

# Human consumption and popular knowledge on the conservation status of groupers and sharks caught by small-scale fisheries on Abrolhos Bank, SW Atlantic

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## ABSTRACT

Despite marine fish being an important food resource for coastal communities, the amount of fish caught by small-scale fisheries is unsustainable at many locations. Fish consumers have a critical role in species conservation because they can choose responsibly and avoid consuming overexploited or endangered species. In this study, local human consumption patterns and local knowledge about groupers and sharks caught by small-scale local fisheries were investigated in a Brazilian coral reef complex. Fish consumers were interviewed in a fish market setting regarding their monthly fish consumption, knowledge of endangered species, and strategies they do to consume fish responsibly. Of the 126 local fish consumers, 94% and 76% reported to buying sharks and groupers, respectively, on a monthly basis. The main strategies they used to consume fish responsibly were 1) getting fishmonger's advice and 2) buying fish on reliable fish markets. Our findings are important to understanding fish consumption preferences, which can contribute to the implementation of educational initiatives aiming to raise consumers' awareness regarding responsible consumption.

## 1. Introduction

Fish are a valuable source of animal protein for humans, especially in coastal regions. Tropical coral reefs provide high social and economic importance for small-scale fisheries, mainly among developing countries and small island-nations [1,2]. Nevertheless, several stocks are being steadily overfished worldwide. Although long-term data series are uncommon for small-scale fisheries, declines in apex- and mesopredator biomass, (i.e. groupers and sharks) have been widely reported [3]. Overfishing has put these species under increasing extinction risk, or in some instances has led to extinction [4,5]. Large body size, slow growth rates, high longevity [6,7], long generation times among sharks [4] and formation of spawning aggregations [8] are among the shared characteristics that make groupers and sharks particularly vulnerable to overfishing.

The dynamic of fish capture and trade is conditioned by market factors, wherein the law of supply and demand determines the values and yields. The development of fisheries is driven mainly by profit [9],

and the prices of seafood (and consequently fishing effort) are determined by market demand. Understanding local and regional fish consumption and the knowledge of consumers regarding the status of stocks is an important step measure to improve fishery management [10]. Incorporating consumer preferences into conservation strategies is essential to halt the declining trend in fish resources [11]. For instance, the Monterey Bay Aquarium's Seafood Watch in the USA and the Responsible Fish Consumption campaign in Brazil are both initiatives that encourage people to consume fish from healthy stocks.

In the last decade, an increasing number of surveys have addressed topics related to fisheries' characteristics, fish consumption, and market demand that have contributed to overexploitation. Depletion of fish stocks is influenced by distance to markets [12], human population size [13], and market forces inducing unsustainable consumption [14]. However, the preferences and attitudes toward sustainable fish consumption in small-scale fisheries have been poorly investigated. Also, there is no information regarding responsible fish consumption in relation to consumer age. Given this context, the present study aimed to

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investigate the human consumption and the knowledge of consumers regarding the stock status of groupers and sharks on Abrolhos Bank, off Brazil. In addition, it was investigated the consumer awareness of responsible fish consumption by conducting strategies to not consume endangered or overexploited species according to interviewee age. Finally, recommendations to support responsible fish consumption were suggested.

## 2. Materials and methods

### 2.1. Study site

The study was conducted in the municipality of Nova Viçosa (17°53'31"S, 39°22'19"W), situated along the core of Abrolhos Bank. It comprises an enlargement of the continental shelf harbors the largest and richest coralline reefs of the south Atlantic [15] and has the most productive fisheries of the eastern Brazil [16]. Nova Viçosa has a population of 38,500 people who live off *Eucalyptus* monoculture, small-scale fishing, and beachside tourism [17,18]. Population influx during austral summer raises number of inhabitants to ~70,000.

### 2.2. Data collection

Data were collected during austral summer (January 16th to 20th 2013; 8:00 to 10:00 a.m.). Surveys were conducted in the main fish market of Nova Viçosa. Fish consumers that visited fishmongers were invited to participate in the study. As the survey aimed to understand the fish consumption patterns of people residing along the Abrolhos Bank, only local people were interviewed. Therefore, before the interview starts consumers were asked if they live permanently in Nova Viçosa. The consumers that met the criteria were interviewed individually through a semi-structured questionnaire.

