

# AGE, GROWTH AND MORTALITY OF WHITE GRUNT CAUGHT IN PERNAMBUCO STATE, BRAZIL

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## ABSTRACT

The aim of the present study was to measure the primary growth parameters and to estimate the mortality of the white grunt *Haemulon plumierii* in the state of Pernambuco, Brazil. Sagittal otoliths were collected monthly from May 2013 to April 2014 from three different commercial fishing landings along the coast of Pernambuco. A total of 333 individuals measuring 10.5 to 32.2 cm total length were caught. The total length distributions were different between locations. The weight-length relationships and the von Bertalanffy equations were statistically different between the three fishing sites. The weight-length relationship indicated negative allometric growth, therefore the von Bertalanffy equation for pooled sexes was  $TL_t = 31.1[1 - e^{-0.1(t+4.57)}]$ . The maximum observed age was 21 years and the mortality rate was 0.21 year<sup>-1</sup>. The conducted analysis indicates a species with long life cycle and slow growth. Small reef fish with slow movement, such as the white grunt, are susceptible to fishing efforts, environmental factors and degradation, which affect growth and mortality. Therefore, we suggest an assessment of the status of the stock.

**Key words:** otolith; von Bertalanffy equation; artisanal fishery; trap fishery.

## IDADE, CRESCIMENTO E MORTALIDADE DE *Haemulon plumierii* CAPTURADA NO ESTADO DE PERNAMBUCO, BRASIL

## RESUMO

O objetivo do presente estudo foi estimar os primeiros parâmetros de crescimento e mortalidade de Biquara *Haemulon plumierii* no estado de Pernambuco, Brasil. Os otólitos *sagittae* foram coletados mensalmente de maio de 2013 a abril de 2014 a partir de desembarques da pesca comercial ao longo da costa de Pernambuco. O total de 333 indivíduos medindo 10,5 a 32,2 cm foram capturados. As distribuições de frequência de comprimento foram diferentes entre as áreas. Consequentemente, as relações peso-comprimento foram diferentes entre as áreas, bem como os parâmetros de von Bertalanffy. A relação peso-comprimento indicou crescimento alométrico negativo. Portanto, a equação de von Bertalanffy para sexos agrupados foi  $TL_t = 31.1[1 - e^{-0.1(t+4.57)}]$ . A idade máxima observada foi 21 anos e a mortalidade total foi 0,21 ano<sup>-1</sup>. As análises conduzidas indicam uma espécie com ciclo de vida longa e crescimento lento. Pequenos peixes recifais de pouca movimentação, como a biquara, são susceptíveis ao esforço pesqueiro, fatores ambientais e degradação, que afetam o crescimento e a mortalidade. Portanto, sugerimos uma avaliação do status atual do estoque.

**Palavras-chave:** otólito; equação de von Bertalanffy; pescaria artesanal; pesca de armadilha.

## INTRODUCTION

The White grunt, *Haemulon plumierii* (LACÉPÈDE, 1801), is member of the family Haemulidae and is known in Brazil as *biquara*, *abiquara*, *cocoroca*, *cambuba*, *boca-de-fogo*, *boca-de-velha*, *xira* or *sapuruna*. This reef species is distributed throughout the eastern coast of America from Chesapeake Bay in the United States to the southeastern region of Brazil (SMITH, 1997) at depths of 3 to 40 m (POTTS and MANOOCH, 2001). The white grunt forms schools (DARCY, 1983) and feeds mainly on fish, mollusks, crustaceans and annelids (RANDALL, 1967). It is faithful to the location in which it resides (TULEVECH and RECKSIEK, 1994), matures at approximately 17 cm (SHINOZAKI-MENDES *et al.*, 2013 a) and its life span is

estimated to be 15 to 28 years (POTTS and MANOOCH, 2001; NEVES ARAÚJO and SILVA MARTINS, 2007).

