The Socio-ecological system of selected Brazilian small-scale fisheries

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Abstract
Small-scale fisheries are very important food producers in Brazil. In this study, we focus on analyzing ten variables relative to SES (socio-ecological system) for the small-scale fisheries of Fernando de Noronha Island (NE Brazil), Itaipu, Niterói, Grande and Gipóia Islands and Ihabela Island (Bonete, São Paulo State) (SE Brazil). From this analysis we perceive that having local leadership is a necessary, but not a sufficient condition, to take collective actions. Thus, we need to better understand what factors are obstacles to collective action for local governance. We observed similarities among the communities studied, especially concerning the users and the nature of the resource.

Key words: Atlantic Forest, Brazilian fisheries, Governance, Small-scale fisheries, SES (Socio—Ecological System)

O sistema sócio-ecológico de selecionadas comunidades pesqueiras do Brasil

Resumo
Comunidades pesqueiras artesanais são importantes para a produção de alimento no Brasil. Nesse estudo, estudamos dez variáveis relativas a SES (sistemas sócio-ecológicos) para as comunidades pesqueiras de Fernando de Noronha (NE Brasil), Itaipu, Niterói, Ilhas Grande e da Gipóia, bem como de Ihabela (Bonete, São Paulo State) (SE Brasil). Dessa análise, percebemos que possuir uma liderança local é uma condição necessária, mas suficiente para resultar em ações coletivas. Dessa forma, precisamos entender melhor os fatores que são obstáculos à ações coletivas para a governança local. Há similaridades entre as comunidades estudadas, especialmente relacionadas à usuários e à natureza do recurso.

Palavras chave – Comunidades Pesqueiras do Brasil, Mata Atlântica, Governança, Pesca de Pequena Escala, SES (Sistema sócio-ecológico)

1. Introduction

Small-scale fisheries are very important food producers, especially because they often bring a higher diversity of fishes to the table compared to the few species that are the focus of industrial fisheries. This importance is even more apparent in Brazil, where approximately half of the fish catch comes from small-scale (artisanal) fisheries (Vasconcellos, 2007).

However, the management or co-management of these fisheries remains very problematic, since governmental approaches are still top-down, and there is little or no positive interaction among governmental environmental protection agents and fishers. Jentoft (2003) observed that fishery co-management failures can result in people being negatively disposed toward the viability of this approach; bureaucrats are often the most '*vociferous sceptics*'. Begossi and Brown (2003), Begossi (2006) and Begossi et al. (2013) observed that incipient forms of management by small-scale fishers from the Atlantic Forest coast of SE Brazil, which are characterized by the application of local property rules to the fishing areas, are completely ignored by the environmental authorities. These local rules could be a starting point for a process of collective action and co-management. Seixas (2006), in a review of some small-scale fisheries in SE and NE Brazil, presented several barriers to participation and management, including socioeconomic and cultural marginalization of artisanal fishers, a culture of a patron-client relationship and corruption, misrepresentation of fishers within their associations, lack of government support and recognition, and a lack of effective government presence, among others. In another study, Seixas et al. (2009) examined five different fisheries management contexts in Brazil,

including the freshwater riverine of both the Amazon and SE Brazil and the coastal marine sites of the Atlantic Forest in SE Brazil. Several factors were shown to be obstacles to co-management, including a lack of government support, conflicts among user groups, a lack of stock information, violations of locally devised rules, and difficulties in defining and estimating users and beneficiaries. However, different paths have been taken by other small-scale fishers: examples include the lobster fishers of Maine, who undertake collective action by following their local rules (Acheson, 2003).

The analysis of collective action and other management processes have gained a strong multidisciplinary focus comprising fields such as anthropology, ecological economics, evolutionary ecology and sociology, among others, due to the classic studies by Ostrom (1990, 2005). Ostrom (2005: part I) states, in general terms, that '*institutions are the prescriptions that humans use to organize all forms of repetitive and structured interactions*'. Thus, frameworks must be developed to understand the collective actions ('*collective choice arenas*') associated with the management of common pool resources (Ostrom 1990: 52-53). The theory of Olson (1965) supported many aspects of Ostrom's frameworks, such as the analysis of the organization of groups, including their sizes and behaviors.