Because fishing of some endangered species is banned, to avoid concerns regarding how scientists would use the survey data, it was emphasized to respondents that interviews would be anonymous [19]. The profile questions encompassed the respondents' age and educational level. Regarding fish consumption, respondents were questioned if they: (a) consume species of groupers and/or sharks on a monthly basis; (b) know about species of groupers and sharks that were endangered or under fishing ban; (c) consume species of groupers and sharks that were endangered or under fishing ban; (d) use strategies to enhance responsible consumption of groupers and sharks, and if yes, what are they. To confirm species' identification, photographs of selected species were shown to fish consumers during the interview. Endangered species were classified under Brazilian fishing regulations available in January 2013.

### 2.3. Data analysis

Logistic regressions were fitted using age as the independent variable and the answer to questions (yes or no) as dependent variables to verify the probability of: a) consumption of sharks and groupers; b) consumption of endangered sharks or groupers; c) perception of a given species' conservation status; and d) use of a given strategy for responsible fish consumption. For the analysis purpose, responses "I do not know" were excluded. A Poisson regression was fitted to verify if the number of strategies described for a responsible fish consumption varied according to consumer age. To verify differences for age among education levels, an ANOVA was fitted. Analyses were conducted using the software R at a significance level of 5%.

## 3. Results

A total of 126 fish consumers were interviewed. Ages ranged from 16 to 81 years old (average =  $39 \pm 4.3$  SE). Regarding education level, 41% did not complete elementary school, 48% had high school, and

**Table 1**

Logistic regression results from binary questions (yes or no) on consumption of sharks and groupers and knowledge about endangered species. P-values in bold are significant.

Question	Frequency of respondents (yes)	Estimate	Std. Error	Z-value	P-value
<b>Sharks</b>					
Consumption	94	−0.006	0.02	−0.32	0.74
Consumption of endangered species	10	0.02	0.01	1.2	0.22
Species described as endangered					
<i>Ginglymostoma cirratum</i>	7	−0.87	1.08	−0.81	0.42
<i>Galeocerdo cuvier</i>	10	0.30	0.71	0.42	0.67
<i>Sphyrna</i> spp.	8	0.44	0.72	0.61	0.54
<i>Alopias</i> spp.	5	0.80	0.76	1.05	0.29
<b>Groupers</b>					
Consumption	76	0.005	0.01	0.5	0.62
Consumption of endangered species	12	0.02	0.01	1.1	0.26
Species described as endangered					
<i>Epinephelus itajara</i>	71	−1.82	0.63	−2.88	<b>0.004</b>
<i>Mycteroperca bonaci</i>	14	1.19	0.56	2.13	<b>0.03</b>
<i>Epinephelus morio</i>	13	0.54	0.58	0.92	0.36
<i>Cephalopholis fulva</i>	7	0.93	0.68	1.37	0.17

11% were graduated. The average age of education levels differed significantly (ANOVA,  $df = 2$ ,  $F = 8.91$ ,  $p < 0.001$ ). The interviewees that had incomplete elementary school had an average of 51 years, those who had some elementary school 40.6 years and graduates were an average of 31.5 years.

Ninety-four percent of respondents reported to consuming sharks on a monthly basis and 10% reported consuming endangered shark species. A non-significant decrease in the probability of consumption according to age increase was observed (Table 1). Groupers were consumed monthly by 76% of the respondents. Consumption of grouper species considered as endangered were mentioned by 12%. A non-significant increase in the probability of consumption in relation to age increase was verified (Table 1).

Nearly 52% of consumers did not know any endangered shark species. Remaining respondents mentioned nine species: the tiger shark (*Galeocerdo cuvier*) was cited by 10% of respondents cited), the nurse shark *Ginglymostoma cirratum* (7%), the hammerhead shark *Sphyrna* spp. (8%), and the thresher shark *Alopias* spp. (5%). There was no significant change in probability of citing a shark by respondents with respect to their age. Sharks mentioned as under fishing moratorium by the respondents were the hammerhead shark (7%), the thresher shark (6%) and mainly the nurse shark, represented by 80% of consumers that cited the species as endangered.