The White grunt is very common in waters off northeastern Brazil (FEITOZA *et al.*, 2005) and, despite not having commercial importance, is often captured as incidental catch (NEVES ARAÚJO and SILVA MARTINS, 2007). In 2006, 15.5 tons were caught in the state of Piauí, 572 tons were caught in the state of Ceará, 420.5 tons were caught in the state of Rio Grande do Norte, 20.5 tons were caught in the state of Paraíba, 183.5 tons were caught in the state of Pernambuco, three tons were caught in the state of Bahia and less than one in the Espírito Santo (IBAMA, 2008). Between 2008 and 2010, the white grunt was the second most captured species of the family Haemulidae, representing an average of 35.22% of the total catch, behind the Torroto grunt *Genyatremus luteus* (44.85%) and ahead of the Tomtate grunt *Haemulon aurolineatum* (8.86%) (BRASIL, 2012).

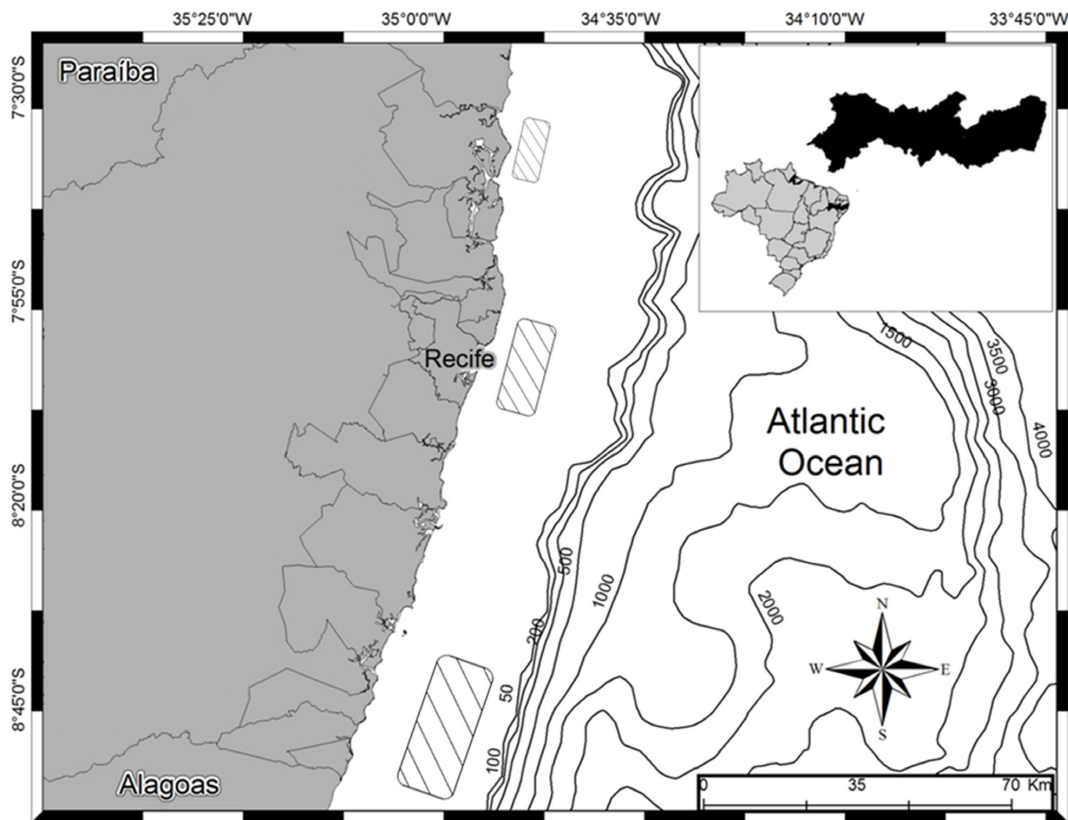
The International Union of Conservation of Nature and Natural Resources (IUCN) evaluated the white grunt recently as “Least Concerned” in regard to a decreasing population trend (LINDEMAN *et al.*, 2016). Although studied by some authors in Brazil (NEVES ARAÚJO and SILVA MARTINS, 2007; SHINOZAKI-MENDES *et al.*, 2013 a, b), there is still little known about their growth in the northeastern region of the

country. It is important to emphasize that the current growth curve of *H. plumierii* in Brazil was estimated on an area of low catches.

The fishing effort affects the population structure and their rates, hence information on age, growth and mortality rates need to be updated periodically, considering the anthropic impact on age used for the management of species. Therefore, the aim of the present study is to provide the first von Bertalanffy growth curve using otolith analysis for *Haemulon plumierii* caught in northeastern Brazil, estimate mortality rate and compare it to other studies. Our hypothesis consists that differences in fishing pressure are related with the obtained parameters.