In this context, analytical frameworks, such as predictive SES (Social Ecological Systems) models, were developed. According to Ostrom (2007), many variables affect the self-organization and robustness of common property regimes. The framework developed in this study enables the analysis of the interactions among the variables in the resource system, the resource units, the users and the governance system (the '*second-tier variables*

in the framework for analyzing SES'). This framework, which enables different disciplines to analyze the complexity of SES (a 'common framework'), was further developed by Ostrom (2009), who stressed ten key variables that determine whether users will self-organize.

Thus, we developed descriptions of the SES framework for the Paraty fisheries of the Atlantic Forest Coast of SE Brazil (Begossi et al., 2012). In Latin America, Basurto et al. (2013) used this framework to analyze small-scale benthic fisheries, and Cantareli (2015) described the SES of two different small-scale fisheries in Brazil: one in the NE (Fernando de Noronha Island) and one in the SE (Bonete, Ilhabela Island). In this study, we focus on analyzing the ten key variables mentioned by Ostrom (2009) for the small-scale fisheries of Fernando de Noronha Island (NE Brazil), Itaipu, Niterói, Grande and Gipóia Islands and Ihabela Island (Bonete, São Paulo State) (SE Brazil).

2. Study sites

Information about the Fernando de Noronha and Bonete (Ilhabela) study sites is available in Cantareli (2015) and the Itaipu (Niterói) and Grande and Gipóia Islands (Rio de Janeiro) in Begossi et al. (2010, 2013). Brief descriptions follow (Figure 1):

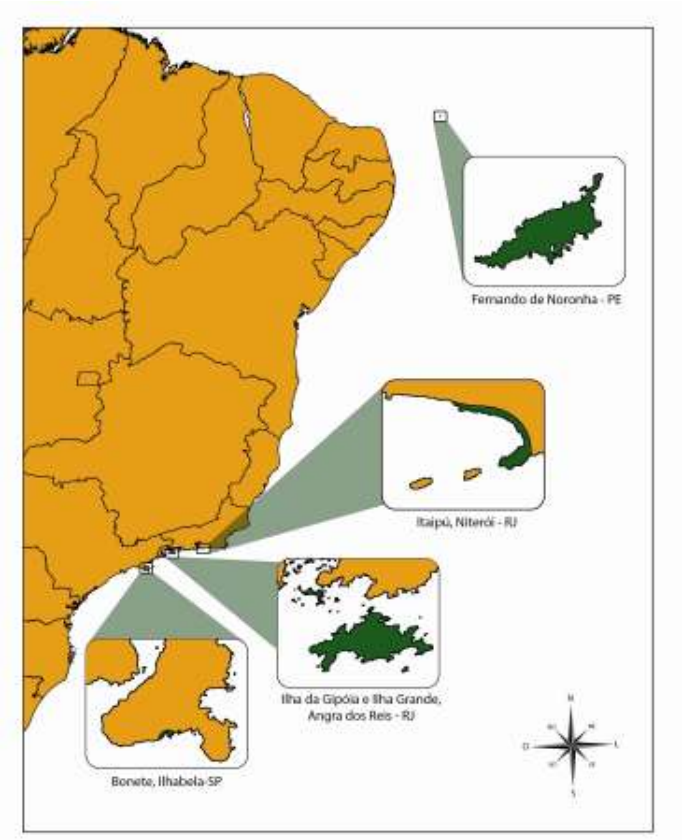

Figure 1 – Geographical distribution of the study areas. Fernando de Noronha Island – PE (State of Pernambuco); Itaipu (Niterói) and Grande and Gipóia Islands (Ilha Grande Bay), RJ (Rio de Janeiro State); Bonete (Ilhabela Island) – SP (São Paulo State).