Ten species of groupers were mentioned as overexploited or endangered, and other three species were described erroneously as a grouper by seven respondents. The Atlantic Goliath grouper *Epinephelus itajara* was the most cited (90%), followed by the black grouper, *Mycteroperca bonaci* (13%), the red grouper *Epinephelus morio* (12%) and the coney *Cephalopholis fulva* (7%). Twenty one percent of consumers did not know about any overexploited grouper species. Atlantic Goliath grouper was known to be under fishing ban by virtually every respondent that mentioned that species as endangered, except four elderly consumers. A fishing ban on black grouper was mentioned erroneously by 4% of young consumers, and one respondent mentioned fishing ban on red grouper.

The number of strategies described for responsible fish consumption did not vary significantly according to interviewee age (Table 2). The most cited strategies were "get advice of fishmonger" (29%), "buy at a

**Table 2**

Parameters of the Poisson Generalized linear model for the number of strategies described by fish consumers to make responsible consumption according age.

	Estimate	Std. error	Z-value	P-value
(Intercept)	−0.073	0.233	−0.315	0.753
Age	0.003	0.004	0.733	0.464

**Table 3**

Logistic regression results from binary questions (yes or no) on strategies to make responsible fish consumption. P-values in bold are significant.

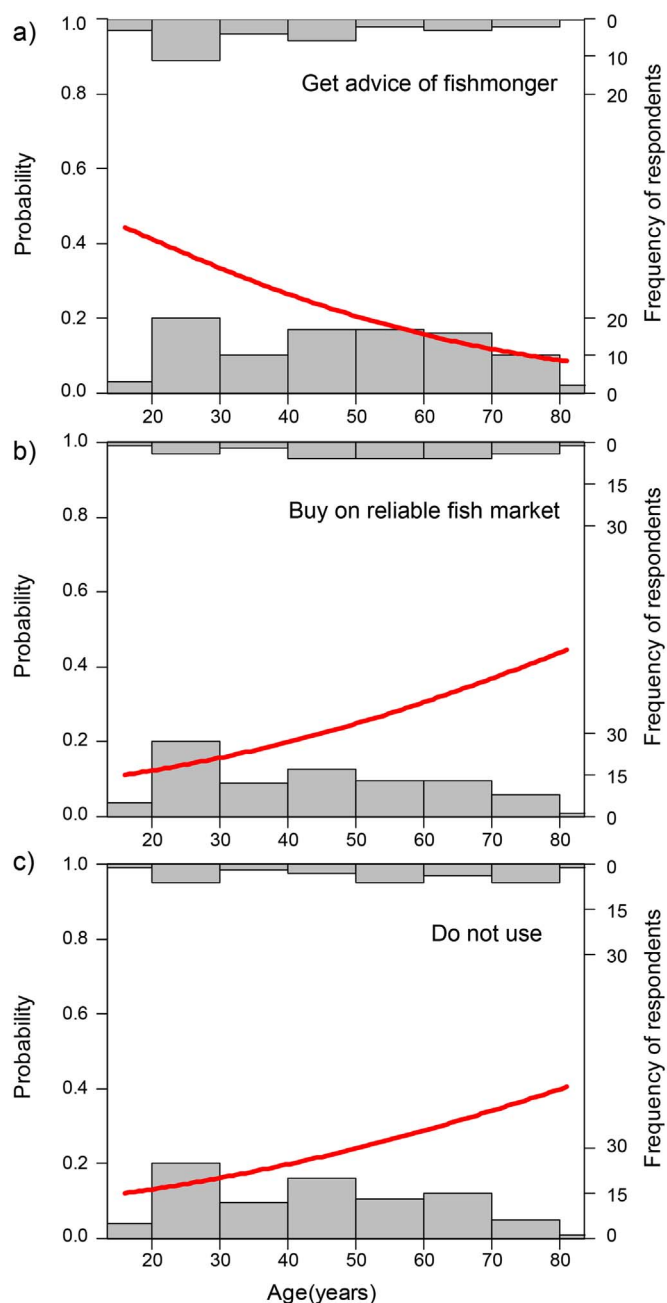
Strategy	Frequency of respondents (yes)	Estimate	Std. Error	Z-value	P-value
Get advice of fishmonger	29	−0.03	0.01	−2.63	<b>0.008</b>
Buy on a reliable fish market	27	0.03	0.01	2.40	<b>0.01</b>
Ask species name	23	0.008	0.02	0.68	0.49
Learn about fishing closures	11	0.008	0.01	0.53	0.59
Reduce fish consumption	5	−0.04	0.03	−1.22	0.21
Do not buy fillet	5	−0.03	0.03	−1.18	0.23
Do not use	26	0.02	0.11	2.1	<b>0.04</b>

