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### Research Letters

# The crab harvest in a mangrove forest in south-eastern Brazil: Insights about its maintenance in the long-term

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### ABSTRACT

Mangrove ecosystems and their resources are important for traditional coastal communities. We analysed the efficiency of traditional management practices developed by crab (*Ucides cordatus*) gatherers in the mangrove forest of the Paraíba do Sul River estuary (~21°S), south-eastern Brazil, considering the carapace width of specimens harvested for commercial purposes in two different periods (2002–03 and 2015–16). The continuity of this crab harvest between 2002 and 2016 was likely possible because of decreased harvest pressure, which does not necessarily represent the traditional management efficiency needed to sustain this resource. Thus, this crab harvest system may be more fragile than expected by the local gatherers. Community-based proposals for the management of this *U. cordatus* harvest system, which integrate communities, researchers and decision-makers, can improve both local productivity and ecosystem-resource maintenance, mitigating local conflicts.

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### Introduction

Mangroves are among the most productive ecosystems worldwide and occupy brackish water zones along tropical and subtropical coasts. This ecosystem has habitat functions for many organisms as fishes, crustaceans and molluscs and provides sediment trapping, nutrient recycling and protection of the shoreline from erosion (Barbier et al., 2011). However, since 1980, mangrove areas have been declining rapidly, becoming highly stressed forests with a global reduction of approximately 25% (FAO, 2007; Ahmed and Glaser, 2016). Mangrove products are important sources of income for traditional coastal communities. Fishing and related activities, such as the harvesting of crustaceans and bivalves, are generally the prime income-generating activities in these communities, which are generally economically depressed and marginal (FAO, 2007).

In general, traditional communities apply their local ecological knowledge (LEK) in exploitation practices and natural resource

utilisation to develop traditional management methods (Côrtes et al., 2014a; Roy, 2016). Dimitrakopoulos et al. (2010) defined community-based conservation (CBC) as conservation strategies that emphasise the role of local communities as partners in management practices and decision-making. Thus, CBC should be by and for communities. The main reason for promoting CBC models is to achieve sustainable management, where traditional communities can manage and extract benefits from the locally available natural resources to improve their livelihoods and encourage a conservation attitude (Baral and Stern, 2011). In this sense, both researchers and decision-makers have advocated community-based mangrove management as a viable alternative for sustainably managing mangrove forests, with higher numbers of initiatives in South Asia and fewer in South America and Africa (Datta et al., 2012).

Considering the mangrove resources with commercial value to traditional communities, the crab *Ucides cordatus* Linnaeus, 1763 has economic prominence on the western Atlantic coast, especially along the Brazilian coast from 3°N to 27°S (e.g., Glaser and Diele, 2004; Côrtes et al., 2014a; Nascimento et al., 2017). According to the Brazilian policy that regulates the exploitation of this resource, the minimum size for *U. cordatus* harvest in Brazilian mangroves is 60 mm of carapace width for both

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males and females. The legal requirements also exclude from commercial harvest females with eggs of any size and crabs during the ecdysis phase as well as the harvest during the crab's reproductive activity (Ministerial Order 52/30.09.2003, available at [http://www.icmbio.gov.br/cepsul/images/stories/legislacao/Portaria/2003/p\\_ibama\\_52\\_2003.defesocaranguiejouca.se.s.pdf](http://www.icmbio.gov.br/cepsul/images/stories/legislacao/Portaria/2003/p_ibama_52_2003.defesocaranguiejouca.se.s.pdf)).

The crab gatherers from northern Rio de Janeiro State (~21°S), south-eastern Brazil, have developed traditional management practices to maintain the local viability of this economic activity (Rodrigues et al., 2000; Passos and Di Benedetto, 2005; Côrtes et al., 2014a). Two main management practices are employed by the local gatherers: (i) selection of crabs by sex and size, avoiding the commercialisation of females with eggs and smaller crabs of both sexes and (ii) rotation of the most exploited mangrove areas throughout the year. The crab harvest occurs during all months, decreasing during the breeding season (October, November and December). The gatherers still use forbidden gear, as a net locally called 'redinha', which is prohibited by the Brazilian policy that regulates the *U. cordatus* exploitation (Côrtes et al., 2014b).

These gatherers harvest *U. cordatus* along the mangrove forest of the Paraíba do Sul River estuary that is characterised mainly by *Avicennia germinans* [L.] Stearn. 1764 (53% of coverage), *Laguncularia racemosa* [L.] Gaertn f. 1807 (28%) and *Rhizophora mangle* L. 1753 (19%) (Bernini and Rezende, 2011). The harvest effort during the summer period (November to April, according to the gatherers) is greater in *R. mangle* forests, while in the winter (May to October, according to the gatherers) it is greater in *A. germinans* forests. Seasonal and spatial occurrence of larger crabs drive this practice. According to the gatherers, the 'resting' period of these mangrove forests contributes to the growth of the *U. cordatus* population, maintaining the resource for commercial harvest (Côrtes et al., 2014a).

