

## Local Ecological Knowledge of the Whitemouth Croaker, *Micropogonias furneri* among the Caiçaras in the Sepetiba Bay, SE Brazil

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**Abstract** Local Ecological Knowledge of artisanal fishers (*Caiçaras*) was employed to investigate various biological aspects of the Whitemouth croaker (*Micropogonias furneri*) in the Sepetiba Bay, in the state of Rio de Janeiro. This included migration patterns, reproduction, feeding habits, and interactions such as parasitism. Semi-structured interviews were carried out with 40 fishers in two communities using the “snowball” technique. It was found that the fisher’s information coincides with the academic literature for some aspects of the biology and ecology of the species. Furthermore, the fishers provided descriptions of novel patterns, which contributed to a deeper understanding of the species’ natural history. These included observations of reproduction occurring almost throughout the entire year, the influence of east and north winds on the species’ entry into the bay, interactions with marine catfish (Ariidae), and notable records of the isopod Cymothoidae as an important parasite of the Whitemouth croaker. This study contributes new insights to the ecological understanding of this fish species, which holds significant socio-environmental importance. It also documents changes in the livelihoods of artisanal *Caiçaras* communities resulting from the increasing anthropogenic activities in the region. Finally, it highlights the species’ significance in terms of its sale and consumption within these communities, owing to its relative abundance in the area, despite the environmental impacts.

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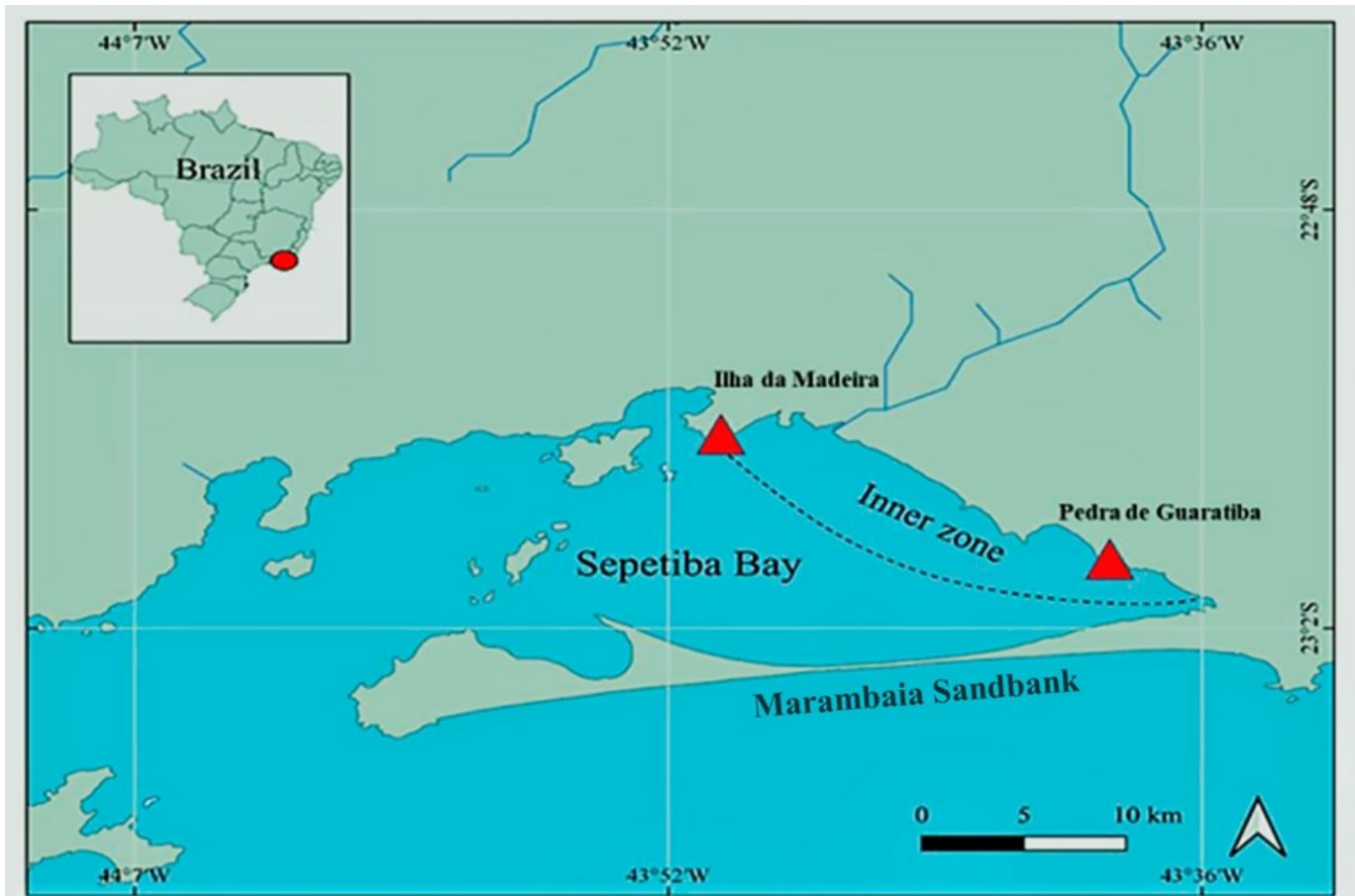
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### Introduction

Artisanal fishing communities self-identify as a traditional and cultural group, manage the development of their own economic activities, and deep social and historical connections to the territory (Giraldi and Hanazaki 2010). In the Sepetiba Bay, a semi-enclosed area spanning 450 m<sup>2</sup> on the south-eastern coast of Brazil, fishing serves as a subsistence activity for the local traditional community. As such, artisanal fishers maintain an ecological and cultural relationship with fishing. According to Begossi (2014), artisanal fishers and their families have relied on fish for both commercial purposes and personal consumption since the 1950s.