A - Fernando de Noronha Island, NE Brazil, is a volcanic island located approximately 545 km off the coast of Pernambuco State in the far northeast of Brazil. According to IBGE data (2015), the residential population is 2,930. We found 75 fishers at this island, and interviewed 28 of them about their daily use of the environment around the limits of PARNAMAR (*Parque Nacional Marinho*). They specifically fish on the edge of the sea wall to depths of approximately 1000 meters. The community also includes a fisher cooperative with only a few members (approximately 10 fishers), but they serve a strategic

function and actively assert their rights to the government and the local authorities. The main techniques are hand line, followed by line and rod fishing. Casting nets are only used to catch sardines (*Harengula* sp.) in the APA (Area de Protecao Ambiental); this species is famous and largely used as bait by the fishermen. The most hooked fishes are xaréu-preto (black jack, *Caranx lugubris*), xixarro (horse-eye jack, *Caranx latus*), xaréu-branco (crevalle jack, *Caranx hippos*), and guarajuba (yellow jack, *Caranx bartholomaei*), but the most sought-after fishes are barracuda (*Sphyraena barracuda*), cavala (wahoo, *Acanthocybium solandri*), dourado (mahi-mahi, *Coryphaena hippurus*), albacora (yellowfin tuna, *Thunnus albacores*) and pargo (schoolmaster snapper, *Lutjanus apodus*) (Cantareli, 2016).

B - Itaipu, Niterói, RJ is a tourist beach in Niterói, Rio de Janeiro (a city located at the mouth of Guanabara Bay, opposite the city of Rio) and the location of a fishing village represented by the 'Colonia de Pescadores Z-7'. We found approximately 44 fishers that regularly fish the sea and the Itaipu lagoon, and they primarily use set gillnets and hook and line (for fish and squid). Important target species are espada (cutlass fish, *Trichiurus lepturus*), corvina (sand drum, *Micropogonias furnieri*), bagre (catfish, *Genidens barbus*), squid (*Loligo* sp.), and pescada (drum, *Cynoscion* spp.) (Begossi, 2006; Begossi et al. 2013).

C - Grande and Gipóia Islands are also tourist islands located in Grande Island Bay with several communities of small-scale fishers. In 1996, we estimated that there were 50 families on Gipóia Island, and the fishers use set gillnets, hook and line and covo, a fishing trap. Fishers use set gillnets, among other nets, and hook and line, including the zangarelho,

which is used to fish squid; it is also used in the other SE coastal communities. Target species especially include corvina (sand drum), espada (cutlass fish), bonito and cavala (Scombridae) in addition to shrimp and squid.

D – *Ilhabela (Bonete)* is an archipelago located on the north shore of Sao Paulo, 210 km from the capital and 350 km from the city of Rio de Janeiro. The economy of Ilhabela is mainly sustained by tourism. The community of Bonete beach is located on the south of the island and is accessible by hiking (12 km) or by boat (one hour of travel). It is inhabited by 243 people (CMDCAI, 2012), of which 60 fishermen were identified, and 35 were interviewed; we did not find any fish cooperatives or local organizations. The fishing techniques used include trawling, cerco (a floating trap), line, hand, harpoon, and gillnets**.** The most hooked species are lula (squid, *Loligo* sp.), enchova (rainbow runner, *Elagatis bipinnulata* Quoy & Gaimard, 1825), garoupa (grouper, *Epinephelus marginatus*) and sororoca (Serra Spanish mackerel, *Scomberomorus brasiliensis*), but the most desired species are cavala (king mackerel, *Scomberomorus cavalla*) and tainha (liza, *Mugil liza*) (Cantareli, 2016).

3. Methods

In Fernando de Noronha, the field activities and the interviews occurred in 2015 and 2016 with the support of ICMBIO (Instituto Chico Mendes da Biodiversidade e Conservação); forty-four interviews were conducted, of which 28 were with fishers. The average local residential time was 37 years, and the average time spent fishing was 27 years. We obtained fish landing data from Lessa (1988) and Domingues (2016).

At Itaipu beach, the research project was supported by Fapesp (01/00718-1), and

we made monthly visits from December 2001 to April 2003. Fieldwork included 48 interviews with forty-four fishers and four fish sellers; among these, twenty-two had been inhabitants of Itaipu beach for approximately 10 years or more. We also obtained data from our 142 landings (Begossi, 2006; Begossi et al., 2013).

Several trips were made to Grande Island as part of earlier projects from 1995 to 1998 (Begossi et al.**,** 2013), which were also supported by Fapesp (94/6258-7 and, later, 97/06167-0). In 2009, we conducted a very detailed study (Begossi et al., 2010) and observed that the number of fishers on Gipóia Island had dropped; we estimated that there were 7 fisher families. Grande island, on the other hand, includes several small-scale communities, and we estimated that there were approximately 211 small-scale fishers in 2009. At these sites, we interviewed 131 fishers, including 3 from Gipóia Island (Begossi et al, 2010; 2013).