reliable fish market” (27%) and “ask species name” (23%). Twenty six percent of fish consumers do not use any strategy for responsible consumption (Table 3). A significant decrease in the probability of use along the interviewee age increase was verified to the strategy “get advice of fishmonger” and a significant increase was verified to “buy on reliable fish market” and “do not use any strategy” (Table 3; Fig. 1a–c).

#### 4. Discussion

Findings from this study revealed that fish consumers are aware that some marine fish species are endangered; however, this does not appear to be a reason for not occasionally consume them. Some of the interviewees justified the consumption of endangered species by being sporadic and influenced mainly by lower price than taste. Sharks were sold at lower prices than more appreciated fishes, such as snook (*Centropomidae*) and snapper (*Lutjanidae*) [20]. For grouper species, the meat of large individuals is considered to be of low quality and less tasty, therefore sold at lower prices [21]. Consumers’ budget contributes to the choice of fishes with lower commercial value [22]. In fact, economic aspects are one of the main influences on fish consumption patterns in Brazilian coastal communities, along with social and cultural aspects [23,24]. Another suggested influence on fish consumption is linked to optimal foraging theory—where time of manipulation decreases preference for food because of its increase in effort and time of consumption [25]. Consumers may prefer species that are less bony such as sharks because of less time of manipulation. Interestingly, the relatively high frequency of shark consumption verified in Nova Viçosa was not observed in other Brazilian communities. Shark meat was considered ‘loaded’ or ‘heavy’—bad for one’s health—in southern [24] and northeastern Brazil [22].

The relatively high frequency of grouper and shark consumption may have influenced the overexploitation of the stocks on Abrolhos Bank. Anecdotal evidence suggests that groupers and sharks suffered massive declines in abundance during the last three decades [21,26,27]. Currently, the main commercially important species of groupers are likely to be overfished [28]. However, findings of this study must be interpreted carefully because the sample represented only one community in the Abrolhos Bank and did not investigate the quantity of fish consumed. Further studies are needed to verify these questions and its contribution to the decrease of fish resources on Abrolhos Bank.



**Fig. 1.** Fitted logistic regression curves showing the probability of a given strategy to make responsible fish consumption. a) “get advice of fishmonger” is significantly dependent on fish consumer age, decreasing with age increasing. The opposite pattern was verified to b) “buy on a reliable fish market” and for consumers that do not use any strategy (c). Results of logistical regressions are available in the Table 2.

Consumers were well informed regarding the conservation status and fishing ban for the Atlantic Goliath grouper, which is the most threatened species in the area. This can be explained by a previous campaign made by a non-governmental organization that widely publicizes the conservation status of the species on Abrolhos Bank. Sharks, locally known by its vernacular name “caçã”, were easily identified as a group and linked to elasmobranchs, which is in direct contrast to consumers of larger markets in southern Brazil, which perceive “caçã” to be a different type of marine fish [29]. Consumers in the Abrolhos Bank were able to differentiate among genera of endangered sharks and identify the only shark species that was under the fishing ban, the nurse shark. This is probably due to the close relationship between consumers and fishers, and consequently the fishing norms. Nova Viçosa is a small

coastal city in which fishing is one of the main activities. Most of the families are composed of relatives that make a living by either fishing or working in the fishing sector.