Scientific knowledge has been enriched and compared with Local Ecological Knowledge (LEK),

which represents the collective wisdom, practices, and beliefs, passed down orally from generation to generation. LEK encompasses the understanding of the intricate relationship between beings and their environment, including how these relationships have evolved in response to socio-historical changes within local populations (Fogliarini et al. 2021; Reyes-García et al. 2007). Despite their distinct epistemological foundations, the LEK of artisanal fishers can provide valuable insights that are not accessible through traditional biological approaches. As a result, it can complement and be considered on equal footing with scientific biological knowledge (Albuquerque et al. 2020). Ethnobiology incorporates both emic information, which comprises concepts specific to local populations, and etic information, which



**Figure 1** Sepetiba Bay with indication of the two locations (Ilha da Madeira and Pedra de Guaratiba) of the interviews with artisanal fishers.

encompasses the scientific perspectives and values of researchers (Shagrir 2017).

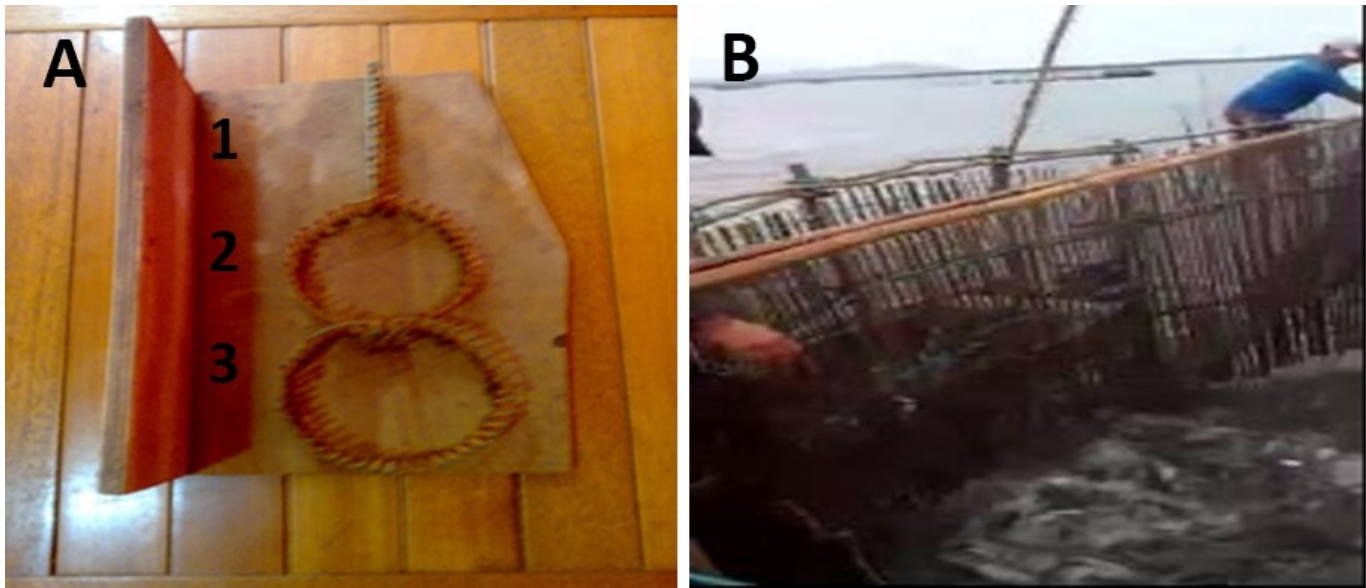
This study aims to analyze the LEK of artisanal fishers regarding the Whitemouth croaker (*Micropogonias furnieri*). The specific focus is on migration, reproduction, feeding, and parasitism, with the aim of identifying convergences between popular and scientific knowledge. By doing so, the study intends to provide complementary insights that might have been overlooked by existing biological information. By doing so, it contributes to a more comprehensive understanding of this fish species, which holds significant socio-environmental importance. Additionally, we include ethnographic records of the cultural aspects associated with the Whitemouth croaker within the *Caiçaras* communities, the local artisanal fishers residing in Sepetiba Bay. These records highlight the traditional fisheries, utilization, and significance of this species within these communities.

## Methods

### *Study Location*

Sepetiba Bay, located at coordinates 22°54'–23°04'S; 43°34'–44°10'W (Figure 1), is an elliptically shaped coastal feature spanning an area of 450 km<sup>2</sup> in the coast of the Rio de Janeiro State, SE Brazil (Kjerfve et al. 2021). The coastline is bordered by the Marambaia double sand barrier also known as the Marambaia Sandbank, which stretches for approximately 40 km. This sand barrier has an average width of 5 km and rises only a few meters above sea level, effectively separating the coastline from the South Atlantic Ocean (Kjerfve et al. 2021).

The formation of the bay creates a natural breeding ground for numerous species within its mangrove areas and estuarine zones. Fishing activities play a vital role in the economic and social support of the region. Furthermore, the bay's waters serve as a habitat for preserving diverse fauna and flora, while also providing opportunities for recreation,



**Figure 2** **A** This photograph depicts a miniature version of a large fishing trap known as a “curral” or “cercada,” skillfully crafted by a *Caiçara* artisanal fisher from Pedra de Guaratiba. The trap consists of three sections: 1) “Espia,” 2) “Sala,” and 3) “Chiqueiro,” with the latter being the specific location where fish are caught during the “despesca” process. The photo, taken by Claudio Nona Morado in 2018, showcases the intricate details of the trap. **B** Another image captured by an artisanal fisher from Pedra de Guaratiba in 2018 shows the fishers engaged in the “despesca” activity, with the picturesque Marambaia Sandbank forming the background.

navigation, and tourism. The region's scenic beauty, featuring waterfalls and islands, offers enticing areas for visitors to explore and enjoy (Ottoni 2018). The most recent human interventions in the bay include the expansion of the Sepetiba Port, which involved dredging the access channel to a depth of 20 meters. Additionally, a significant steel factory was constructed in 2010, followed by the establishment of a submarine building terminal in 2013 (Araújo et al. 2016).