## METHODS

A total of 333 specimens were obtained from commercial points (fish shops) monthly along the coast of the state of Pernambuco between May 2013 and April 2014. Fish were collected from three commercial corrals along the coast of the state: 2 km away from the coast at a depth of 3 m (07°37'35" S; 34°48'51" W) (north); traps in 5 km from the coast at a depth of 15 m (08°00'34" S; 34°51'19" W) (center), and gill nets in 10 km from the coast at a depth of 20 m (08°35'21" S; 35°06'55" W) (south) (Figure 1).



**Figure 1.** Coast of the state of Pernambuco with collection sites of the *Haemulon plumierii* samples.

For each specimen, total length (TL) and total weight (TW) were measured and its sex was identified macroscopically. Normality was tested with the Shapiro Test. The Mann-Whitney-Wilcoxon Test was used to assess the frequency distributions. Differences of the weight-length relationships were estimated for both sexes with an analysis of covariance (ANCOVA). The level of significance was set to  $\alpha = 0.05$  for all statistical analyses and for confidence intervals of the parameters  $a$  (intercept) and  $b$  (slope). Student's t-tests with the statistic  $t = b - 3 / S_b$ , with  $S_b$  the standard error of  $b$  where used for the isometric growth ( $H_0 = 3$ ) (FROESE, 2006; ZAR, 2010).

Growth marks were analyzed on the otoliths: the otoliths were removed, washed and embedded in polyester resin and cut with a low-speed metallographic saw in cross-sections (dorsal-ventral) of a thickness of 600  $\mu\text{m}$  containing the nucleus (SECOR *et al.*, 1992). The surface was polished with aluminum oxide (0.3  $\mu\text{m}$ ) and felt until reaching a final thickness of 200 to 350  $\mu\text{m}$  (SECOR *et al.*, 1992). The cuts were examined at a magnification of 25x under transmitted light with a stereo microscope equipped with a micrometric ocular. The growth marks were measured by two independent readers counting opaque zones along the reading axis beginning with the nucleus and ending at the border with no prior knowledge regarding the TL or period in which the individuals were caught. Linear regression was performed to establish the relationship between the otolith length (OL) and TL of the specimen.

The index of average percentage error (IAPE) (BEAMISH and FOURNIER, 1981) was calculated to compare readings, using the following equation:

$$IAPE = \frac{1}{N} \sum_{j=1}^N \left[ \frac{1}{R} \sum_{i=1}^R \frac{|X_{ij} - \bar{X}_j|}{\bar{X}_j} \right] \times 100\% \quad (1)$$

in which  $N$  is the number of individuals sampled,  $R$  is the number of readings for the same individuals,  $X_{ij}$  is reading  $i$  of

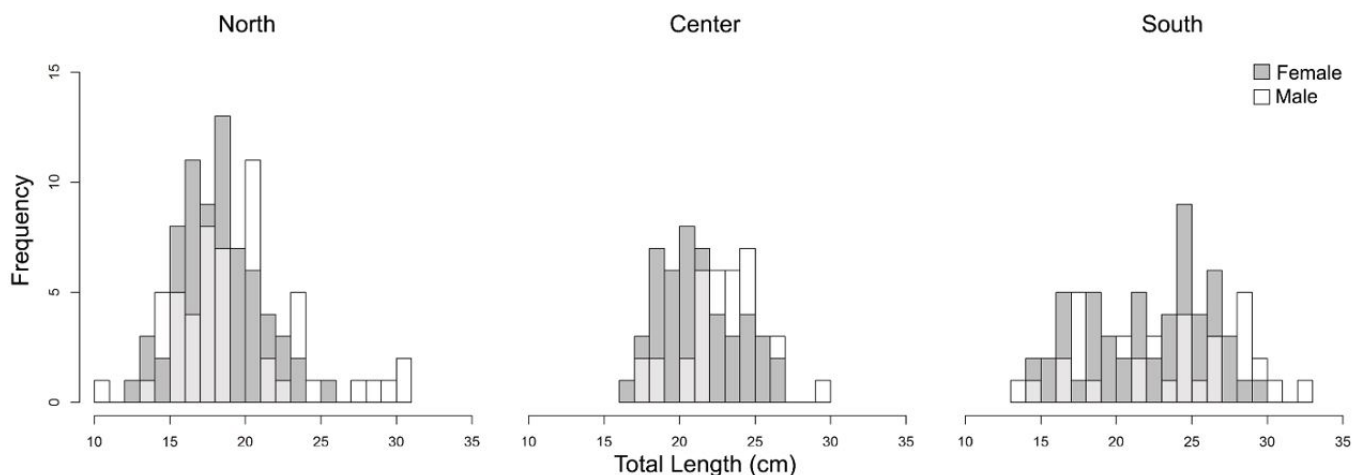
individual  $j$  and  $\bar{X}_j$  is the mean of the readings for individual  $j$ . For IAPE values equal to or greater than 10%, a third reading was performed. 33 samples were excluded from final analysis by meeting the exclusion criterion of an IAPE equal to or greater than 10% after three readings.