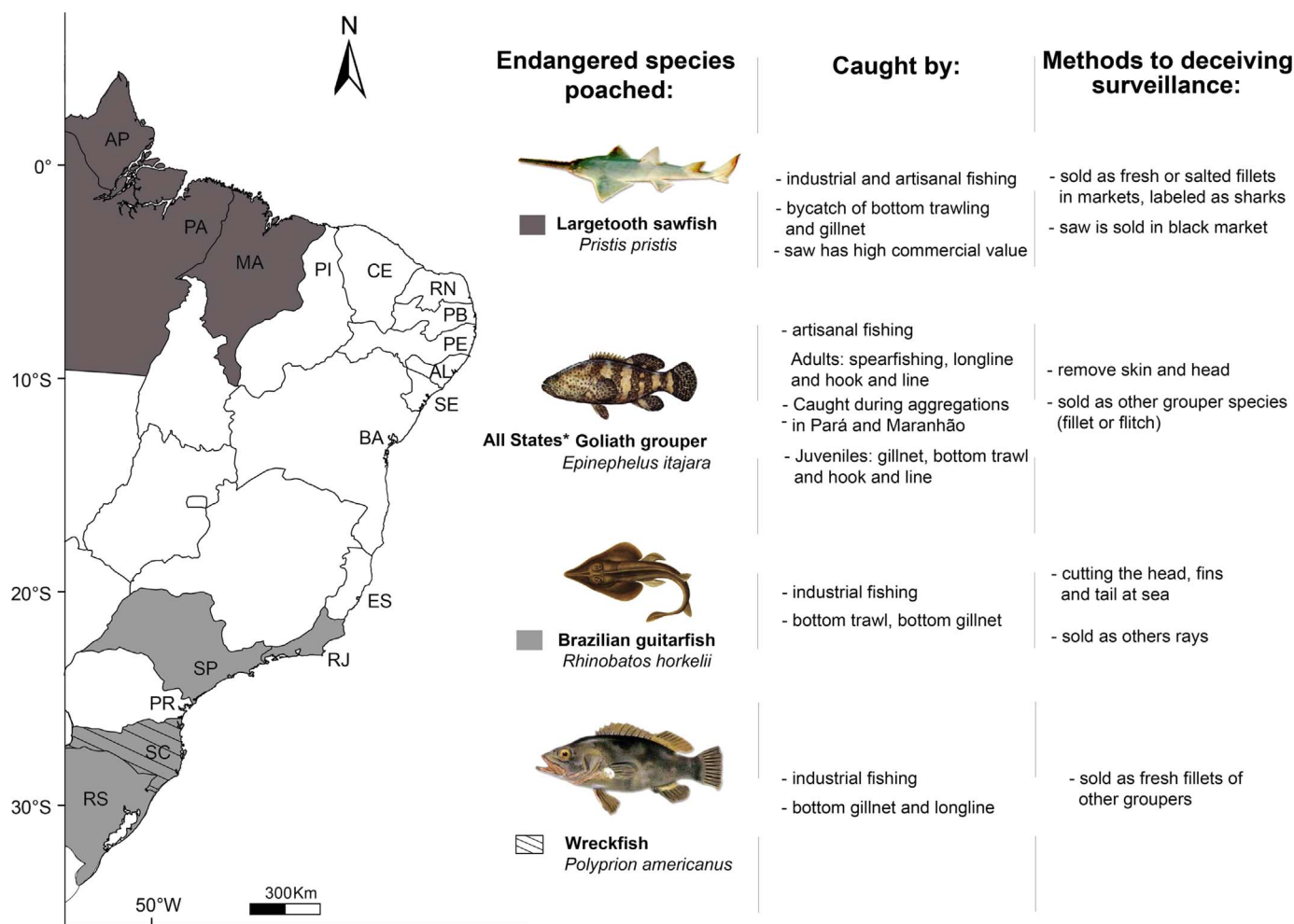
To consume fish responsibly, interviewees rely mostly on fishmonger experience to inform them about the status of stocks and the norms of purchasing fish in reliable markets. Younger consumers were more inclined to get the advice of fishmonger than elders. In contrast, elder consumers were more prone to buy from reliable fish market. This difference can be explained because elder consumers use their experience and trust with fish markets to assist them. Despite those practices, poaching and mislabelling of endangered groupers and sharks remain frequent in Brazil and a matter of concern [30–32]. Besides harming the consumer, mislabelling could affect stock size estimates [33], which is essential information for fisheries management. Mislabelling is particularly evident where fish are filleted or used as components of processed foods. In such situations, the buyer cannot see the whole specimen [34]. Vernacular names can also be a problem as this prevents consumers from making their conscious choices. For instance, the vernacular name *cação* is given to dozen of species from abundant to endangered ones [35].