#### *Fishers*

The southeastern coast of Brazil is home to a group of artisanal fishers known as *Caiçaras* (Figure 2 c, e, g). They are descendants of the indigenous Tubinambá tribe and Portuguese settlers. Additionally, their cultural heritage bears influence from other diverse backgrounds, including African and Japanese traditions.

The *Caiçaras* have successfully sustained their way of life by responsibly utilizing natural resources, thereby preserving a territory abundant in both biological and cultural diversity. For centuries, they have occupied these spaces without causing degradation or harm to the environment (Nogara 2003). Over time, the *Caiçaras* have witnessed shifts in

their economic activity. Initially, they engaged in agricultural pursuits, particularly the cultivation of manioc for flour production, rice, bean, cane, banana, coffee, corn, and different types of fruits. They typically exploit environmental resources for personal consumption, such as artisanal fishing, a practice observed from the beginning of the last century until the mid-1950s (Maciel 2011). In more recent times, tourism has emerged as their primary activity (Begossi 2006). Their primary protein source is fish, which are caught using gillnets, hooks, and lines to target fish, shrimps, and squids (Begossi 1996). In Pedra de Guaratiba, there is a traditional fishing method practiced by Indigenous people known as “curral” or “cercada.” This method involves constructing a trap using wooden logs, bamboo, and canvas (Figure 2a, b).

According to the Fundação Instituto de Pesca do Estado do Rio de Janeiro (FIPERJ), in 2010, fishing vessels in the state of the Rio de Janeiro are either affiliated with one of the 25 fishing colonies or are associated with the Union of Fishers Shipowners of the State of Rio de Janeiro (FIPERJ 2020). Despite the existence of these institutionalized fishing organizations, it has always been challenging for artisanal fishers to join, as it requires affiliation with



**Figure 3** In these photographs taken by Claudio Nona Morado (2018, 2019), we can observe various elements related to artisanal fishing practices. **A** A wooden “caique” or “caico” is depicted alongside wooden logs used in the construction of fishing “curral” or “cercada,” with the scenic Marambaia Sandbank in the background. **B** A “baleeira” boat is captured against the backdrop of the Marambaia Sandbank. **C** Artisanal fishers (*Caiçaras*) from Pedra de Guaratiba return from their fishing expedition in a “caique” or “caico,” accompanied by a “baleeira” and bamboo, which will be utilized in the construction of a “curral” or “cercada.” The Marambaia Sandbank forms a striking backdrop. **D** A traditional canoe is shown. **E** Artisanal fishers (*Caiçaras*) from Ilha da Madeira (A) are seen preparing their fishing nets. **F** A “caique” or “caico” and a canoe from the fisher colony of Ilha da Madeira Island are depicted. **G** A “lanchinha” boat and fishers (*Caiçaras*) from Ilha da Madeira are captured in the photograph. **H** A “baleeira” boat from Ilha da Madeira is shown, with a submarine building terminal visible in the background.

specific colonies and associations. As a result, fishers operating outside the institutional framework remain even more marginalized and overlooked (Silva and Suiama 2018). Within the Sepetiba Bay, there are three colonies of artisanal fishers, comprising 3,500 registered fishers and it is estimated that there are an additional 1,500 non-members (Silva and Suiama, 2018).

Recently, there has been a significant increase in industrial fishing activities along the south-eastern coast of Brazil, leading to conflicts with artisanal fisheries (Begossi et al. 2017). The fishing fleet operating in this region consists of small, medium, and large vessels from states including Rio de Janeiro, Espírito Santo, São Paulo, and Santa Catarina (Figure 3). These photographs offer a glimpse into the fishing activities carried out by the *Caiçaras* fishers from Pedra de Guaratiba and Ilha da Madeira, showcasing the various vessels, tools, and settings involved in their traditional practices.

The establishment of port terminals results in the creation of designated “safety zones,” spanning 500 meters on each side of the landing and berthing pier. These zones effectively become private spaces, restricting the utilization of maritime territory and giving rise to fishing exclusion zones. Consequently, artisanal fishing activities in these areas are constrained, as outlined in the study by Silva and Suiama (2018).

#### *The Fish*

The Whitemouth croaker (Figure 4) has a wide distribution range, spanning from the Yucatán Peninsula (Mexico, 28°N) to the Gulf of San Matías

(Argentina, 41°S) (Cousseau and Perrota 2013). This broad distribution can be attributed to the eurythermal and euryhaline characteristics of the species, enabling it to adapt to various habitats, exhibit reproductive plasticity (Franco et al. 2019), and display trophic plasticity (Martins et al. 2017). The species' diverse feeding habits suggest its potential participation as an intermediate or definitive host in parasitic transmission systems in tropical regions (Marcogliese 2002).

The Whitemouth croaker holds significant importance as a traditional demersal resource in estuarine areas of the southeastern and southern coasts of Brazil, constituting a crucial component of artisanal fisheries (Haimovici and Cardoso 2016). It has consistently ranked among the most abundant fish species in the Sepetiba Bay for several decades (Araújo et al. 2018; Costa and Araújo 2003) and currently represents the primary target species for artisanal fishers in the bay (Morado et al. 2023).

