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Multiple management strategies to control selectivity on parrotfishes harvesting

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ABSTRACT

Small-scale fisheries are exploiting large numbers of parrotfishes from Brazilian reefs, leading to significant changes in the community structure. Specifically, three now vulnerable species, *Scarus trispinosus* (Valenciennes, 1840), *Sparisoma frondosum* (Agassiz, 1831) and *Sparisoma axillare* (Steindachner, 1878), have been intensively targeted on the Brazilian northeast, although little is known about such fisheries. The vulnerable status of these species has brought about the need to officially regulate their fisheries. Here, the effects of different gear types on the fishing of these three species are analyzed regarding catch composition, size and species selectivity. Landings of gillnet, speargun, and handline fishing were sampled during one year, when information of each fishery operation and size frequencies of fishes caught were recorded. Gillnets are the least selective gear, catching a greater proportion of immature individuals of *S. trispinosus*. Handline showed the lowest values of capture per unit effort (CPUE) and only caught *S. axillare* and *S. frondosum* above the size at first maturity; it did not catch *S. trispnosus*. Speargun is the only gear that caught a higher proportion of mature individuals of *S. trispinosus*, which by no means should exempt it from further regulations, as it is important to assure that neither immature nor exceptionally large individuals are removed from the population. Comprehensive parrotfish fishing regulation is urgently needed if the species harvest is to be allowed. Slot size delimitation and gear control are some of the suggested measures to avoid overfishing and changes in life history traits of targeted species.

1. Introduction

Reef fisheries are an important source of income and protein to many poor coastal populations around the world (Moberg and Folke, 1999). Although reef fisheries are mostly performed by small scale and artisanal fishermen, improved gear technology and growing coastal populations and market demands have significantly increased the pressure on reef fish stocks (Cinner and McClanahan, 2009). Such pressures have led to many significant effects on reef communities, such as reduction in species diversity and biomass, loss of resilience and phase shifts (Hughes et al., 2007; Mumby et al., 2007). Avoiding these effects requires the maintenance of some key ecosystem processes, including predation, herbivory and fish and coral recruitment (Dulvy et al., 2004; Bellwood et al., 2004). Many of these processes are performed by fishes, markedly those representing functional groups like top predators and large herbivorous, such as parrotfish (Labridae: Scarini).

Parrotfish are large-body and long-living herbivorous fishes that are associated with tropical and subtropical reef habitats around the world (Choat and Randall, 1986). As benthic algae consumers, parrotfish are classified into three functional groups (excavators, scrapers and grazers) and exert top-down control of macroalgae (Streelman et al., 2002; Mumby et al., 2006; Francini-Filho et al., 2008). The intensity of the ecological function performed by parrotfish is determined by both the local fish abundance and individual body-size, with higher abundances and larger individuals contributing disproportionally more to the grazing function (Bonaldo and Bellwood, 2008; Lokrantz et al., 2008).

Hence, overfishing of parrotfishes and removal of large individuals can simultaneously affect multiple ecosystem functions (Bellwood et al., 2012). Unfortunately, fishing pressure on

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parrotfishes has grown in last decades around the world (Edwards et al., 2013), including the southwestern Atlantic (Francini-Filho and Moura, 2008; Previeiro, 2014; Bender et al., 2014). In Brazil, for example, parrotfishes are targeted along the coast mainly by small-scale artisanal fishery with the use of different gears, including gillnets, handlines and spearguns (Francini-Filho and Moura, 2008; Previeiro, 2014; Bender et al., 2014). Additionally, artisanal fisheries also catch parrotfishes at night, when parrotfishes are asleep (see Grutter et al., 2011). Fishing pressure on these species has also grown in the industrial and recreational sectors, although more markedly in the first one (Cunha et al., 2012).

Some of these species have shown alarming signs of decline, as observed with species of the genus *Sparisoma*, including *S. axillare* and *S. frondosum* (Bender et al., 2014). The largest Brazilian parrotfish, *Scarus trispinosus* (Valenciennes, 1840), which is an endemic long-living species, is now listed as Endangered by the Union for Conservation of Nature (IUCN; Ferreira et al., 2012). Large-bodied species, such as *S. trispinosus*, tend to be more vulnerable due to several factors, including late maturity and low intrinsic rates of population increase (Reynolds et al., 2001).

As an attempt to halt declining populations of fishing species, in December 2014 the Brazilian Ministry of the Environment listed five species of parrotfish, among many other groups, in the Brazilian Red List of Endangered Species/BRL-EndS (Decree nº 445; Brazil's Red List, 2014). Four of the five listed species were classified as *vulnerable*, including *S. axillare* and *S. frondosum,* while *S. trispinosus* was listed as *endangered*. The BRL-EndS has been contested by the fishing sector (mainly by the industrial one) and remains in litigation since then. However, such dispute worked as an incentive to scientists and managers to further the discussion on the more biologically vulnerable species.

