported by the fishers. The substitution was a critical step for the preservation of the last extensive remnant of the original mangrove cover that dominated

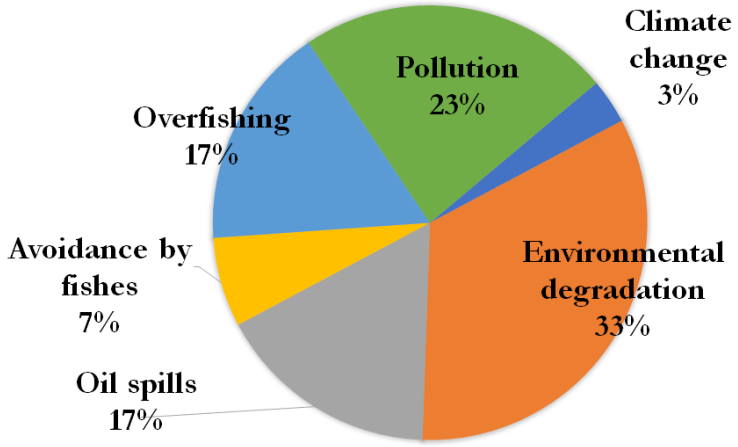

Figure 5: Reasons given for the decline in fish production and the reduction in fish size, by artisanal fishers operating the fish weir (FWR), in Guanabara Bay, Rio de Janeiro, Brazil.

the region in recent centuries, but the interviewees reported that it represented an increase in cost for the fishers, who now had to include the investment in a new source of wood to be able to reform and build new fish weirs, an expense absorbed entirely by the fishers themselves. This history was specifically addressed during the interviews and, while most of the fishers mentioned that they had already completed the transition to the use of bamboo and eucalyptus, most of the FWR visited showed the use of mangrove wood in their structure. The precise location of FWR structures, based on mapping made by agents of the MPA, including the identification of its proprietor, and the periodic surveillance by public agencies increased the fear of punishment, was signaled by some FWR fishers as a considerable factor for the change. The direct contact with fisher's associations created a channel to ease the transition and a permanent forum to voice concerns between both sides still takes place at the consultative committee of the MPA. Despite being contradictory, the indication of the use of mangrove wood by the fishers does not necessarily indicate the depredation of the mangroves protected by the MPA. The wood continues to be valued by the fishers for its resistance to marine conditions, being reused for the construction of new structures and repairs to active FWR.

According to the interviews and on-site visits, we observed that many fishers use mangrove wood on the FWR catwalk. This choice is justifiable, as the catwalk serves as the main structure supporting the fishers' weight during fishing activities or occasional repairs. Therefore, ensuring safety is essential for them to perform their work. Mangrove wood is particularly valued for being firm, malleable, and resistant to the weather conditions of the estuarine environment—qualities that make it more attractive than the available alternatives. In contrast, eucalyptus wood, with low resistance to estuarine conditions, demands a greater investment in the replacement of mats and logs, and consequently, reduces the profit obtained from fishing. The majority of the visited FWR structures still used mangrove wood in at least part of its construction, but fishers indicated also a high rate of reuse of mangrove from inactive FWR, which reduces the need of wood illegally removed from protected forests. The use of mangrove wood for fishing was also reported by traditional communities evaluated by Santos and Lana (2017) for a protected area on the coast of Paraná, Southern Brazil, with the ban on wood extraction being pointed out as an impediment to the practice of fishing.

It is crucial to emphasize that the primary focus of the extraction activity is the utilization of mangrove tree branches for the construction of walkways, as observed in the majority of the assessed FWR structures. Consequently, it can be affirmed that their employment offers a reduced environmental impact since it does not result in the demise of the tree, but rather the sustainable utilization of a portion of the organism. This situation is distinct from the utilization of a mangrove trunk as a supporting structure, as in the case of the "calão", consisting of the trunk of the tree, observed in a smaller but significant proportion of active fish weirs. The lifespan of the "calão" is greater when constructed from mangrove wood due to higher resistance to biofouling, salinity, and chemical processes in the aquatic environment, being a higher quality material than when made from eucalyptus, the legal alternative. This factor reveals the reason why mangrove wood, potentially originated from illegally extracted wood, is still found in use 30 years after the establish-

ment of the Guapimirim MPA. Separating both cases could be crucial for the reduction of conflict and improving the interaction between fishers and managers. Between the use of tree branches or the removal of its trunk, both mostly related to one species of mangrove tree, the white mangrove *Laguncularia racemosa*, only one of them causes the plant's death.