#### *Data Collection*

The selection of informant fishers for this study utilized the “snowball” technique (Albuquerque et al. 2014). The initial artisanal fishers interviewed provided referrals to other local fishing specialists. A total of 40 fishers from two communities were interviewed, with 20 fishers from each community. The interviews were conducted using semi-structured questionnaires with predefined questions of interest (Huntington 2000). This approach allowed for further exploration of new topics that emerge during the interviews (Albuquerque et al. 2014).



**Figure 4** The photograph captured by Claudio Nona Morado (2019) showcases a Whitemouth croaker caught by artisanal fishers from Sepetiba Bay.

**Table 1** The semi-structured questionnaire with the main points of the interviews.

Biological and ecological aspects addressed	Questions
Migration	What is the ideal condition for Whitemouth croaker to migrate?
Reproduction	How big does the Whitemouth croaker get? What is the approximate size of the Whitemouth croaker at the time of the first maturation? When does Whitemouth croaker spawn? Where are the Whitemouth croaker's spawning sites? How does Whitemouth croaker reproduce?
Food and interactions	What does Whitemouth croaker feed on? How do Whitemouth croaker interact (behavior with the group)? Is there any kind of interaction between Whitemouth croaker and other fish species? Do you know any type of parasite or Whitemouth croaker disease?

The interviews covered various topics, including migration, reproduction, food, and interactions, such as parasitism. They were conducted between

November 2017 and January 2019 (Table 1). Prior consent was obtained from the participants, and they signed the Informed Consent Form, following the

**Table 2** Expressions specific to the Local Ecological Knowledge of artisanal fishers (Emic) and to scientific knowledge (Etic) in the Sepetiba Bay.

Emic	Etic
<i>Baleeria</i>	Small trawler, 6 to 8 m long, with cabin and engine.
<i>Baratinha, pulgão, tatuizinho</i>	Fish parasitic isopod of the Family Cymothoidae.
<i>Bate poita</i>	Launching a heavy object (iron ball or stone) in the center of an area surrounded by the net, scaring the fish towards the net.
<i>Caceia</i>	Type of fishing that consists of leaving the net loose, with one of its ends tied to the vessel.
<i>Caique ou caico</i>	Wooden or fiberglass boat, measuring between 4 and 4.5 m.
<i>Calmaria da Restinga</i>	Inner area of Marambaia Sandbank, with good weather.
<i>Cerco</i>	Type of fishing that consists of surrounding the shoal with a net and throwing a heavy object in the center, directing the fish to the net.
<i>Chiqueiro</i>	Terminal area of the Large Fishing Trap, which serves for the effective capture of fish, called <i>despesca</i> .
<i>Curral ou Cercada</i>	Large Fishing Trap. Type of Indigenous peoples fishing, which consists of a large trap with several pieces forming specific compartments, with textures of wooden logs, bamboo sticks, vegetable vines and mats. They have one entrance that allows only big fish to get in, as the small ones escape through the fence. They were first built by the Indigenous people to catch migratory species, such as mullet. This type of fishing was common in several places in Sepetiba Bay, but currently it continues to occur only in Pedra de Guaratiba, bordering the Marambaia Sandbank.
<i>Espia</i>	Initial section of the larger fishing trap formed by a straight line that serves to direct the shoals towards the interior of the trap.
Inside <i>pega ovada</i>	In the inner zone of the bay, it captures Whitemouth croaker females in the reproductive phase.
<i>Lanchinha</i>	Aluminum or fiberglass vessel with a more modern design, ranging in size from 4 to 7 m. In the communities studied, it is also used for tourism and sport fishing, this last one mainly on Ilha da Madeira.
Middle of the water	Water column.
<i>Peixe de fundo</i>	Demersal species
<i>Ronca</i>	Emits sound
<i>Sala</i>	Central area of the fish corral, being the place where the school is when it enters the trap, before going to the <i>chiqueiro</i> .

**Table 3** Number of citations of environmental conditions and respective behavior of the Whitemouth croaker associated with reproduction and interactions with other species in the Sepetiba Bay, according to LEK.

Indicator	Citations	Detailed description
<i>Environmental Conditions</i>		
North and east winds (warmer weather)	06	"North and East winds favor this species to enter the bay or stay near the islands." (Fisher from Pedra de Guaratiba, 38 years old)
High tide	04	"It comes at high tide: it's in the 'middle of the water' and up at the moment—'half water'." (Fisher from Ilha da Madeira, 41 years old)
Food in the estuaries	01	"It comes when there is food in the estuaries." (Fisher from Ilha da Madeira, 49 years old)
Full moon	01	"Full moon favors the fish enter the bay." (Fisher from Ilha da Madeira, 68 years old)
<i>How do you know when the shoals are coming?</i>		
Produce sound	11	"Listen to their noise." (Fisher from Pedra de Guaratiba, 53 years old). "Noise of your 'snoring', I already know that." (Fisher from Ilha da Madeira, 72 years old)
High tide	02	"Tide starts to fill up starts to 'talk'." (Fisher from Ilha da Madeira, 69 years old)
Time of the year	01	"Mostly in August." (Fisher from Ilha da Madeira, 64 years old)
<i>Interactions (behavior with the group)</i>		
They are in the background	11	"They stay deeper." (Fisher from Ilha da Madeira, 52 years old)
Produce an audible sound from the boat	08	"They 'speak' in the shoal." (Fisher from Ilha da Madeira, 50 years old)
Produces odor	02	"You know by smell." (Fisher from Ilha da Madeira, 43 years old)
Eat and vomit	01	"They eat and vomit, forming 'dead waters'." (Fisher from Pedra de Guaratiba, 62 years old)
<i>Capture period</i>		
Whole year	15	"All year round." (Fisher from Pedra de Guaratiba, 66 years old)
Summer	07	"All year round, but more in the summer." (Fisher from Ilha da Madeira, 68 years old)
Winter	07	"In the cold." (Fisher from Pedra de Guaratiba, 79 years old)
<i>Interactions with other fish species</i>		
Catfish Ariidae	11	"With the catfish at the bottom: the catfish turns into mud and 'digs', and the croaker eats the 'worms' that appear." (Fisher from Pedra de Guaratiba, 64 years old)
Dolphin ( <i>Sotalia guianenses</i> ; <i>S. fluviatilis</i> )	03	"Dolphin attacks croaker." (Fisher from Pedra de Guaratiba, 53 years old)
White mullet <i>Mugil curema</i>	03	"Enough fishing for <i>parati</i> ." (Fisher from Pedra de Guaratiba, 58 years old)
Acoupa weakfish ( <i>Cynoscion acoupa</i> )	02	" <i>Corvina</i> and yellow hake 'walk' with the catfish to eat their roe." (Fisher from Ilha da Madeira, 41 years old).
Round sardinella ( <i>Sardinella aurita</i> )	02	" <i>Sardine maromba</i> ." (Fisher from Ilha da Madeira, 68 years old)
Shark (Elasmobranchii)	01	"Shark and dolphin feed on them." (Fisher from Ilha da Madeira, 52 years old)
Sand drum ( <i>Umbrina coroides</i> )	01	" <i>Betara</i> keeps the white <i>corvine</i> , the <i>betara</i> is almost like the croaker." (Fisher from Ilha da Madeira, 33 years old)