Poaching and mislabeling of highly endangered species under fishing ban have been reported in Brazil. The most reported species are the Atlantic Goliath grouper [36,37], the largetooth sawfish, *Pristis pristis* [38], the Brazilian guitarfish, *Rhinobatos horkelii* [39] and the wreckfish, *Polyprion americanus* [40] (see Fig. 2). Fishers use strategies

to confuse surveillance, such as fish mischaracterization. In this scenario, consumers are deceived and deprived to make a sustainable fish consumption. The implementation of a systematic regulatory program allied to more strict penalties and surveillance is needed to impede poaching and mislabelling. DNA-based methods have provided fast and reliable results and have been used increasingly to combat such fraudulence [41].

## 5. Conclusions

Groupers and sharks are common fish food items among consumers of all generations along the Abrolhos Bank. Endangered species were well-known by consumers, but they can occasionally eat some of these species. Fish consumption in Brazilian coastal communities is influenced by a range of cultural, social and economic aspects. However, the conservation status of the species needs to be considered as a primary aspect in the consumer choice. Strategies for a responsible fish consumption were based on consumer-seller trust relationship. Nevertheless, consumers are not free from mislabelling fraud involving endangered species. A plausible initiative to improve responsible fish consumption is the promotion of educational campaigns to make consumers aware of the importance of sustainable fish consumption by eating fish only from healthy stocks.



**Fig. 2.** Poaching and mislabeling of fish species highly endangered and under fishing ban in Brazil. States: AP = Amapá, PA = Pará, MA = Maranhão, PI = Piauí, CE = Ceará, RN = Rio Grande do Norte, PB = Paraíba, PE = Pernambuco, AL = Alagoas, SE = Sergipe, BA = Bahia, ES = Espírito Santo, RJ = Rio de Janeiro, SP = São Paulo, PR = Paraná, SC = Santa Catarina; and RS = Rio Grande do Sul. \* = Atlantic Goliath grouper does not occur in RS.



