



Shifting baseline syndrome highlighted by anecdotal accounts from snapper (*Ocyurus chrysurus*) fishery

Cleverson Zapelini^{1,*}, Patricia Sousa da Silva² and Alexandre Schiavetti^{2,3}

ABSTRACT

The fishes of the Lutjanidae family are widely distributed throughout the Atlantic, Indian and Pacific Oceans and have relevant commercial importance. Yellowtail snapper (*Ocyurus chrysurus*) is a targeted species in the small-scale fishery of the northeastern coast of Brazil, notably for hand-line fishing. We used the local ecological knowledge (LEK) of three generations of fishers from Ilhéus (southern Bahia State, Brazil) to evaluate the perception of weight, best day of capture and relative abundance of the species. More experienced fishers captured the largest specimens, had larger catches and were more likely to indicate a decrease in species abundance. On the other hand, younger fishers had smaller catches and were more likely to indicate that the species abundance is stable or increasing. The results suggest the occurrence of shifting baseline syndrome among fishers and emphasize the importance of including information from fishers in the construction of management measures. Fishers can play a key role in developing viable proposals that are aimed at the management of fishing of species with spawning aggregation, such as yellowtail snapper.

Keywords: Lutjanidae; Management; Overfishing; Small-Scale Fisheries; Yellowtail Snapper.

¹ Ethnoconservation and Protected Areas Lab (LECAP), Collaborator researcher of Programa de Pós-Graduação em Sistemas Aquáticos Tropicais, Universidade Estadual de Santa Cruz, Rodovia Jorge Amado, Km 16, Salobrinho, 45662-900, Ilhéus, BA, Brazil.

² Ethnoconservation and Protected Areas Lab (LECAP), Universidade Estadual de Santa Cruz, BA, Brazil.

³ Departamento de Ciências Agrárias e Ambientais (DCAA), Ethnoconservation and Protected Areas Lab (LECAP), Universidade Estadual de Santa Cruz, BA, Brazil. Research associate CESIMAR, CENPAT, Chubut, Argentina

* Corresponding author. ✉E-mail address: (CZ) clever.zapelini@gmail.com; (PSS) ptrsousa@gmail.com; (AS) aleschi@uesc.br.

INTRODUCTION

With continuous environmental degradation at the local, regional and global scales, people of different generations have distinct perceptions about environmental conditions; a psychological and sociological phenomenon called shifting baseline

syndrome (SBS; Soga and Gaston 2018). Examples come from changes in bird abundance (Papworth et al. 2009), quantity and quality of water (Alessa et al. 2008) and fishery (Sáenz-Arroyo et al. 2005).

In the context of fisheries, since the seminal insight of Pauly (1995), a growing number of studies have investigated the

occurrence of SBS among fishers (e.g., Giglio *et al.* 2015; Ulman and Pauly 2016). SBS refers to the situation where different generations of fishers exhibit discordant perceptions of the state of the resource because each generation has as reference the environmental conditions of the beginning of their life in the fishery, ignoring continuous environmental degradation (Sáenz-Arroyo *et al.* 2005; Venkatachalam *et al.* 2010; Ainsworth 2011). In addition to the finding of the occurrence of SBS, these studies can be used as complementation of scientific data (Venkatachalam *et al.* 2010; Castellanos-Galindo *et al.* 2011; Sáenz-Arroyo and Revollo-Fernández 2016).