The periodicity of ring formation was validated with two different methods, the first analyzing the relative marginal increment (NEVES ARAÚJO and SILVA MARTINS, 2007) and the second analyzing also the oxytetracycline in captivity (MURIE and PARKYN, 2005). Both methods demonstrated the formation of one ring per year. The growth curves were compared with the  $\chi^2$  of maximum likelihood KIMURA (1980) and the total mortality rate ( $Z$ ) was estimated using the linearized catch curve (RICKER, 1975).

## RESULTS

The TLs of the 333 individuals were between 10.5 and 32.2 cm. 173 fish were females (mean  $\pm$  standard deviation) ( $20.5 \pm 3.58$  cm TL) and 160 were males ( $21.55 \pm 4.36$  cm TL). TW ranged from 20.08 to 486.2 g ( $176.88 \pm 100.95$  g for males and  $150.39 \pm 73.65$  g for females). The TL were not normal distributed (SW = 0.98;  $p < 0.05$ ) and frequencies distributions were different between area (W = 3747;  $p < 0.05$ ) (Figure 2).

The weight-length relationships (Figure 3) had significant difference in relation to the fishing sites (ANCOVA,  $F = 117.75$ ;  $df = 329$ ;  $p < 0.05$ ) but not for sex (ANCOVA;  $F = -0.54$ ;  $df = 329$ ;  $p = 0.59$ ). The t-test rejected the null hypothesis for the slope for all fishing sites (ANOVA;  $F = 107.11$ ;  $df = 318$ ;  $p < 0.05$ ) (Table 1). The relationship between TL and otolith length was  $OL = 0.035TL + 0.2$  (ANOVA;  $F = 1506.72$ ;  $df = 123$ ;  $p < 0.05$ ), indicating a presupposition of proportionality.



**Figure 2.** The frequencies distribution the TL of *Haemulon plumierii* for each fishing site. North = 143 individuals, Center = 87 individuals and South = 103 individuals.

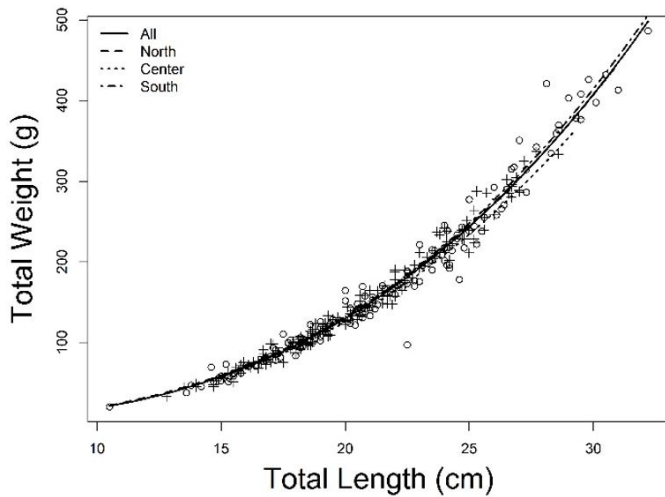
A total of 333 slides were prepared for otolith ageing, 33 of which were discarded due to an IAPE greater than 10%. The remaining otoliths had 1 to 21 rings (Figure 4) and were included in further analysis. Agreement between readers occurred among 81 slides (27%). The largest difference between readers were four rings, resulting in an IAPE of 6.93%.