ethical guidelines approved by the Committee of Ethics in Research in Human Beings from the Castelo Branco University (approval number 3,089,110). Consistent with the methodology outlined by Herbst and Hanazaki (2014), the interviews were transcribed and organized into a database spreadsheet.

#### *Analyses*

The collected data were carefully selected, condensed,

and subject to qualitative analysis. This qualitative analysis aimed to comprehend the meanings and situational characteristics expressed by the interviewees (Marconi and Lakatos 2010). Additionally, a quantitative analysis was performed, examining measures such as means and frequencies.

The analysis sought to provide a descriptive comparison between Local Ecological Knowledge

**Table 4** Reproductive indicators of the Whitemouth croaker according to the LEK.

Indicator	Citations	Detailed description
<b>Size (mm)</b>		
		<b>Mean ± standard deviation</b>
Maximum size	31	700 mm ± 40 mm
Minimum spawning size	29	340 mm ± 15 mm
<b>Reproductive period</b>		
		<b>Descriptions</b>
Summer	13	"Mostly in summer." (Fisher from Pedra de Guaratiba, 64 years old)
Whole year	11	"All year round." (Fisher from Ilha da Madeira, 52 years old)
Winter	03	"Winter." (Fisher from Ilha da Madeira, 67 years old)
<b>Breeding sites</b>		
Marambaia Sandbank	05	" <i>Calmaria da Restinga</i> ." (Fisher from Pedra de Guaratiba, 66 years old)
Mangroves	04	"At the bottom of the bay, closer to the mangrove swamp." (Fisher from Pedra de Guaratiba, 62 years old)
Rivers	03	"On the rivers: Mouth of São Francisco, Guandu and Itaguaí rivers. Enter to spawn." (Fisher from Ilha da Madeira, 53 years old)
Mud	02	"Near Mud." (Fisher from Pedra de Guaratiba, 62 years old)
Open sea	01	"Open sea." (Fisher from Pedra de Guaratiba, 57 anos)
<b>Reproductive process</b>		
Enter the river to spawn	06	"It goes to the slopes of the rivers, now silted up, probably on the wharf, because it has a protected area." (Fisher from Pedra de Guaratiba, 65 years old)
Go to the mangroves	04	"They look for mangroves. The rivers are silted up, shallow, making reproduction difficult." (Fisher from Pedra de Guaratiba, 66 years old)
Shallow and warm water	02	"They look for shallow and warm water." (Fisher from Pedra de Guaratiba, 64 years old)
Spawn in the bay	02	"Spawning all over the bay." (Fisher from Ilha da Madeira, 67 years old)
In August	01	"In August the croaker approaches the entrance to the bay to spawn." (Fisher from Ilha da Madeira, 49 years old)
Inside (inner zone)	01	"Inside (internal area) <i>pega ovada</i> ." (Fisher from Ilha da Madeira, 58 years old)
It reproduces in the "sand", where there is sand	01	"It reproduces in the sand, where there is sand." (Fisher from Ilha da Madeira, 69 years old)
Open sea	01	"Open Sea." (Fisher from Pedra de Guaratiba, 57 years old)
It enters the bay to spawn	01	"It enters the bay to spawn because it has more food to reproduce." (Fisher from Pedra de Guaratiba, 51 years old)

(LEK) and scientific ecological knowledge, highlighting promising perspectives on topics including migration, reproduction, feeding, and interactions (e.g., parasitism). Interestingly, it is in instances where LEK diverges from biological knowledge that its greatest contribution arises. At this juncture, LEK unveils new insights and presents avenues for further investigation. Thus, these two epistemologies complement one another, supporting the concept of an "ecology of knowledge," as developed by Santos and Meneses (2009). This concept underscores the idea that knowledge is interdependent, recognizing that each epistemology alone is incomplete.

We compared the responses provided by the fishers and calculated the frequencies and proportions of occurrences where fishers mentioned similar patterns. For qualitative approach, textual analyses were conducted for certain questions. To accomplish this, the free software Interface de R pour les

Analyzes Multidimensionales by Textes et de Questionnaires (IRAMUTEQ) (Ratinaud 2009) was utilized. This software utilizes functionalities provided by the statistical software R to perform statistical analyses and assists in organizing, separating, and encoding data. The software employs text lemmatization, which allows words to be searched and related based on their root, disregarding verb tense, gender, and plurality (Kami et al. 2016). The summary of information contained in the similarity matrix is graphically represented in a tree structure.