In Brazil, fishery control and statistics have already been carried out by various governmental agencies (e.g., IBGE 1980; IBAMA 2000; MPA 2012). This frequent change in the control of fishery statistics results in discontinuous data or publication of data in different formats, making comparisons difficult over time. This problem with fishery statistics highlights the importance of research carried out in partnership with fishers. Fishers have been an additional source of information in scientific research as they have a broad knowledge of a range of ecological and biological aspects of the resources they exploit (e.g., Coll *et al.* 2014; Silvano *et al.* 2006, 2008). Thus, it adds evidence to the growing literature on the importance of fisher's local ecological knowledge (LEK) in understanding trends in species abundance in marine ecosystems (Sáenz-Arroyo and Revollo-Fernández 2016; Thurstan *et al.* 2016). From the fishers' LEK, it becomes possible to construct and complement several studies on bony (Bender *et al.* 2013; Zapelini *et al.* 2017) or cartilaginous fishes (Baum and Myers 2004; Giglio *et al.* 2015, 2016), in addition to other species of

commercial importance (Turvey *et al.* 2010; Alleway and Connell 2015).

Species of the family Lutjanidae constitute important fishing resources in several reef environments worldwide (Heyman *et al.* 2005; Sadovy and Domeier 2005; Freitas *et al.* 2011). These species are found in the Atlantic, Pacific and Indian Oceans in tropical and subtropical regions (Randall 1967). On the Brazilian tropical coast, some of these species have high commercial value and have suffered high fishing pressure, and the yellowtail snapper *Ocyurus chrysurus* (Bloch 1791; Figure 1) is one of the primary components of the catches in the northeast region (Frédou *et al.* 2009a,b; Freitas *et al.* 2011; Bender *et al.* 2013). Some studies point to an unclear situation with regard to SBS in yellowtail snapper fisheries: fishers of different generations indicate some stability in catches of the species, which may be related to their higher relative abundance when compared to other target species, such as groupers (Bender *et al.* 2013; Zapelini *et al.* 2019).

In the Ilhéus municipality (state of Bahia, Brazil), yellowtail snapper is one of the main resources of small-scale fisheries (Cetra and Petrere 2014). Therefore, this work has the following objectives: (i) to verify the temporal dynamics of the environmental references of the fishers regarding the best fishing day (greater quantity captured), (ii) the largest individual weight of yellowtail snapper ever caught, and (iii) the catch per unit effort (CPUE), assuming that the weight and quantity of yellowtail snapper reduced over time.



Figure 1 - Yellowtail snapper (*Ocyurus chrysurus*), one of the most important fishing resources in the region of Ilhéus / Bahia.

MATERIAL AND METHODS

Study area

The study was conducted in the municipality of Ilhéus (Lat: 14° 47' 50", Long: 39° 2' 8"), southern Bahia state (Figure 2). Small-scale fishing is one of the main economic activities in the region (CEPENE 2003; Souza and Petrere Jr. 2008). The fishing fleet uses a coastal strip approximately 175 km long, between Itacaré (in the north) and Canavieiras (in the south). The most common vessels range from 6-9 m and use fishing gear, such as hand lines and shrimp trawls (Barbosa-Filho and Cetra 2007).

Data collection

Fishers were interviewed between February and August 2014 through a semi-

structured questionnaire due to the flexibility provided by this format (Young *et al.* 2017). Daily, the interview site was shuffled between three different fishing landings sites. The interview included general information such as name or surname, age and fishing time in Ilhéus. Later, the issues focused on the target species of the research: weight of the largest yellowtail snapper ever caught (kg), the largest amount caught (kg) and the perception of relative abundance (decreased, stable or increased). Photographs were used to confirm that the interviewee and the researcher were referring to the same species. All interviews were conducted by the same researcher (P.S.S.). Fishers were interviewed individually to avoid the influence of third parties.