We found significant differences between the growth estimates by fishing sites (Figure 5) (Table 2), but no significant difference between sexes in all hypothesis (Table 3). Therefore, sexes were pooled for calculations of the growth parameters. The maximum observed age

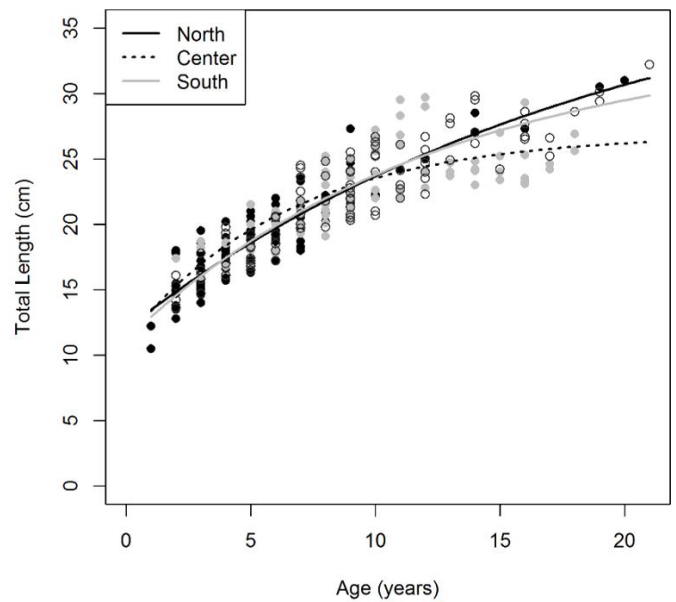
was 21 years and the total mortality rate estimated by catch curve was  $Z = 0.21 \text{ year}^{-1}$  with confidence interval 0.17 and  $0.24 \text{ year}^{-1}$  (Figure 6). Table 4 shows comparisons with results from similar fish studies.

**Table 1.** Parameters estimates for weight-length relationship of *Haemulon plumierii* caught in Pernambuco for each site with pooled sex,  $TW = a TL^b$  and their confidence intervals. All regressions were significant ( $p < 0.05$ ).

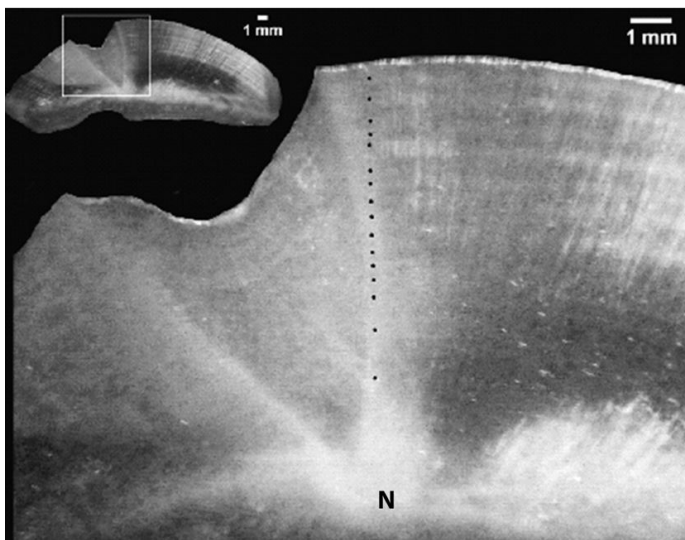
Site	n	r <sup>2</sup>	a	b
All	333	0.98	0.027 (0.022 - 0.031)	2.83 (2.774 - 2.878)
North	143	0.97	0.032 (0.026 - 0.037)	2.77 (2.72 - 2.834)
Center	87	0.94	0.029 (0.015 - 0.043)	2.79 (2.637 - 2.944)
South	103	0.99	0.028 (0.019 - 0.037)	2.82 (2.722 - 2.919)



**Figure 3.** Weight-length relationships of *Haemulon plumierii* caught in Pernambuco for each fishing site. Circles represent males and crosses females.



**Figure 5.** Growth curve of *Haemulon plumierii* caught in Pernambuco fitted to the von Bertalanffy model for each site: north (118 ind., black points), center (84 ind., white points) and south (98 ind., gray points).