## Results

Various typical expressions utilized by artisanal fishers from the two communities in Sepetiba Bay were documented (Table 2). These expressions are associated with the Whitemouth croaker or various aspects of fishing for this particular fish species.

Some fishers noted that the presence of north and east winds, which are associated with warmer waters, along with the beach sea conditions, is correlated with



**Table 5** Feeding of the Whitemouth croaker indicated by LEK.

Indicator (Food)	Citations	Detailed description
Sardine	13	"Sardine." (Fisher from Pedra de Guaratiba, 66 years old)
Shrimp	12	"Shrimp." (Fisher from Ilha da Madeira, 47 years old)
Seafood	09	"Seafood, eat what's at the bottom." (Fisher from Pedra de Guaratiba, 49 years old)
Crustaceans	05	"Crustaceans." (Fisher from Ilha da Madeira, 67 years old)
Algae	05	"Algae." (Fisher from Ilha da Madeira, 52 years old)
Anchovies	04	"Shrimp, anchovies and seafood." (Fisher from Ilha da Madeira, 68 years old)
"Little worms" (Polychaetes)	03	"'Earthworm' that stays in the mud and sardines." (Fisher from Ilha da Madeira, 53 years old)
Barnacle	03	"Barnacle." (Fisher from Pedra de Guaratiba, 62 years old)
Sludge	03	"Seaweed and 'sludge' from the bottom." (Fisher from Pedra de Guaratiba, 52 years old)
Catfish roe	01	"Catfish roe, shrimp, seafood, and barnacles." (Fisher from Ilha da Madeira, 41 years old)
Slime	01	"Slime and seaweed." (Fisher from Pedra de Guaratiba, 53 years old)
Clay	01	"Clay and gravel." (Fisher from Pedra de Guaratiba, 58 years old)
Gravel	01	"Clay and gravel." (Fisher from Pedra de Guaratiba, 58 years old)
Shells	01	"Shellfish, shells and sardines." (Fisher from Pedra de Guaratiba, 38 years old)
Oyster	01	"Shrimp, seafood, oyster, clam." (Fisher from Pedra de Guaratiba, 65 years old)
Vongole	01	"Shrimp, seafood, oyster, clam." (Fisher from Pedra de Guaratiba, 65 years old)

a higher abundance of the Whitemouth croaker in the bay (Table 3). It was observed that the species emits sounds and tends to inhabit deeper areas (Table 3). According to the fishers, artisanal fishing for the species occurs almost throughout the year (Table 3). The fishers also reported interactions between the Whitemouth croaker and other species in the bay, such as marine catfishes from the Ariidae family (Table 3).

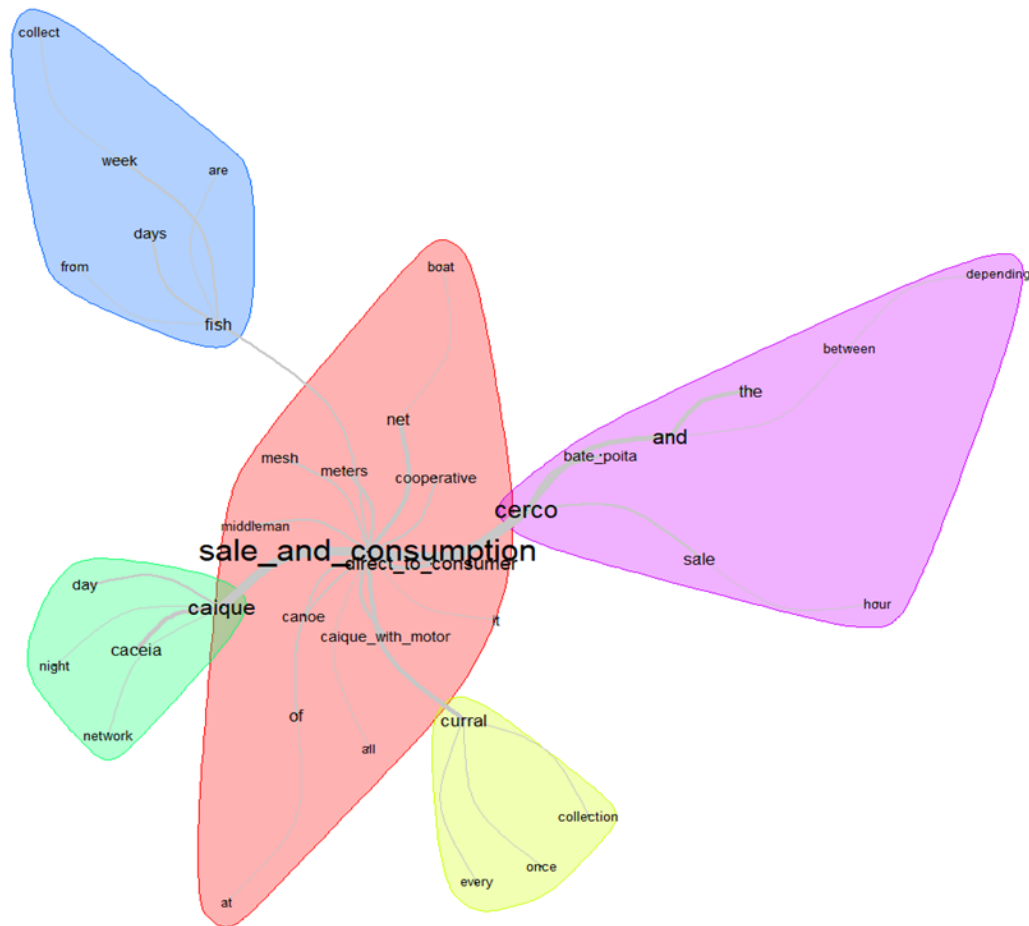
The Whitemouth croaker was reported to reach a maximum size of approximately 70 cm ( $\pm$  40 cm standard deviation), while the minimum size of mature individuals ready for reproduction averaged around 34 cm ( $\pm$  15 cm) (Table 4). According to fishers, the species engages in reproductive activities throughout the year, with a preference for the summer season (Table 4). Fishers indicate that the innermost part of the bay, the mangroves, and the lower river reaches are preferred spawning sites for

this species (Table 4). This behavior is considered by fishers as one of the key characteristics of the Whitemouth croaker's reproductive process in Sepetiba Bay (Table 4).