We argue whether the traditional management practices developed in this mangrove forest are sufficient to maintain the long-term crab harvest. Sustainability assessments of activities that involve natural resources exploitation include many variables, as social, cultural and economic characteristics of the communities as well as biological and ecological aspects of the resources or target species (Singh et al., 2009). This study considered only the size of the crabs available for commercialisation, considering the minimum size for *U. cordatus* harvest in Brazilian mangroves. The monitoring of this single variable (size) over the two periods (2002–03 and 2015–16) allows a rapid assessment of how the local crab population is structured against the pressure resulting from the commercial harvest. Size monitoring of target species is successfully used in fisheries management, supporting risk assessments of fishing impacts (Shin et al., 2005; Froese et al., 2008). Additionally, this study presents integrative strategies involving traditional communities, researchers and decision-makers to drive local management practices.

## Methods

### Study site

The study site is the mangrove forest of the Paraíba do Sul River estuary (Fig. 1). The mangrove stand occupies approximately 725 ha and lost more than 20% of its original area in 15 years (1986–2001) because of sedimentation, erosion, cattle grazing and urban development (Bernini, 2008). The traditional communities of Atafona and Gargaú have harvested crabs for decades in this mangrove forest, and gatherers from both communities share the harvest area (Fig. 1) (Rodrigues et al., 2000; Côrtes et al., 2014a). During our samplings, local gatherers described this activity as having occurred in the region for more than 100 years.

Local crab gatherers are members of Fishermen's Colony Z-2 (Atafona) and Colony Z-1 (Gargaú). Before 2012, at least 46 gatherers from Atafona and 50 from Gargaú participated in the crab harvest in this mangrove forest (Côrtes et al., 2014b). In 2012, the number of gatherers decreased in Atafona ( $n=16$ ), but remained constant in Gargaú ( $n=50$ ) (Côrtes et al., 2014a). In 2015, only six gatherers from Atafona participated in the crab harvest, while the number remained constant in Gargaú (present study).

### Data collection

The crab specimens were collected, cleaned in the river water to remove the mud excess, separated as male or female, measured for carapace width with a vernier caliper (1 mm) and grouped into two sampling periods: (i) 2002–03 and (ii) 2015–16.

In the first sampling period, the specimens were obtained monthly, directly from the gatherers in local markets (commercialised crabs), except during the months determined by law for the closure of crab gathering in the region (October to December). In this sampling, the crabs were previously selected by size: the gatherers released alive in the mangrove, before the commercialisation, smaller crabs of both sexes (Passos and Di Benedetto, 2005; Côrtes et al., 2014a).

In the last period, the sampling was done throughout the mangrove forest with the collaboration of the same local gatherer for three consecutive days in September 2015 and in March 2016. This sampling was done biannually, as suggested by Pinheiro and Almeida (2015). The crab sampling was done along the three types of vegetation (*A. germinans*, *L. racemosa* and *R. mangle*) that are normally used as harvest areas during the commercial captures.

The harvest area used by the gatherers from Atafona and Gargaú overlaps, and is mainly along the islands located in the inner estuary of the Paraíba do Sul River (Fig. 1). The loss of the original mangrove area reported by Bernini (2008) occurred mainly in the continental portion. The crab samplings in both periods were in overlapping or close areas.

In the study site, the net referred to as 'redinha' is the main gear for harvesting crabs, composed of a monofilament net 50 m long, 40 cm high and with 8 cm mesh between adjacent knots. The local gatherers use this gear for more than 30 years (Côrtes et al., 2014b). The crabs from 2002–03 sampling were caught by this gear (Passos and Di Benedetto, 2005).

In 2015–16, 'redinha' was also used to catch the crabs. The net was positioned over the openings of the crabs' burrows in the substrate, which is the typical practice during the regular commercial harvest (Côrtes et al., 2014a), remaining for two hours in each mangrove vegetation type (*A. germinans*, *L. racemosa* and *R. mangle*). This sampling collected crab specimens eligible for commercial harvest; however, the size selection was achieved only by the gear and not subsequently by the gatherer as in the other sampling period (2002–03). All specimens captured during the 2015–16 sampling were released alive in the same sampling site immediately after carapace measurement.

### Data analysis

The carapace width data were tested for normality using a Kolmogorov–Smirnov test. As the data did not meet the statistical assumptions required for the use of parametric methods, a Mann–Whitney *U*-Test was applied to test for differences between sex and sampling periods. Despite the sexual dimorphism in carapace size, with males being larger than females (Pinheiro et al., 2005; Costa et al., 2014), the minimum size for *U. cordatus* harvest in Brazilian mangroves is the same for both sexes (60 mm of carapace width). In the study site, the gatherers catch and commercialise both males and females (Côrtes et al., 2014a).

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