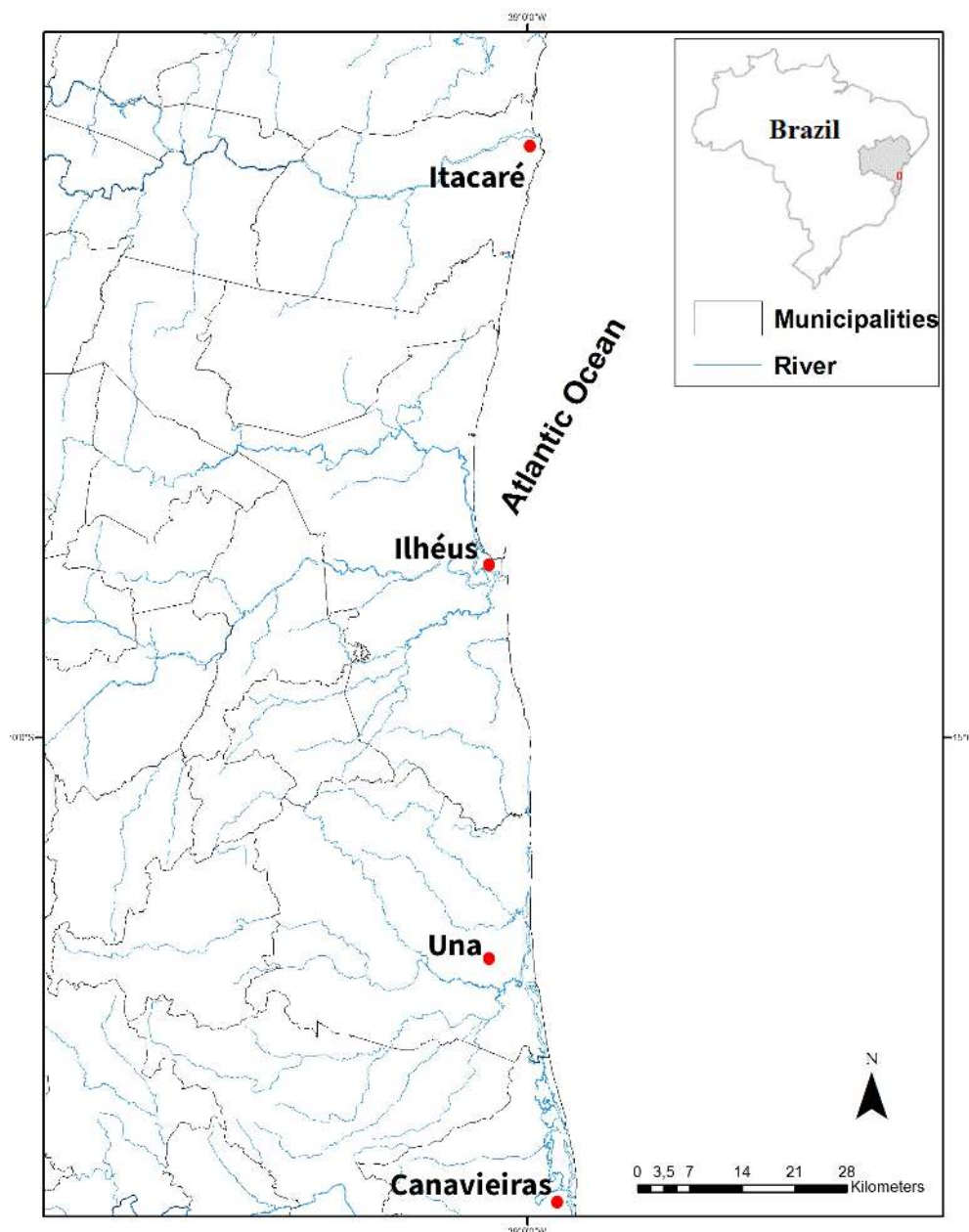


Figure 2. Location of the study area.

Statistical analyses

Fishers were categorized by time of experience: beginners (≤ 15 years of practice); intermediate (16 to 30 years) and experienced (≥ 31 years; Bender *et al.* 2014). For each fisher, the catch per unit effort (CPUE; kg.fisher⁻¹.day⁻¹) of the best catch day was calculated. Polynomial regression was adjusted to verify the relation

of the best catch day (and CPUE) in relation to the decade of the beginning of the fishing career of each fisher. For the analysis of the best catch day (and CPUE), the fishers of the 1940s and 2010s were grouped together with the 1950s and 2000s, respectively. This was done due to the small sample number in these two periods (1940 / 2010).

