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Fishers' knowledge in Southeast Brazil: The case study of the Brazilian sardine

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ABSTRACT

Fishers' local ecological knowledge (LEK) presents the enormous potential to assist in the conservation of depleted natural resources available to small-scale fisheries worldwide. Due to the significant socioeconomic value of sardines in the Southwestern Atlantic, the objective of this work was to register the LEK about Brazilian sardine of the traditional fishing village of Arraial do Cabo, Rio de Janeiro State, Brazil. Social science tools were used to extract data from biology, ecology, food taboos and human uses of Brazilian sardine. A qualitative analysis was performed through accurate coding and cross-checking using an emic-etic approach and all data made available was taken into consideration. Fishers highlighted information on areas of habitat, migration patterns, trophic ecology, and reproduction season. The LEK showed compliance with scientific literature in relevant points of the ecology and biology of this species which have a life the history that leads to increased vulnerability due to overfishing and management difficulties. We emphasize the importance of continuously sharing the LEK of the sardines between the community, researchers, and managers in favor of a more effective socio-ecological conservation of this fishing resource in Arraial do Cabo.

1. Introduction

The search for understanding the diversity of the relationships between human cultures and natural resources is crucial so that these human beings can continue to ensure the sustainable use of the resources available and ecosystem services (Pardo-de-Santayana and Macía, 2015). In situations where the lacking of historical and physical data from a particular region is evident, traditional knowledge gains strength and becomes the only available source of information about that environment (Huntington, 2011).

Ethnoecological studies in this context emerge with the function of providing the local ecological knowledge (LEK) of human communities about the biology and ecology of natural resources (Begossi, 2008). This knowledge essentially aims to understand a specific group of human beings about their ecosystems through the interaction between organisms and the environment, and between the organisms themselves (Olsson and Folke, 2001). The worldwide current research of fishers' knowledge has been showing conservationist insights (Braga et al., 2017a, b; Frans and Augé, 2016; Mathé and Rey-Valette, 2015; Quynh et al., 2018; Whitmore, 2016; Zhang and Vincent, 2017), and crucial ecological and biological information on marine species (Gaspare et al., 2015; Liu et al., 2016; Manzan and Lopes, 2016; Martins et al., 2018; Zapelini et al., 2017).

LEK still presents as a reliable partner of scientific knowledge, as it may possess the ability to supplement data from traditional science where they are scarce or absent (Le Fur et al., 2011; Uprety et al., 2012). Small-scale fishers, in particular, can provide detailed information about fish species and thus assist in the conventional management of fishery resources, as well as generate testable hypotheses for science (Silvano and Begossi, 2010). Another critical link to LEK is its importance for tropical coastal fisheries where available information on fish stocks is not yet sufficient for fishing management (Berkes, 2003;

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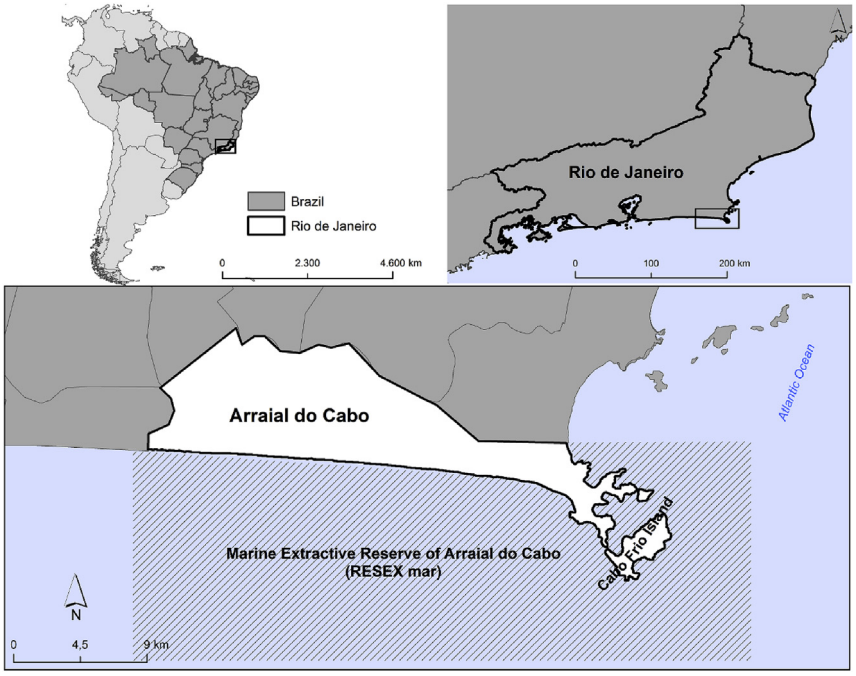

Fig. 1. Area of the study showing the municipality of Arraial do Cabo, and the limits of the Marine Extractive Reserve of Arraial do Cabo in Southeast Brazil. Credits: Anjos, M.