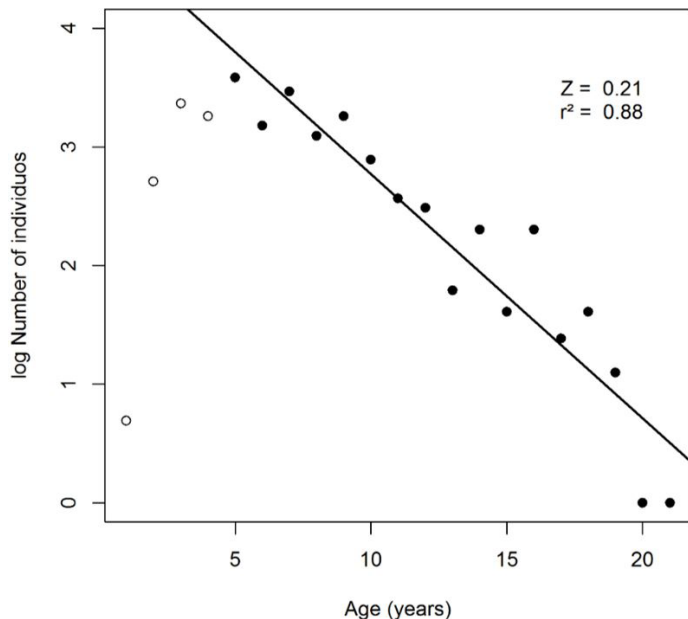
**Figure 4.** Otolith section: the black points mark the opaque bands. N indicates the core.

**Table 2.** Parameters estimates for von Bertalanffy model of *Haemulon plumierii* caught in Pernambuco for each site. All regressions were significant ( $p < 0.05$ ).

Area	Regression	R <sup>2</sup>
All	$TL = 31.15(1 - e^{-0.1(t+4.57)})$	0.81
North	$TL = 41.08(1 - e^{-0.05(t+6.75)})$	0.83
Center	$TL = 26.9(1 - e^{-0.15(t+3.45)})$	0.59
South	$TL = 34.21(1 - e^{-0.07(t+5.02)})$	0.83

**Table 3.** Chi-square test of maximum likelihood of von Bertalanffy parameters for *Haemulon plumierii* males (a) and females (b) on the coast of Pernambuco.

Tests	Hypothesis	RSS	$\chi^2$	df	p
Ho	None	1259.56			
Ho vs H1	$TL_{\infty}^a = TL_{\infty}^b$	1259.94	0.09	1	0.764
Ho vs H2	$K^a = K^b$	1260.54	0.23	1	0.632
Ho vs H3	$t_0^a = t_0^b$	1261.02	0.35	1	0.554
Ho vs H4	$TL_{\infty}^a = TL_{\infty}^b, K^a = K^b, t_0^a = t_0^b$	1263.30	0.89	3	0.828

**Figure 6.** Catch curve for *Haemulon plumierii* on the coast of Pernambuco.

## DISCUSSION

The frequency distribution of *Haemulon plumierii* along the northern coast of Brazil in the state of Pernambuco revealed differences in length among the three different locations (north, center, south) presumably due to the selectivity of the gear and/or the spatial distribution in the ontogeny of the species. The northern portion of the state of Pernambuco had a modal class of 18 cm TL, whereas the central coast had a modal class of 20 cm TL and the southern coast of the state had two modes (17 cm and 24 cm TL). It is a reflection of the fishing devices: the corrals directed at larger specimens such as scombrids and serranids that are predominant in the first region, traps targeting lutjanids and serranids (medium size fish) are deployed in the second region and the two modes in the southern portion of the state are likely due to different types of devices, such as traps and gill nets.

Previous studies (POTTS and MANOOCH, 2001; MURIE and PARKYN, 2005; NEVES ARAÚJO and SILVA MARTINS, 2007) that involved *H. plumierii* did not report individuals with less than 16 cm in TL. Moreover, these studies reported a higher upper limit (>40 cm TL) of the length spectrum in comparison to the present study which might stem from the area of fishing operations, as larger individuals of reef fishes are distributed among greater depths (BELLWOOD and WAINWRIGHT, 2005). This could explain the maximum observed age found by NEVES ARAÚJO and SILVA MARTINS (2007), who collected samples on the continental shelf margin and reported a maximum age of 28 years for *Haemulon plumierii* on the central coast of Brazil. This is also corroborated by the maximum length observed in the southern portion of the study (32.2 cm TL), where fishing operations occur at a farther distance from the shore and at a greater depth, and the smaller length on the northern shore (10.5 cm TL), where operations occur close to the coast at shallower depths.