One-way ANOVA was used to (i) compare the weight of the largest specimen captured as a function of the experience time; (ii)

compare the best catch day (and CPUE) according to the respective decades of the beginning of fishing careers. The best capture day values were log-transformed to obtain a normal distribution. Tukey's post hoc test was used to verify differences between groups. Kruskal-Wallis was used in situations with some violation of the parametric assumptions.

The perception of change in relative abundance was verified using an ordinal logistic regression model (OLR) through the 'polr' function (MASS package, Ripley *et al.* 2014). The function adjusts an OLR model with proportional odds (link function = logistic) for an ordered response variable (perception: decreased, stable, increased). The perception of qualitative abundance was transformed into a quantitative scale with three levels (decreased = -1, stable = 0, increased = 1). We ran the model considering the perception in relation to the experience (in years) of each fisher. The use of the OLR model is appropriate to verify the effect of a predictive variable on all levels of an ordered response variable. It does not assume normality in data distribution and constant variance but requires the premise of parallel lines between all levels of the categorical result (McCullagh 1980; Chen and Hughes 2004).

The premise of parallel lines of the OLR model was verified in SPSS software v.21 (IBM 2012). All other statistical tests were conducted in R (R Core Team 2013) software at a significance level of 5%.

This study was approved by the Committee of Ethics in Research with Human Beings of the Universidade Estadual de Santa Cruz under protocol number 25612313.9.0000.5526.

RESULTS

We interviewed 188 fishers, ranging in age from 22 to 88 years (mean \pm sd: 49 \pm 12.6) with fishing experience ranging from 4 to 69 years (32.0 \pm 13.8). There was a difference between the 'intermediate' and 'experienced' classes of experience in relation to the largest yellowtail snapper ever captured (ANOVA: $F_{2,165} = 5.0$, $p < 0.01$; Figure 3).

There was a difference in the best catch day as a function of the decade (ANOVA: $F_{5,148} = 12.04$, $p < 0.001$; Figure 4A), and we observed a decreasing trend in the best catches (polynomial regression: $r^2 = 0.25$, $p < 0.001$; Figure 4B). There was a difference in CPUE over the decades ($\chi^2 = 22.05$, $p < 0.001$; Figure 4C), and the trend has declined ($r^2 = 0.13$, $p < 0.001$; Figure 4D).

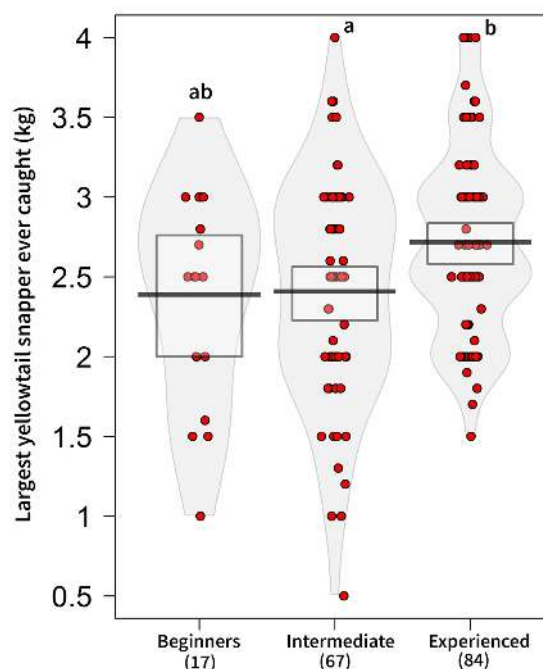


Figure 3. Largest yellowtail snapper caught according to the fishers' experience. Red dots are the raw data, horizontal black line represents the mean, bean is the density and the rectangle is the inference (95% Bayesian range of highest density). Different letters above the plots indicate significant differences (ANOVA, $p < 0.01$).