Gerhardinger et al., 2009), as occurs with the Brazilian sardine.

The Brazilian sardine *Sardinella brasiliensis*, (Steindacher, 1879) is a small pelagic fish, distributed in the Western Atlantic, mainly found in the Gulf of Mexico, Brazil, and Uruguay (Fishbase, 2018). It is an oceanodromous and short-lived species of the Clupeidae family, forms compact schooling and lives in coastal waters near areas of high primary productivity (Cervigón, 1992; Paiva and Motta, 2000). Sardine is an omnivorous and fast-growing species (Schneider and Schwingel, 1999) and presents a diet based on phytoplankton and zooplankton (Costalago et al., 2015). This species has prominent ecological importance in the marine ecosystem due to its high abundance and its intermediate position in the food webs, which makes it a crucial keystone species (Jordán, 2009; Padovani et al., 2012).

This clupeoid is found mainly inhabiting coastal waters on the Southern Brazilian shelf, specifically between Rio de Janeiro State (22° S) and Santa Catarina (29° S) (Jablonski, 2007). According to the latest report released by the Rio de Janeiro State Fisheries Foundation, sardines are the most caught species in the fishing ports (47,204.60 tons), which represents 77.8% of all state production (FIPERJ, 2015). Precisely in the Cabo Frio system that includes the coast of Arraial do Cabo, sardine also stands out as the leading natural resource landed at the regional fishing port (FIPERJ, 2015). In addition to this fishing pressure, sardine mortality on the Brazilian coast is also linked to external forces such as climate change, starvation in the larval phase, predation, and death from pollution and habitat degradation (Cergole and Dias-Neto, 2011).

In the Southwestern Atlantic, Brazilian sardine is considered a biological resource of extreme socioeconomic importance for the fishing communities (Dallagnolo et al., 2010). Traditional artisanal fisheries in Arraial do Cabo captures this species of fish through purse seines in fishing boats known as small trawlers (Diegues, 2003). In the industrial fishing of the State of Rio de Janeiro, the capture of Brazilian sardines occurs mainly in industrial trawlers, but may also happen in tuna and "*douradeiros*" fleets (Ibama, 2015).

In Arraial do Cabo, all segments of the sardine fishing production chain, are present. However, this productive chain is in a fragmented way, showing distancing between production and consumption, where the middlemen are the most benefited (Mendonça et al., 2012). *S. brasiliensis,* in this frame of fishery production, stands out for presenting an essential regional stock mainly within the Marine Extractive Reserve of Arraial do Cabo (Coelho-Souza et al., 2012), where the local community presents exclusive permission for the fishing (Giglio et al., 2017).

Even with all the difficulties faced by sardine fishing around the world and its close relationship with traditional livelihood, fishers' LEK studies with this small pelagic fish are almost non-existent. There is only one report of an ethnozoological study with Brazilian sardines, but with a focus on conservationist attitudes (Braga et al., 2018b). Only two other scientific investigations of this scope focused on clupeoids but were based on another species in the North Atlantic (Braga et al., 2017a, b).

Thus, given the current vulnerability of small-scale fisheries management in Latin America, the adoption of innovative management approaches is essential to undermining the viability and sustainability of this sector (Leis et al., 2019). The Brazilian sardine in this scope becomes a potential object for the study of LEK in Arraial do Cabo (Braga et al., 2018a). Due to all the socio-ecological characteristics presented by the study area and its dependence on this fishery, there is an imminent possibility for local fishers to generate a set of knowledge about this fishery resource. In this perspective, the goal of this study is to summarize and document in detail local ecological knowledge (LEK) on the biology, ecology, food taboos and human uses of Brazilian sardine (also known as Brazilian sardinella) using the ethnobiological data collection tool. Fishers' LEK from the fishing village of Arraial do Cabo, Rio de Janeiro, Brazil, were also compared and discussed with the available scientific literature about sardines.

2. Methods

2.1. Study site

Community-based interviews were conducted in Arraial do Cabo (22° 57′57″S, 42° 01′41" W) State of Rio de Janeiro, Brazil (Fig. 1). This region is located 117 km north from the city of Rio de Janeiro in a straight line and has a population of 29,304 inhabitants (IBGE, 2017). Arraial do Cabo presents itself in the form of a small peninsula with