The reduction of conflict between the public interest and fishers socioeconomic survival could lessen the need of an extensive regulatory apparatus, while also promoting a more positive setting for the fisheries co-management approach, not necessarily limited to FWR fishers, but all fisheries in the region. This conclusion is not new nor exclusively applicable to the Guanabara bay case, Friess et al. (2016), based on several cases across Southeast Asia, describe that Marine Protection Areas aimed at preserving mangrove forests can have positive ecological but perverse socioeconomic impacts, a conclusion in line with what was reported by our interviewees. Concerns over the social impacts of the prohibition in the use of mangrove forests was already pointed out by Glaser et al. (2003) for a Brazilian Extractive Reserve on the northern coast of Brazil. Local fishers continued to make use of mangrove wood for boat building, construction and fuel, despite being an illegal act, but recognized the unsustainable nature of the activity and the need for an effective management. At the same time, most fishers signaled to be in favor of a co-management approach. In a recent study from the same region but 20 years apart, Galvão et al. (2024) identified the traditional use of mangrove wood in the area and emphasized the need to take this knowledge, as well as the associated communities, in consideration when designing conservation strategies. The authors suggest that the bleak picture of mangrove conservation can be reversed through a joint management framework that includes stakeholders, like FWR fishers, alongside local officials in sharing the responsibility for the conservation effort.

A final hopeful example for Guanabara Bay traditional fisheries comes from the community-led mangrove conservation case from West Kalimantan, in Indonesia, Miller et al. (2020) reported an increase in crab harvest rate and reduction of mangrove deforestation, with the local communities overall showing improved income, health and education. All fundamentally connected to a locally led natural resource management system. The Guapimirim MPA has a management committee that already includes local fishers representation, a crucial step to lessen the local conflict, but as the fishers left exposed in their report, the constitution of an effective joint conservation effort would greatly benefit if they perceive their interest be taken into account when local conservation policies are decided.

Interviews with Expert Fishers

Brazil stands out as a leading reference in the use of traditional knowledge to underpin scientific production on small-scale fisheries (Sousa et al. 2022). While this position is demonstrates academic interest in accessing a relevant source of information, it also reflects a historical scarcity of fisheries data, whether from commercial production or subsistence fishing, as well as the technological characterization of fisheries practiced along the Brazilian coast and in its watersheds. The inability to organize a national monitoring system has relegated the country to a situation of deep lack of knowledge about the current scale of production of Brazilian fishery resources, as well as the historical evolution of the exploitation of various commercial species (Dias et al. 2022). Thus, it was left to the scientific community to explore a local source of information with the potential to fill, even if partially, this scarcity of information, even though precautions about the quality of the information provided need to be taken for the full validation of the shared data (Davis and Wagner 2003; Santos et al. 2022).

The average aging of the artisanal fishing group has already been pointed out for another fishing community on the Rio de Janeiro coast by Trimble and Johnson (2013), with fishers indicating that their dedication to fishing was the result of belonging to a long lineage of artisanal fishers. However, they do not expect that future generations will continue to act as professional fishers, attributing the prediction to the decline in fish production and the inherent difficulties of the profession. The scenario described by Trimble and Johnson (2013) for a traditional community in Paraty—a coastal city about 270 km further south—partially mirrors the reality observed in Guanabara Bay. In this region, the interviewed fishers also belong to a traditional community and are, for the most part, children, grandchildren, or great-grandchildren of FWR fishers. They describe a context marked by the decline in the production of their main resource: the mullet.

The reduction in the volume landed over the last 30 years and also in the main fish categories of the FWR fisheries, reported by all interviewees, is also echoed in the reports of artisanal fishers from other parts of the Brazilian coast. Martins et al. (2018), based on interviews with fishers from the coast of Santa Catarina, southern Brazil, pointed to a 94% drop in whitemouth croaker catches, while 81% of fishers reported a drop in mullet production. Both whitemouth croaker and mullet are important resources exploited by traditional communities in southeastern and southern Brazil (Begossi et al. 2017), and it is necessary to consider the food security and economic viability of these populations in the management plans for these

species. While the decline in mullet and whitemouth croaker production was reported, monitoring the fluctuation of the populations of these species is essential to characterize the extent of the compromise of these resources over time. The interviewees' warning is further supported by the observation that whitemouth croaker is sold locally under a different common name, often associated with size classes smaller than the species' first maturation size (L50). Santos et al. (2015) found values of L50 for the population on southeastern Brazil at 34.1 and 32.9 cm for females and males, respectively. A sample of over 8,000 croakers caught along the entire Guanabara bay area resulted in around 80% of juveniles, with a median total length of 10.6 cm (Mulato et al. 2015). This is further corroborated by the fact that one of these variants of common names, known as 'corvinota,' was identified by a fisher as a category whose catch has increased in recent decades—indicating a growing fishing pressure on the immature segments of *Micropogonias furnieri*.