The primary food sources mentioned by the fishers were sardines and shrimp (Table 5). Fishers identified the presence of parasites as the main health issue affecting the species, referring to them using ethnotaxonomic terms such as *baratinha* (cockroach), *pulgão* (aphid), or *tatuizinho* (small armadillo). According to the interviewees, these parasites resemble white or yellow water cockroaches, aphids, or small armadillos, measuring approximately 1 to 2 cm in size. They attach themselves to the fish's gills, mouth, or tongue, with only one parasite per fish (Table 6). By analyzing the textual corpus containing the responses of artisanal fishers to questions regarding the fish utilization and fishing techniques associated with the Whitemouth croaker, the results of

**Table 6** Parasitism and changes in health of the Whitemouth croaker indicated by LEK.

Indicator	Citations	Detailed Description
<i>Baratinha</i> , <i>pulgão</i> , or <i>tatuizinho</i>	16	" <i>Baratinha</i> clings to the mouth or gills, white and about 1 cm." (Fisher from Ilha da Madeira, 68 years old).  " <i>Baratinha</i> : it looks like a small armadillo that enters the mouth and it becomes weak and dies. It is white and measures about 2 cm." (Fisher from Pedra de Guaratiba, 38 years old). " <i>Pulgão</i> that comes in and eats (he likes the sole a lot): a very small, yellow 'bug' eats the fish meat and sucks it." (Fisher from Ilha da Madeira, 52 years old)
Worm	06	"Worm, roundworm, inside the body, white, up to three in the same animal. I have been observing this for about ten years." (Fisher from Ilha da Madeira, 50 years old). "Earthworms: like an earthworm, 1 to 2 cm, ranging from white to red, more than 100 in the same animal, usually in large Whitemouth croakers." (Fisher from Pedra de Guaratiba, 24 years old)
Injury	02	"They have mouth sores." (Fisher from Ilha da Madeira, 51 years old)
Slim	02	"Lean meat, no blood, no color." (Fisher from Ilha da Madeira, 53 years old)



**Figure 5** Similarity Analysis Tree depicting the responses of fishers regarding the utilization and fishing techniques associated with the Whitemouth croaker. Source: Field Research, IRAMUTEQ (2020).

Classic Textual Statistics (ETC) revealed the analysis of 40 texts. This analysis identified 42 text segments (ST), 578 words occurrences, 224 different word forms, and 146 hapax (words that appear only once). The forms accounted for 65.18% of the total, while the occurrences represented 25.26% (Figure 5).

The term “sale and consumption” is positioned at the center of the representation, interconnected with other words, forming a semantic “fan.” These interconnected words exhibit a higher degree of similarity and collectively represent specific aspects or contexts related to factors associated with Whitemouth croaker fishing in Sepetiba Bay. These aspects are derived from the questions that comprise the textual corpus.

The keywords of this textual corpus were: “sale and consumption” (31), “*cervo*” (21), “*caique*” (18),

“direct to consumer” (12), and “*curreal*” (12). The expression “sale and consumption”, in the textual corpus, reflects the fact that Whitemouth croaker is a very important species for these communities both as a source of income and as a source of food. The word “*cervo*” demonstrates that this technique is the most used in capturing this species, while “*caique*” indicates that this is the type of vessel most used today. The expression “direct to consumer” indicates that in these communities the sale of Whitemouth croaker directly to consumers predominates. The word “*curreal*” demonstrates the great importance of this type of fishing even today for the community of Pedra de Guaratiba, but no longer for the community of Ilha da Madeira, which no longer uses it.

### Discussion

We found that the Whitemouth croaker is commonly



utilized by fishers for direct sale to consumers. This direct selling approach is crucial for maximizing the fishers' income from the fish, as intermediaries often result in lower earnings. Additionally, the Whitemouth croaker serves as an important dietary resource for the fishers themselves. Along the Brazilian Atlantic Forest Coast (BAFC), fishers rely on fish resources for sustenance and income. Consequently, any decline in catch or overexploitation of targeted fish species could have detrimental effects on the livelihoods of the fishers (Begossi et al. 2017).

The primary fishing technique employed is *cerco*, although *curral* or *cercada* remains significant in Pedra de Guaratiba. The prevailing vessel type is the *caique* or *caico*, which is gradually replacing the traditional *Caiçara* canoe. The transition is attributed to the flat base of the former, which facilitates navigation through the muddy areas caused by silting. According to Ottoni (2018), Sepetiba Bay currently faces significant siltation due to excessive solid and liquid waste from draining rivers and soil erosion. As a result, the waterline has receded from the fishing beaches, necessitating fishers to navigate through mud, which poses considerable physical exertion during fishing trips and returns. This phenomenon is more pronounced in Pedra de Guaratiba. Additionally, on Ilha da Madeira Island, there is a shift from artisanal fishing to tourism, particularly in association with sport fishing, utilizing more modern *lanchinhas* boats.