Notwithstanding the justifiable biological concern, studies approaching the fisheries of parrotfish are still rare (Previeiro, 2014; Bender et al., 2014) and to the extent of our knowledge, none has examined the effects of different gears on their harvesting. The effects that gears have in a given fishing are important to be understood because they may change catch composition, catch per unit effort (CPUE) and fish size frequencies (McClanaham and Mangi, 2004; Mangi and Roberts, 2006; Campbell and Pardede, 2006).

Besides, evolutionary responses in fish can be induced by size-selective gears (Kuparinen and Merilä, 2009; Liang et al., 2014), such as earlier maturation, reduced fecundity and the gradual replacement of large-bodied individuals for small-bodied ones, a process known as *fishing-down* (Welcomme, 1999). The fishing-down process predicts that the body length and weight of exploited fishes at the same age decrease consistently over time due to the removal of the large and usually pricier large-bodied individuals (Welcomme, 1999).

Therefore, the understanding of the effects of gear may guide suitable management strategies to maintain fish populations and long-term fishing yields. In this study, we assessed gear size selectivity and fishing pressure on the three most caught species of parrotfishes in the Brazilian northeast, a region where parrotfish are abundant and increasingly targeted by fishermen: greenbeak parrotfish (*Scarus trispinosus,* Valenciennes, 1840), agassiz's parrotfish (*Sparisoma frondosum,* Agassiz, 1831) and gray parrotfish (*Sparisoma axillare,* Steindachner, 1878). Specifically, we identified the effects of each fishing gear used on the proportion of juvenile caught and on size frequencies. We also briefly assessed the economic figures resulting from their exploitation to better understand the losses for local fishers associated to fishing management recommendations.

By identifying the more selective and productive gears we expect to establish a baseline for management through recommendations of regulations adjusted to the complexity of this fishery and its fishing environment and to the still poorly understood ecology of the target species.

2. Material and methods

2.1. Study area

This study concerns analyses done on data gathered during landings from fishing that took place in waters within 3 miles off the coast, within a loosely protected area (APARC, from the Portuguese acronym, “Área de Proteção Ambiental dos Recifes de Corais”) (5°00′5°30′S – 35°10′35°30W), in Rio Grande do Norte, Brazil. The APARC was established in 2001, encompassing 180,000ha. Fishing is done mostly by people from nearby towns and villages (approximately 700 fishermen) (Fig. 1). The area is a complex of rocky reef, formed by various types of benthic environments (rhodolith, prairies of phanerogams, corals, algae and sandy fund) (Amaral et al., 2005).

The population size living around the area is estimated at 51,000 people, who mainly perform fisheries, tourism and agriculture. Fishing is mostly done in the reef areas and along the coastline (MMA, 2006). Tourism occurs mostly in the reef areas and is regulated and supervised by the state environmental agency IDEMA (from the Portuguese acronym, “Instituto de Desenvolvimento Sustentável e Meio Ambiente”). The agency establishes limits for tourist exploitation within the APARC and sets quotas for boats and visitors based on field studies; the breach of the rules is subjected to penalties to tourism agencies. Recent data suggests that tourism has not yet negatively affected abundance and richness of reef species (Silva, 2015). The region is also distant from large cities and neither has industries nor intense coastal development, therefore being relatively pristine regarding pollution.

Despite the growing tourism, fishery still represents the main threat to parrotfish due to their ecological features and natural history. Parrotfish species have restricted spatial distribution (Roos et al., 2015), are resident in reef areas, have late maturity and low intrinsic rates of population growth (Choat et al., 1996). Together, such features increase the rate of encounters and the probability of successful catches of juveniles and mature individuals alike.

Fisheries in the area are mainly small-scale, done mostly using small sail vessels, between 4 and 6m long, with small engines. These vessels may employ various types of fishing gears, although not simultaneously, with the predominance of bottom-set panel gillnets with stretched mesh size from 30 to 60 mm (knot-to-knot), handlines and spearguns. Lately there has been an increase in the exploitation by the industrial fleet, which fishes with traps and focuses on *Sparisoma* sp (gray and agassiz's parrotfish). However, here we did not include industrial fishing, which represents trap catches, because their landings happen inside the fishing companies while small-scale fishermen land their catches on the beach. Besides, industrial fishing activity is performed in open waters and deeper environments while small-scale fisheries pressure is highly localized on shallow reefs areas, a very vulnerable habitat due to their accessibility and closeness to the coast and its impacts.

About 60 small-scale fishermen, mostly from two villages (Maracajaú and Rio do Fogo) were targeting parrotfishes, using gillnets, handlines and spearguns, at the time of the study. Fishermen from Rio do Fogo were the only ones using gillnets (25%; N = 15) to catch parrotfishes. They used 40–50 mm (knot-to-knot) mesh size gillnets to catch mainly *S. axillare*, *S. frondosum*, and 50 mm–60 mm mesh size gillnets to catch *S. trispinosus* (Fig. 1).

The remaining parrotfish fishermen used either handline or spearguns. Specifically, handline fishery was performed by 41% (N = 25) of the fishermen to catch *S. axillare* and *S. frondosum* in