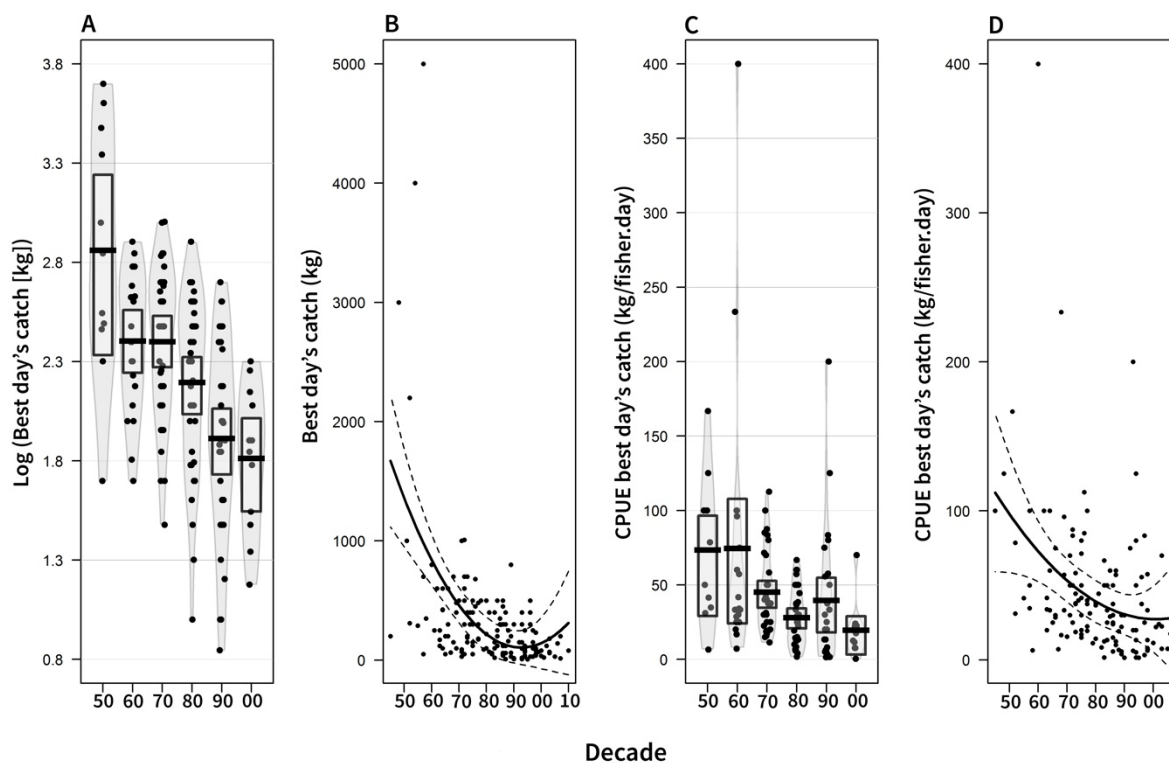


Figure 4. Capture of yellowtail snapper by fishers from Ilhéus: A) Log of the best catch day per decade; B) Relationship of the best catch day over the decades; C) CPUE of the best catch day ($\text{kg}\cdot\text{fisher}^{-1}\cdot\text{day}^{-1}$) per decade; D) CPUE of the best catch day over the decades. In A and C: Points are the raw data, horizontal black line represents the mean, bean is the density and the rectangle is the inference (95% Bayesian range of higher density); in B and D, dashed lines represent the confidence interval (99%).

The OLR result indicates that fishers who started fishing more recently are more likely to indicate that the relative abundance of yellowtail snapper is stable or increasing, whereas more experienced fishers are more likely to indicate that abundance has decreased; that is, we see a shift in perception among generations of fishers (Table 1; Figure 5).

The few historical landing records point to a trend of increasing catches (Figure 6). However, the information is for the regional scale (state of Bahia). Thus, comparisons between scales should be interpreted with caution.

