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Temporal changes of a coastal small-scale fishery system within a tropical metropolitan city

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ABSTRACT

Small-Scale Fishery Systems have changed in the last decades under the influence of multiple human activities. The Itaipu Small-Scale Fishery System is under the influence of gentrification of an almost exclusive fishing village, allied to economic demands and technological advances. The present study aimed to understand the adaptive strategies of this system based on the analysis of changes that have occurred in the last four decades regarding the following parameters: catch composition and fish production, characteristic fishing methods and the gear and vessels used in the activity. The spatial distributions of gillnet and hook-and-line catches and their relationship with the defined area of the Itaipu Marine Extractive Reserve was also evaluated. The results indicate the capability of the Itaipu Small-Scale Fishery System to adapt over time concerning disturbances. These results may contribute to the management of the fishing system at the Marine Extractive Reserve.

1. Introduction

Small-Scale Fisheries (SSF) are globally important productive sectors, contributing to more than half of the world fish production (FAO, 2015). Over 90% of the 4.36 million active fishing vessels in the world are small-scale (Schuhbauer and Sumaila, 2016), acting as suppliers of local and regional markets (FAO, 2016). Teh and Sumaila (2013) also estimated that SSF support up to 22 million fishers, making up about 44% of all fishermen in the primary production sector, with an additional 100 million people involved in SSF post-harvest sectors (Béné et al., 2007). The most recent official data in Brazil indicates that SSF are responsible for 65.0% of the national seafood production (fish and shellfish), and employ 957,000 people, corresponding to 99.2% of the officially registered professional fishermen (IBAMA, 2007; MPA, 2012).

In addition to their economic importance, and their dynamic and diversified character, SSF are, many times, associated with local communities, often reflecting historical relationships with the environment and its natural resources, as well as traditions and adjacent values, favoring social cohesion processes incorporating globally relevant cultural wealth (FAO, 2015). Despite their importance, evidence of the decline or disappearance of small-scale fisheries is increasingly apparent (Ainsworth et al., 2008; Kittinger et al., 2013; Tesfamichael et al., 2014), especially in marine coastal areas close to major urban centers, where approximately half of the world population lives or works (Small and Nicholls, 2003). While the importance of SSF is widely acknowledged, information about this sector is limited, which makes it challenging for defining management strategies adapted to their multiple contexts (Salas et al., 2007).

Urban populations increase pressure on ecosystems and their natural resources. The historical evolution of such pressures upon fishing communities led to the adaptation of these social groups to new scenarios, but also the disruption of both social structure and infrastructure (Olson, 2010; Colburn and Jepson, 2012). Coastal fishing communities are picturesque, attracting tourism and part-time residents from time to time. This population influx may be seen as a coastal gentrification process, where external, nonlocal economic forces alter these nonmetropolitan communities, establishing a new power structure and driving fishermen away from their working environment (Gale, 1991; Thompson et al., 2016).

Impacts of multiple human activities such as pollution, disputes over space and resources with other productive sectors, like industrial and recreational fishing, the oil industry, as well as overfishing, also cause SSF alterations (e.g., Jackson et al., 2001; Lotze et al., 2006; Harnik et al., 2012). Furthermore, SSF sustainability may be further

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jeopardized by global climate changes, especially in tropical countries (Sumaila et al., 2007; Lam, 2012). Small-scale fisheries in local communities may become vulnerable (*sensu* Kasperson and Kasperson, 2001) to these myriad threats. The degree of exposure to a given threat, how the local people are affected by this threat (sensitivity) and how they respond (resilience) are incorporated in the vulnerability concept (Thompson et al., 2016). As these threats persist, integrated approaches to management are needed to ensure SSF sustainability while benefiting resource users and protecting the marine environment (Afflerbach et al., 2014).

Territorial Use Rights for Fisheries (TURFs) are a spatial form of property rights granted to individuals or a group of fishermen, in which they have access privileges and fishing rights to exploit fisheries resources within a designated area (Christy, 1982; Quynh et al., 2017). In Brazil, public policies directed at traditional SSF include the establishment of a TURF-type reserve called Marine Extractive Reserves (RESEX-Mar). The Itaipu fishing community, located in the city of Niterói and within the metropolitan circle of the Guanabara Bay and the city of Rio de Janeiro, recently became one of these reserves (Itaipu RESEX-Mar). Local traditional fisheries have been studied since the 70's, describing fishing methods, and the local ecological knowledge related to fishery resources (Lima and Pereira, 1997; Pessanha, 2003; SEA/INEA, 2013). Available information encompassing three different periods across more than four decades, have provided an important dataset to test for significant changes in the traditional fishery system under several economic and gentrification pressures. Our hypothesis is that the gentrification of an almost exclusive fishing village, combined with economic demands and technological advances, have influenced artisanal fisheries, leading to changes and adaptations in fisheries technologies (from traditional to novel), fisheries production, and the use of the traditional fishing areas. Thus, the main aim of the present study is to use the Itaipu RESEX-Mar as a study case for identifying trend adaptation capacities in a SSF system, located in a large metropolitan region, facing the dilemma of fisheries collapse due to several economic, social and environmental pressures.