At the Bonete community of Ilhabela, the field activities and interviews were carried out in 2013 and 2014, and the work was supported locally by Caa-Oby (Santos) and the Bonete Institute (Ilhabela). Forty-four people were interviewed, 35 of whom were fishers. The local average residence time was 37 years, and the duration of fishing activity averaged 27 years. To date, we have only found a few records of fish landings (Cantarelli, 2016).

4. Results and Discussion

The main results for the areas of Fernando de Noronha, Itaipu, Grande Island Bay and Ilhabela are shown in Table 1, which includes data related to the ten key variables that influence the capacity of systems to self-organize from Ostrom's framework (Ostrom,

2009). Table 1 shows the 'Resource System' variables of size, productivity and predictability; the 'Resource Unit' variable of mobility; the 'Users' variables of number, leadership, norms, knowledge and importance; and finally, the governance variable of collective action rules.

Many features of the four areas are similar, which is probably due to the nature of the resource and the extractive properties of fishing. For example, the resources are highly mobile, unpredictable and very important to the communities since the small-scale fishers in all of the communities depend on the fish for consumption and sale. Concerning the existence of norms and local knowledge, we also observe similarities among the four communities. However, these small-scale fisheries differ in terms of collective-choice rules, for which governance is the main context. Therefore, the question becomes what determined these varied outcomes (concerning the collective actions).

It is interesting to note that fishers from Itaipu showed a relatively high level of organization when they decided to interfere with some top-down governmental initiatives (to transform Itaipu into an extractive reserve) that would have been managed (or co-managed) by the federal government. At that time, small-scale fishers determined that some of their freedoms would be lost and that fishers that were not residents of Itaipu beach (but of nearby neighborhoods) would lose their fishing permits (Begossi, 2006). Additionally, at Paraty, several conflicts were observed especially conflicts with environmental protection agents and industrial trawlers (Begossi et al., 2011). However, Trindade, one of the Paraty communities, was found to have historically shown a high level of self-organization and the capacity to exert pressure against landowners, authoritative laws and government agents (Begossi and Lopes, 2014).

Among fisheries in Madagascar, Cinner et al. (2009), by focusing on household flexibility and learning capacity (among other attributes of social resilience) observed high levels of flexibility in formal institutions and households along with participatory decision making, which suggested a latent capacity for community resource management. Gutierrez et al. (2011) found leadership to be one of the most important attributes influencing the capacity for resource management. Leadership was found in the studied communities (Table 1), but we are unsure of the transposing bridge between leadership and collective action (the latter was shown to be weak in the studied communities).

In Brazil, Lopes et al. (2011) analyzed variables linked to social resilience, such as socio-economic flexibility and the capacity to organize, in fisheries located in extractive reserves in the Amazon and concluded that the degree of participation in management processes and plans were crucial for success. Finally, Lopes et al. (2015) analyzed the trade-offs of marine reserves, fishing activities and tourism among small-scale fisheries of the Ilha Grande Bay and Paraty region (Rio de Janeiro State) and suggested that protected areas should provide benefits to poor, rural inhabitants (such as fishers) in the form of value-adding mechanisms, among others.

5. Conclusions

Despite the importance of conserving biodiversity in Brazil, the process by which co-management mechanisms are developed between local fisheries and the institutions that manage biodiversity (particularly governmental institutions that are responsible for

protected areas) seems counter-productive. In this study of five small-scale fisheries in SE Brazil, we analyzed variables considered to be key factors in the capacity to self-organize. From this analysis, we perceive that a gap between having local leadership and taking collective action is a common feature of these communities. Thus, we need to better understand what factors are obstacles to collective action for local governance. In another words, which are the factors that are an obstacle to take an action in spite of a presence of a local leadership? Biodiversity conservation and social ecological systems must be integrated to benefit small-scale fishers if these communities are to support protected areas. Further studies are thus needed for small-scale fisheries, conservation and governance rules.

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Author contribution

CVC collected data and this study is based partially on the results of his Master's dissertation Ecomar/Unisanta, advised by AB and MR; AB wrote this manuscript; CVC, AB & MR contributed with ideas and with the organization of the data.

Conflicts of Interest

"The authors declare no conflict of interest".