The environmental degradation of Guanabara Bay is widely known and a reality that still compromises the environmental quality. Despite successive programs dedicated to mitigating the effects of industrial and agricultural effluent discharged into its drainage basin, as well as raw sewage produced by the disorderly growth of the metropolitan area, the scenario remains challenging (Fistarol et al. 2015; Soares-Gomes et al. 2016; Silva Jr. et al. 2016). This fact has also been incorporated into the popular knowledge of fishers, composing, along with oil spills, the main culprits for the decline in catches. The latter is mentioned especially due to the memory of the accidental release of 1,300 m3 of naval fuel in January 2000 (Meniconi et al. 2001). The occurrence generated a point of conflict between the compensation offered by PETROBRÁS S.A., responsible for the damaged pipeline, and the losses felt by the fishing community, which is reflected in a negative perception that persists to this day.

Bernardes (1958) reports in detail the introduction of bottom-trawling, which was a more profitable alternative that attracted boats and their operators to an area originally dedicated to FWR fishing. Finally, the continuous alteration of the bay with successive landfills and the increase in boat traffic eliminated the areas where the FWR structures used to be built, forcing the fishers to take refuge in the upper estuary. Prestrelo and Vianna (2016) mapped the spatial conflicts between different fishing modalities and other economic activities, highlighting that the arrival of new actors in the bay, along with the implementation of new legislation that restricted fishing to a very limited area, led to noncompliance with the regulations imposed on the fishing fleet. These changes also intensified conflicts between different fishing sectors, aligning with the tensions between trawling and FWR fishing reported by the interviewees.

While the analyses were based on information provided by 20 traditional fishers, the female role tends to be obscured by the emphasis given only to the capture of fish and not to the entire production chain of this fishery. In these traditional communities, the act of fishing remains mostly characterized by male labor, even though female participation is detected but little evaluated. Women's participation is largely concentrated in fish processing activities (Trimble and Johnson 2013), which contribute to increasing the market value of species that are otherwise not highly appreciated by consumers. This dynamic was observed in the case of the siri-mirim (*Callinectes danae* Smith, 1869), a sustainably harvested species in the region (Garcia et al. 2022), as well as in the salting of catfish such as *Genidens barbus* (Lacépède, 1803) and *Genidens genidens* (Cuvier, 1829). The latter is a traditional preparation that was once commonly commercialized but is now primarily produced to meet the demand of the fishers themselves. These observations, reported by fishers and witnessed in fieldwork, coincide with studies for other traditional communities on the Brazilian coast (Santos 2015).

The use of TEK to access information about the dynamics of fishing in a region requires a positive relationship between researchers and the traditional communities being studied. The possibility of rescuing data that is unavailable in the specialized literature and in government agencies also implies an exchange that is beneficial to these communities. The necessity to make available the knowledge locked in these communities may offer an alternative route to access current and past catches of main targeted species. This data could help the Academy and future environmental policies derived from it, but also need to consider solutions that reconcile the economic viability and the success of management and conservation plans. The need has already been highlighted by Ticheler et al. (1998) in a study developed with the participation of traditional swamp fishers in Zambia. This simple act of acknowledging the community's collective memory strengthens its relationship with academia and lays the groundwork for future collaborative research, providing access to a broad spectrum of past and present knowledge (Silvano and Valbo-Jorgensen 2008). It also creates opportunities to encourage more active community involvement in the sustainable management of the natural resources on which they depend, both economically and culturally. In this context, participatory management becomes especially significant, given that it involves traditional communities located within an environmental protection area.

CONCLUSION

Guanabara Bay is an important Brazilian estuarine environment, both for its historical significance and the richness that still exists in the region. The interviews allowed us to record the perception of fishers over the environmental and technological changes, as a result of new conservation efforts being implemented. A direct assessment of fish production is currently underway to allow us to compare how catch data and fishing effort compare with fishers perceptions here described. It is important to emphasize that although the measure of implementing an MPA to protect the bay's mangroves was, and still is, essential for the preservation of local trophic webs, the policy generated an increase in costs for the region's FWR fishers. The cost of construction and maintenance of a fishing gear is central to the economic viability of a fishery, and it is essential to be taken into account by the developers of management plans, since the resistance of the fishers to its implementation or their participation as partners will depend on this equation and, consequently, the success of the management measure.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

CONTRIBUTION STATEMENT

Conceived of the presented idea: SRS, TRM, MV. Carried out the experiment: SRS, TRM, ABS, LCFG.
Carried out the data analysis: SRS, TRM, MV.
Wrote the first draft of the manuscript: SRS, TRM, ABS, LCFG, MV.
Review and final write of the manuscript: SRS, TRM, ABS, LCFG, MV.
Supervision: MV.

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