2. Methods

2.1. Study area

The research was carried out in a traditional fishing community located in the coastal zone adjacent to Guanabara Bay, in the South Atlantic Ocean. Guanabara Bay is one of the most important and urbanized estuarine environments in the Brazilian coast, surrounded by the metropolitan region of Rio de Janeiro, with a population of more than 12 million inhabitants (IBGE, 2016). The average annual population growth in the region was of 0.86% in the last decade (Chediek, 2014). The fishing area includes a variety of ecologically relevant environments, including two coastal lagoons (Itaipu and Piratininga lagoons) and a three-island cordon that aggregates high fish and invertebrate biodiversity (Mendonça-Neto et al., 2008; Chaves and Monteiro-Neto, 2009). The region is mainly influenced by tropical ocean currents, with the occasional upwelling of cold-water masses (SACW) predominantly in the summer, and a frequent supply of coastal waters from Guanabara Bay and Itaipu and Piratininga lagoons (Monteiro-Neto et al., 2008; Cerda et al., 2013, 2016) (Fig. 1).

Itaipu and Piratininga beaches maintain records of the occupation of ancient human hunter-gatherer populations, called sambaqueiros (4500 years ago). These pre-historic groups already explored fishery resources in the area for their own consumption (Kneip et al., 1981; Mello and Coelho, 1989; Anjos et al., 2010), indicating strong fishing traditional roots. The artisanal fisheries currently found at Itaipu date back more than 200 years (BRASIL, 1876; Araujo, 1945). Fishermen Traditional Ecological Knowledge (TEK) from ancestral populations has been transmitted throughout generations of fishermen (Lima and Pereira, 1997; Pessanha, 2003). Since the 1920s, local professional fishermen have been institutionally linked to the Z-7 Fisheries Colony (Federal Bill Nº 11.699/2008), which also includes fishermen from neighboring areas or local fishermen's associations. Currently, most of the fisheries are concentrated within a TURF type reserve, the Itaipu Marine Extractive Reserve (Itaipu RESEX-Mar) (Fig. 1). The reserve was officially created by decree on September 30, 2013 (Decree No. 44.417, Official Gazette of the State of Rio de Janeiro). The Itaipu RESEX-Mar encompasses an area of 3943.28 ha, which was previously approved by the fishermen, and other representative groups, following the national legislation guidelines (SNUC, 2000).

2.2. Sampling and data analysis

Current data on catch composition and fish production were obtained by a daily landing monitoring program, developed by the Institute for Fisheries of the State of Rio de Janeiro (Fundação Instituto de Pesca do Estado do Rio de Janeiro - FIPERJ), from January to December 2013. During this period, the following information was recorded: date of landing, fishing gear, fishing area, composition and specific production (kg) of the catch. The species were identified based on relevant literature (Figueiredo, 1977; Figueiredo and Menezes, 1978, 1980; Menezes and Figueiredo, 1980, 1985, 2000; Carvalho-Filho, 1999). The fishing yield (Catch Per Unit Effort - CPUE) was calculated using the number of fishing trips as the unit of effort. Information on the characteristics of each type of fishing methods, the gear used and active vessels were obtained from structured and semi-structured interviews conducted with the fishermen, between March 2013 and February 2016.

To identify the spatial patterns of gillnet and hook-and-line catches, the fishing locations reported by the fishermen were geographically positioned within 2 nautical mile quadrants and plotted on maps. The presented information refers to the fishing yield (CPUE) per quadrant, calculated by the sum of the catch divided by the total number of trips performed in each quadrant.

To verify changes in fisheries over the last four decades, previously published information was compiled and used as reference for the following parameters: (i) catch composition, (ii) production, (iii) fishing yield (CPUE) (iv) general characteristics of the fishing methods, (v) boat type and (vi) fishing area. The main sources were: 1st period (1970–1973): Lima and Pereira (1997), and Pessanha (2003); 2nd period (2000–2003): Tubino et al. (2007, 2014); 3rd period (2013–2016), FIPERJ official statistical data and the present study. To assess possible modification vectors affecting the fisheries over time, relevant information about the evolutionary history of the local fishing system were chronologically compiled from the available literature.

3. Results

3.1. Fishermen and people associated with fish production

Currently, Itaipu fisheries comprise approximately 110 fishermen directly engaged in fishing activities, and 13 fish buyers (traders). Among the 81 fishermen interviewed, 73.6% were men, 49.0% were over 50 years old, and 43.0% between 30 and 50 years (average = 50.0 years, SD = 13.7). Just over half (51.0%) stated their father was also a fisherman and 85.0% were affiliated to the Z-7 fishermen's colony. Most were engaged in gillnet and hook-and-line fisheries (43.0% and 35.0%, respectively). A small number (13.0%) participated exclusively in beach seine fisheries.

Daily production is landed at a single point on Itaipu beach and the sale is carried out through an auction system between fishermen and local traders. Subsequently, the catches are sold in in-store benches on the beach to local restaurant owners, the general population, and brokers from nearby markets. At least 20 restaurants and snack bars that offer fish as part of their menu are located on the same beach where the landings take place.