These facts demonstrate the transformation in the livelihoods of artisanal *Caiçaras* fishers in the two communities under study, which have been shaped by their adaptations to the anthropogenic influences on their traditional territories. Nevertheless, the sale and consumption of fish continue to serve as a crucial source of income and sustenance. In this context, the Whitemouth croaker remains a significant species for these communities due to its relatively abundant presence in the region, despite the escalating adverse effects of human activities in Sepetiba Bay.

The maximum reported body size reached by the Whitemouth croaker in Sepetiba Bay was 700 mm in total length. According to Haimovici and Reis (1984), females of the Whitemouth croaker achieve their largest size after gonadal maturation as an adaptation to increase total fecundity, ensuring reproductive success by spawning a large number of eggs. Reported here are declines in the size of Whitemouth croaker over time, as this species was previously captured

using a 70 mm mesh net with opposing nodes. However, due to the decrease in size, the largest net currently used has a 60 mm mesh size. Costa and Araújo (2003) suggest that larger fish may be experiencing higher mortality rates caused by fishing activities in the bay. Overfishing has been recognized as a significant factor in altering the abundance and biomass patterns of species and reducing the body size of individuals within populations (Peñaherrera-Palma et al. 2018). The Whitemouth croaker is known to be overfished by industrial fishing in southern Brazil (Haimovici and Cardoso 2016). Moreover, the additional stress of pollution, habitat destruction and climate change are likely to further jeopardize the sustainability of estuarine fisheries and exert detrimental effects on exploited species. The escalation of pollution resulting from human activities in Sepetiba Bay (Araújo et al. 2016) is likely to be a significant contributing factor that could have detrimental effects on various fish species, including the Whitemouth croaker.

In this study, fishers reported that the presence of north and east winds, associated with high temperatures and high tide, were the environmental conditions most favorable for the entry of the Whitemouth croaker into Sepetiba Bay. Whitemouth croaker is known to undergo seasonal migrations within the shelf ecosystem, primarily driven by reproductive movements that cause changes in composition of fish populations (Jaureguizar et al. 2004). In our study, we found that this species exhibits a practically year-round breeding period, with a preference for the warmer period. Fishers associate the breeding season with the observable behaviors, such as the presence of “oval” fish, which they interpret as spawning and procreating (Ramires et al. 2007). However, different studies have reported varied spawning periods for the species, including summer (Silvano and Begossi 2012); late spring and summer (Vizziano et al. 2002); winter and spring (Vazzoler 1991). The discrepancies among these studies suggest either a distinct spawning peak for Whitemouth croaker in the studied region or a potential shift in its spawning season since the 1990s, as noted by Silvano and Begossi (2012). To further elucidate the reproductive period and associated factors, more comprehensive biological research is necessary.

Two types of ecological relationship between marine catfishes and Whitemouth croaker were

reported in this study. The first is a competitive relationship, as described by the fishers: “With the catfish at the bottom: the catfish turns to mud and ‘digs’ and the Whitemouth croaker eats the ‘worms’ that appear.” In this case, it is likely that the catfish is stirring up the substrate in search of food, mainly polychaetes. The second type of relationship between Whitemouth croaker with marine catfish is predation. According to the fishers “Whitemouth croaker and yellow hake walk together with catfish to eat their roe”. This clearly indicates a case of predation, where the Whitemouth croaker approaches the catfish during their reproductive period to feed on their eggs. Further studies should focus on exploring these interactions to gain a comprehensive understanding of the ecological dynamics in the estuarine ecosystems of southern Brazil.

Another aspect of Whitemouth croaker interactions with other species, as reported in the LEK of artisanal fishers, is parasitism. The LEK strongly suggest the presence of a specific type of parasite affecting Whitemouth croaker. According to the fishers, this parasite bears a resemblance to a “small cockroach”, “aphid”, or “small armadillo” due to its anatomical similarities with these organisms. They describe this parasite as being white or yellow, measuring between 1 and 2 cm in length. It attaches itself to the fish’s mouth, tongue, or gills, with only one parasite per host. Infected fish appear visibly emaciated, as if their blood had been drained by the parasite. The reported parasite by the fishers is a cymotoid, an Isopod from the family Cymothoidae. It is worth noting the interesting study conducted by Luque et al. (2010), which explored the parasites of the Whitemouth croaker along the longitudinal gradient of the Brazilian coast. The study identified members of the Cymothoidae family as parasites infesting mouths of Whitemouth croaker from Pedra de Guaratiba, thus corroborating our findings.

In summary, the Whitemouth croaker’s reproductive period in Sepetiba Bay, as perceived by fishers, extends throughout the year, with a notable peak during the summer. This differs from the existing literature, which only mentions the summer as the reproductive period for the species. Fishers have also observed a decrease in both the size of the fish and the size at which they reach gonadal maturity, potentially indicating the effects of overfishing or climate change. Additionally, the fishers’ perception of breeding areas, such as mangroves and rivers,

contrasts with scientific knowledge that identifies the inner shelf as the primary spawning area. According to the fishers, the entry of the Whitemouth croaker into the bay is associated to north-to-east winds, and their diet consists of sardines, shrimps, and benthic organisms. The interactions with marine catfish and the potential role of Whitemouth croaker as an important host for species of the Cymothoidae family (Isopoda) in the Sepetiba Bay region were also reported, suggesting a possible increasing relationship between them.

This study highlights the significance of incorporating the knowledge held by artisanal fishers to enhance our understanding of the ecology and socio-environmental importance of the Whitemouth croaker. It provides an ethnographic account of key cultural aspects related to fishing and the utilization of this species by artisanal *Caíçaras* communities in Sepetiba Bay. Furthermore, it sheds light on the adaptations made by these communities in response to the escalating anthropogenic impacts on this crucial bay located in the state of Rio de Janeiro.

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### Declarations

*Permissions:* The research was duly authorized by the Committee of Ethics in Research in Human Beings from the Castelo Branco University, registered under number: 3,089,110.

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