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## References

- [1] A.E. Johnson, J.E. Cinner, M.J. Hardt, J. Jacquet, T.R. McClanahan, J.N. Sanchirico, Trends, current understanding and future research priorities for artisanal coral reef fisheries research, *Fish. Fish.* 14 (2013) 281–292.
- [2] V.S. Batista, N.N. Fabr , A.C. Malhado, R.J. Ladle, Tropical artisanal coastal fisheries: challenges and future directions, *Rev. Fish. Sci. Aquac.* 22 (2014) 1–15.
- [3] A. Valdivia, C.E. Cox, J.F. Bruno, Predatory fish depletion and recovery potential on Caribbean reefs, *Sci. Adv.* 3 (2017) e1601303.
- [4] N.K. Dulvy, S.L. Fowler, J.A. Musick, R.D. Cavanagh, P.M. Kyne, L.R. Harrison, J.K. Carlson, L.N.K. Davidson, S.V. Fordham, M.P. Francis, C.M. Pollock, C.A. Simpfendorfer, G.H. Burgess, K.E. Carpenter, L.J.V. Compagno, D.A. Ebert, C. Gibson, M.R. Heupel, S.R. Livingstone, J.N. Sanciango, J.D. Stevens, S. Valenti, W.T. White, Extinction risk and conservation of the world's sharks and rays, *eLife* 3 (2014) e00590.
- [5] Y. Sadovy de Mitcheson, M.T. Craig, A.A. Bertoncini, K.E. Carpenter, W.W.L. Cheung, J.H. Choat, A.S. Cornish, S.T. Fennessy, B.P. Ferreira, P.C. Heemstra, M. Liu, R.F. Myers, D.A. Pollard, K.L. Rhodes, L.A. Rocha, B.C. Russel, M.A. Samoilys, J. Sanciango, Fishing groupers towards extinction: a global assessment of threats and extinction risks in a billion dollar fishery, *Fish. Fish.* 14 (2) (2012) 119–136.
- [6] S.S. Heppell, S.A. Heppell, A.J. Read, L.B. Crowder, Effects of Fishing on Long-lived Marine Organisms, *Marine Conservation Biology: The Science of Maintaining the Sea's Biodiversity*, Island Press, Washington, DC, 2005, pp. 211–231.
- [7] O.J. Luiz, R.M. Woods, E.M. Madin, J.S. Madin, Predicting IUCN extinction risk categories for the world's data deficient groupers (Teleostei: Epinephelidae), *Cons. Lett.* 9 (2016) 342–350.
- [8] Y. Sadovy, M. Domeier, Are aggregation-fisheries sustainable? Reef fish fisheries as a case study, *Coral Reefs* 24 (2005) 254–262.
- [9] S.A. Sethi, T.A. Branch, R. Watson, Global fishery development patterns are driven by profit but not trophic level, *P. Natl. Acad. Sci. Usa.* 107 (2010) 12163–12167.
- [10] J. Olson, P.M. Clay, P.P. da Silva, Putting the seafood in sustainable food systems, *Mar. Policy* 43 (2014) 104–111.
- [11] L. McClenachan, S. Dissanayake, X. Chen, Fair trade fish: consumer support for broader seafood sustainability, *Fish. Fish.* 17 (3) (2016) 825–838.
- [12] T.D. Brewer, J.E. Cinner, A. Green, J.M. Pandolfi, Thresholds and multiple scale interaction of environment, resource use, and market proximity on reef fishery resources in the Solomon Islands, *Biol. Conserv.* 142 (2009) 1797–1807.
- [13] A. Heenan, A.S. Hoey, G.J. Williams, I.D. Williams, Natural bounds on herbivorous coral reef fishes, in: *P. Roy. Soc. B-Biol. Sci.* 283, 2016, 2016176.
- [14] D.D. Miller, S. Mariani, Smoke, mirrors, and mislabeled cod: poor transparency in the European seafood industry, *Front. Ecol. Environ.* 8 (2010) 517–521.
- [15] Z.M. Le o, R.K. Kikuchi, V. Testa, Corals and coral reefs of Brazil, in: J. Cort s (Ed.), Elsevier, 2003, 9–52.
- [16] J. Cordell, Brazil: Dynamics and challenges of marine protected area development and coastal protection, in: *Scaling up Marine Management: The Role of Marine Protected Areas*, The World Bank 58–77, 2006.
- [17] IBGE, Bahia: Nova Vi osa. Dados Gerais do Munic pio < <https://cidades.ibge.gov.br/xtras/perfil.php?Lang=&codmun=292300&search=bahia%20nova-virosa> > (accessed September 2017).
- [18] A.N. Santos, Fisheries as a way of life: gendered livelihoods, identities and perspectives of artisanal fisheries in eastern Brazil, *Mar. Policy* 62 (2015) 279–288.
- [19] R. Thurstan, S. Buckley, J. Ortiz, J. Pandolfi, Setting the record straight: assessing the reliability of retrospective accounts of change, *Conserv. Lett.* 9 (2) (2015) 98–105.
- [20] R.S. Barreto, H. Bornatowski, F.S. Motta, J. Santander-Neto, G.M.S. Vianna, R. Lessa, Rethinking use and trade of pelagic sharks from Brazil, *Mar. Policy* 85 (2017) 114–122.