$TL_{\infty}$  in the present study was smaller than the one reported in previous studies and smaller than the maximum observed total length, while the  $k$  value was similar to that reported in previous studies on the species (Table 4). This can be explained by the length range of the sample. POTTS and MANOOCH (2001) reported on samples (17.3-51.2 cm TL) from commercial handline operations, but did not detail the catch site. MURIE and PARKYN (2005) collected specimens (16-41 cm TL) between 5 to 50 km from the shore at depths down to 24 m using handlines and traps.

**Table 4.** Comparison of von Bertalanffy growth and age parameters of *Haemulon plumierii*: Confidence intervals were used for POTTS and MANOOCH, and the actual ranges for the others.

Parameters/Authors	POTTS and MANOOCH (2001)	MURIE and PARKYN (2005)	NEVES ARAÚJO and SILVA MARTINS (2007)	Present study
Area	North and South Carolina	Florida	Central coast of Brazil	Northeast coast of Brazil
$TL_{\infty}$ (cm)	51.5 - 66.6	29.5 - 34.5	29.8 - 33.1	26.4 - 41.8
$k$	0.04 - 0.12	0.3 - 0.41	0.35 - 0.59	0.05 - 0.15
$t_0$ (year)	-5.77 - -2.64	-3.44 - -0.85	-1.08 - 0.08	-6.75 - -3.45
$t_{obs}$ (year)	1 - 15	0 - 18	2 - 28	1 - 21

NEVES ARAÚJO and SILVA MARTINS (2007) caught samples (21.8-37.8 cm TL) using bottom longlines and handlines, but also did not specify the catch sites. Our value of  $t_0$  was compatible with POTTS and MONOCH (2001). Despite the differences among the parameters from different studies on the same species, the estimates in the present study are similar to those reported for other species of the genus *Haemulon* (MORALES and GONZÁLEZ, 2010; PITT *et al.*, 2010).

The sample composition influenced strongly the von Bertalanffy model and this difference can be evidenced in the comparison of growth parameters to other studies involving *Haemulon plumierii* (POTTS and MANOCH, 2001; MURIE and PARKYN, 2005; NEVES ARAÚJO and SILVA MARTINS, 2007) (Table 4). In addition, the environment factors, food availability and fishing effort can influence growth of fishes (RUSS and ALCALA, 1989). In Florida, the white grunt has importance to recreational and commercial fisheries, and it was caught until 1410 tons. In Pernambuco state, where it has local economic value, 183.5 tons have been caught mainly as a by-catch, while less than one ton was caught in the state of Espírito Santo, Brazil. These three scenarios of fishing pressure could explain the different size distributions and the wide range of growth parameters.

The total mortality rate ( $Z = 0.21 \text{ year}^{-1}$ ) was similar to the one found by NEVES ARAÚJO and SILVA MARTINS (2007) in the coast of Espírito Santo. They estimated the natural mortality rate of  $0.15 \text{ year}^{-1}$  and an exploration rate of 0.28 and concluded that the stock was between low and moderate fishing pressure. Nevertheless, they considered that the life expectancy could be over 30 years. In Brazil, the IUCN did not review yet the total caught in northeastern coast which amounts to over 1200 tons (IBAMA, 2008).

## CONCLUSION

In this study, we analyzed 333 specimens of White grunt from three different sites on the coast of Pernambuco and derived distributions of the total length, the total weight, and age. It is likely that the estimated parameters in the present study represent the growth of a portion of the population exploited by commercial fishing efforts. The parameters indicate a long-living species with slow growth. Small reef fishes with limited movements, such as the White grunt, are susceptible to fishing efforts, environmental factors and degradation, which affect growth and mortality rates. Therefore, we suggest to assess the population of *Haemulon plumierii* in the northeast of Brazil.

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