DISCUSSION

Species that have relevant economic importance provide a great opportunity to assess trends of exploitation over decades. Here, we find that different generations of fishers have divergent perceptions regarding yellowtail snapper, and more experienced fishers reported a greater decrease in their abundance, suggesting the occurrence of SBS.

Yellowtail snapper is a species of socioeconomic importance and is the target of fishing along the Brazilian northeastern coast. More experienced fishers were more likely to indicate that species abundance is

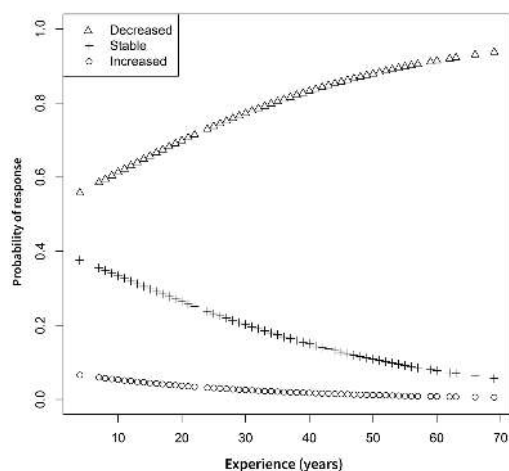


Figure 5. Change in the relative abundance of yellowtail snapper perceived by the fishers of Ilhéus. Triangles indicate the probability of decrease in abundance; crosses indicate the probability of stability; circles indicate the probability of increase. The more experienced the fisher, the more likely it is to indicate that the abundance of the species has decreased.

Table 1. Coefficient indicates the average change perceived with the increase in the fishers' experience time. With the increase of one unit in the fisher's experience, the odds ratio of moving a unit in the perception is multiplied by 0.96. That is, the odds of perceiving change from 'decreased' to 'stable' or 'stable' to 'increased' decreases with fishing experience. *significance ($p < 0.05$).

Model	Coefficient	Standard error	t	Odds Ratio
Perception ~ experience	-0.0381*	0.0141	-2.69	0.9626

decreasing over time. This situation is similar to another study carried out in Porto Seguro, approximately 200 km south of the study area, where more experienced fishers also reported a decrease in the abundance of the species over the last 40 years (Bender *et al.* 2013). Another study, conducted further south of Ilhéus, found that fishers perceive the abundance of yellowtail snapper as

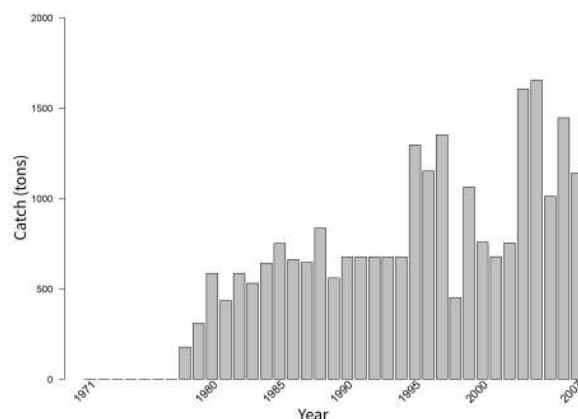


Figure 6. Fishing landings of yellowtail snapper in the state of Bahia between 1971 and 2007.

relatively stable. The authors suggest that the current capture level may not have reached the lowest threshold. In this way, fishers still do not realize the decrease in their abundance (Zapelini *et al.*, 2019). The results complement previous biological studies that indicate over-exploitation of the species in the Brazilian Northeast (Lessa *et al.* 2004; Klippel *et al.* 2005; Frédoú *et al.* 2009a,b) and show a tendency of decline in the captured biomass. Although there is no fishing effort data, it is likely that the effort has an increasing tendency, as suggested in other regions of the country (Lima *et al.* 2016) and in the world (Anticamara *et al.* 2011). In addition, Nóbrega *et al.* (2009) noted the decline in abundance in the northeastern region, and the authors suggest that increasing effort directed at the species may be the factor responsible for this.