- [21] C. Zapelini, V.J. Giglio, R.C. Carvalho, M.G. Bender, L.C. Gerhardinger, Assessing fishing experts' knowledge to improve conservation strategies of a critically endangered grouper in southwestern Atlantic, *J. Ethnobiol.* 37 (3) (2017) 478–493.
- [22] M.F. Pinto, J.S. Mour o, R.R.N. Alves, Animal source foods consumed in two fishing communities on the northeast coast of Brazil, *Environ. Dev. Sustain.* 19 (2017) 679–692.
- [23] A. Begossi, N. Hanazaki, R.M. Ramos, Food chain and the reasons for fish food taboos among Amazonian and Atlantic Forest fishers (Brazil), *Ecol. Appl.* 14 (2004) 1334–1343.
- [24] M.S. Castro, I.M. Martins, N. Hanazaki, Trophic relationships between people and resources: fish consumption in an artisanal fishers neighborhood in Southern Brazil, *Ethnobiol. Conserv.* 5 (4) (2016) 1–16.
- [25] A. Begossi, S. Salivonchyk, N. Hanazaki, I. Martins, F. Bueloni, Fishers (Paraty, RJ) and fish manipulation time: a variable associated to the choice for consumption and sale, *Braz. J. Biol.* 72 (2012) 973–975.
- [26] V.J. Giglio, O.J. Luiz, L.C. Gerhardinger, Depletion of marine megafauna and shifting baselines among artisanal fishers in eastern Brazil, *Anim. Conserv.* 18 (2015) 348–358.
- [27] M. Bender, S.R. Floeter, N. Hanazaki, Do traditional fishers recognise reef fish species declines? Shifting environmental baselines in Eastern Brazil, *Fish. Manag. Ecol.* 20 (2013) 58–67.
- [28] M.O. Freitas, R.L. Moura, R.B. Francini-Filho, C.V. Mente-Vera, Spawning patterns of commercially important reef fish (Lutjanidae and Serranidae) in the tropical western South Atlantic, *Sci. Mar.* 75 (2011) 135–146.
- [29] H. Bornatowski, R.R. Braga, C. Kalinowski, J.R.S. Vitule, "Buying a Pig in a Poke": the Problem of Elasmobranch Meat Consumption in Southern Brazil, *Ethnobiol. Lett.* 6 (2015) 196–202.
- [30] D.C. Carvalho, R.M. Palhares, M.G. Drummond, T.B. Frigo, DNA Barcoding identification of commercialized seafood in South Brazil: a governmental regulatory forensic program, *Food Control* 50 (2015) 784–788.
- [31] H. Bornatowski, R.R. Braga, J. Vitule, Shark mislabeling threatens biodiversity, *Science* 340 (2013) (923–923).
- [32] C.F. Staffen, M.D. Staffen, M.L. Becker, S.E. Lofgren, Y.C.N. Muniz, R.H.A. Freitas, A.R. Marrero, DNA barcoding reveals the mislabeling of fish in a popular tourist destination in Brazil, *PeerJ* 5 (2017) e4006.
- [33] J.L. Jacquet, D. Pauly, Trade secrets: renaming and mislabeling of seafood, *Mar. Policy* 32 (2008) 309–318.
- [34] A. Galal-Khalla f, A. Ardura, K. Mohammed-Geba, Y.J. Borrell, E. Garcia-Vazquez, DNA barcoding reveals a high level of mislabeling in Egyptian fish fillets, *Food Control* 46 (2014) 441–445.
- [35] H. Bornatowski, R. Braga, V. JRS, Threats to sharks in a developing country: the need for effective and simple conservation measures, *Nat. Conserv.* 12 (2014) 11–18.
- [36] V.J. Giglio, A.A. Bertoncini, B.P. Ferreira, M. Hostim-Silva, M.O. Freitas, Landings of goliath grouper, *Epinephelus itajara*, in Brazil: despite prohibited over ten years, fishing continues, *Nat. Conserv.* 12 (2) (2014) 118–123.
- [37] V.J. Giglio, J.R. Leite, M.O. Freitas, M. Hostim-Silva, Mapping goliath grouper aggregations in the southwestern Atlantic, *Braz. J. Oceanogr.* 64 (2016) 423–426.
- [38] C.A. Melo-Palmeira, L.F.S. Rodrigues-Filho, J.B.L. Sales, M. Vallinoto, H. Schneider, I. Sampaio, Commercialization of a critically endangered species (largemouth sawfish, *Pristis perotteti*) in fish markets of northern Brazil: authenticity by DNA analysis, *Food Control* 34 (2013) 249–252.
- [39] B.A. de-Franco, F.F. Mendon a, C. Oliveira, F. Foresti, Illegal trade of the guitarfish *Rhinobatos horkelii* on the coasts of central and southern Brazil: genetic identification to aid conservation, *Aquat. Conserv.* 22 (2012) 272–276.
- [40] OCEANA, Oceana condena pesca irregular de cherne-poveiro, amea ado de extin  o < (<http://brasil.oceana.org/pt-br/blog/oceana-condena-pesca-irregular-de-cherne-poveiro-ameacado-de-extincao>) > (accessed September 2017).
- [41] R.M. Ulrich, D.E. John, G.W. Barton, G.S. Hendrick, D.P. Fries, J.H. Paul, Ensuring seafood identity: grouper identification by real-time nucleic acid sequence-based amplification (RT-NASBA), *Food Control* 31 (2013) 337–344.