The increasing fishing effort is compatible with the modernization of fishing techniques. Barbosa Filho (2013) reports that for 30 years, fishers not yet had access to the nylon line. Thus, they used to twist a certain amount of cotton string to make their fishing lines. For the conservation of this line against the action of salt water and also to resist the force that the fish applied, infusions were used with the stem bark of at

least three plant ethnosppecies found in the mangroves: the “tucum” (*Bactris setosa*), the “red mangrove” (*Rhizophora mangle*) or the “mucuna”. In this way, the current facilities offered by modernization / industrialization enable greater fishing effort and, consequently, a greater impact on fishing stocks.

The decreasing trend in weight and abundance are possible indicators of the occurrence of fishing during critical periods of the species' life cycle. The largest number of landings occur in winter (July to August in the Southern Hemisphere, Costa *et al.* 2003; Cetra and Petrere 2014), a period that overlaps the peak period of the Gonadosomatic Index (GSI; Freitas *et al.* 2011). In addition, some intrinsic characteristics of the species, such as the long-life cycle, late sexual development and formation of reproductive aggregations that are predictable in time and space (Sadovy and Domeier 2005; Sadovy de Mitcheson *et al.* 2012), determine the reduced capacity of population recovery. Although there is still no evidence of fishing directed at reproductive aggregations by Ilhéus vessels, fishers may discover specific aggregation sites and easily contribute to population decline (Claro *et al.* 2009). Future studies may investigate the seasonal pattern of species capture in addition to evaluating the reproductive cycle. In this way, one can explore the possibility of fishing directed towards aggregations (França and Olavo 2015).

The memory of the more experienced fishers can provide an estimate of the population trend of the species and help reveal the real magnitude of losses caused by overfishing as well as provide us with data on structural and functional changes in marine ecosystems caused by exploitation. Although there is still some mistrust regarding the use of LEK among regulatory

resource management agencies (Moller *et al.* 2004; Butler *et al.* 2012), there is increasing evidence that fishers can provide accurate information (Sáenz-Arroyo and Revollo-Fernández 2016) and should be included in the process of constructing management measures (Hind 2015).

Studies show that perceptual construction can be influenced by nostalgia, that is, the longing for things, persons, or situations that are not present (Merchant and Ford 2008). Personal nostalgia is a search for an idealized past. The person who experiences this kind of nostalgia remembers things and events in a more positive way than he really was. Although general consensus links nostalgia to older people, this is not necessarily true. Some studies show that nostalgia is not purely a function of age. Nostalgia increases and decreases in different age groups, depending on the experiences and demands imposed by life. For example, Batcho (1995) found that young university students were more nostalgic than the elderly, in certain subjects. Thus, we have no evidence to indicate that nostalgia may be a bias in the results.

Our results add further evidence to those already reported by previous studies on the need to implement management measures directed at yellowtail snapper (Ferreira *et al.* 2004; Klippel *et al.* 2005; Begossi *et al.* 2011). Unfortunately, since Normative Instruction N° 5/2004, the species has not yet received due attention, remaining outside the most recent fishing management measures established in the country, such as those for southern red snapper (*Lutjanus purpureus*), which has a recovery plan (Brasil 2018). However, any management measure should be constructed in a participatory manner, together with the fishers, to complement and add different knowledge (academic / scientific and

empirical / practical) to minimize possible conflicts and lack of respect for decisions (Lopes *et al.* 2013).

CONCLUSIONS

Our study suggests the occurrence of SBS among different generations of fishers from Ilhéus, where more experienced fishers reported larger total catches and weightier specimens. From the management point of view, we suggest the construction of a partnership between managers, academics and the fishing community with the purpose of investigating possible reproductive aggregation sites of species. In addition, we emphasize the need to re-establish systematic species-level fishery monitoring programmes at the local, regional and national scales. The chronic lack of information causes damage not only to the population of the species but also to the fishing community that depends on the resource for its survival.

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