



UNIVERSIDADE FEDERAL RURAL DE PERNAMBUCO
PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO
PROGRAMA DE PÓS-GRADUAÇÃO EM RECURSOS PESQUEIROS E AQUICULTURA

**PADRÕES DE DISTRIBUIÇÃO E ASPECTOS POPULACIONAIS DOS PEIXES DA
FAMÍLIA HAEMULIDAE NA PLATAFORMA CONTINENTAL BRASILEIRA**

Catarina Cardoso de Melo

Dissertação apresentada ao Programa de Pós-Graduação em Recursos Pesqueiros e Aquicultura da Universidade Federal Rural de Pernambuco como exigência para obtenção do título de Mestre.

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Dissertação julgada adequada para obtenção do título de mestre em Recursos Pesqueiros e Aquicultura. Defendida e aprovada em 09/08/2019 pela seguinte Banca Examinadora.

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Resumo

Haemulídeos, uma das principais famílias de peixes recifais do Brasil, além da sua grande relevância na pesca artesanal, também possuem importante papel ecológico, principalmente por contribuírem com o equilíbrio do ambiente em que habitam, regulando a abundância de invertebrados e transferindo nutrientes nos mais diversos tipos de ambientes. Este trabalho tem o objetivo de descrever os padrões de distribuição e abundância das espécies da família Haemulidae na região Nordeste do Brasil, assim como os aspectos populacionais e a diversidade dessa família, considerando fatores como latitude, distância da plataforma continental e tipo de hábitat. O uso diferenciado do habitat para agregação de juvenis também será considerado neste estudo. As informações foram coletadas em duas expedições científicas que ocorreram em agosto a setembro de 2015, e abril a maio de 2017, ao longo da plataforma continental no nordeste do Brasil (latitude de 9° a 5°S). As espécies foram descritas em porcentagem em número (%N), biomassa (%B) e frequência de ocorrência (%FO), foi obtida a abundância relativa das espécies, descrita como CPUE (Captura por Unidade de Esforço) e ainda foi calculado o índice de dominância para as espécies. Adicionalmente foram obtidas a relação peso-comprimento, proporção sexual, e tamanho de primeira maturação das principais espécies. No total foram capturados 2976 indivíduos, pertencentes a 5 gêneros e 10 espécies. As espécies que apresentaram maiores N% foram *H. aurolineatum* (66%) e *H. squamipinna* (23%). Em B% se destacaram *H. plumierii* (37,6%), *H. aurolineatum* (35,4%) e *H. steindachneri* (10,5%). Os maiores valores de CPUE foram registrados para o estado de Pernambuco e Rio Grande do Norte. Um maior número de espécies foi encontrado na plataforma interna, em áreas onde o habitat predominante eram corais e em latitudes superiores a 8°S, sendo *H. plumierii*, *H. aurolineatum* e *H. squamipinna* consideradas espécies dominantes. Quanto aos aspectos populacionais, *H. plumierii* apresentou maior proporção de fêmeas do que machos enquanto *H. aurolineatum*, *H. squamipinna*, *H. steindachneri*, *Orthopristis ruber* apresentaram proporção 1:1. O tamanho de primeira maturidade de *H. plumierii* foi de 14 cm, 11.8 cm para *H. aurolineatum* e 10.1 cm para o *H. squamipinna*. Os Haemulidae são abundantes e biodiversos no Nordeste do Brasil, portanto aumentar o conhecimento acerca da biologia destas espécies, suas respectivas relações com o habitat e a identificação de áreas de alta importância ecológica são essenciais para melhor desenvolver estratégias de manejo e conservação, bem como para preservar a integridade do ecossistema, garantindo que os processos ecológicos, não apenas da família Haemulidae, mas também das diversas espécies de peixes recifais distribuídos na costa Nordeste, sejam preservados.

Palavras-chave: (Peixes recifais, Ecologia, Corais, Manejo Espacial)

Abstract

Haemulidae, one of the main families of reef fish in Brazil, besides their great relevance in artisanal fishing, also have an important ecological role, mainly because they contribute to the balance of the environment in which they live, regulating the abundance of invertebrates and transferring nutrients in the most diverse types of environments. The objective of this work is to describe the distribution and abundance patterns of the Haemulidae species in the Northeast region of Brazil, as well as the population aspects and the diversity of this family, considering factors such as latitude, distance from the continental shelf and type of habitat. The differentiated use of habitat for juvenile aggregation will also be considered in this study. The information was collected in two scientific expeditions that took place in August to September 2015, and April to May 2017, along the continental shelf in northeastern Brazil (latitude 9° to 5°S). The species were described in percentage in number (%N), biomass (%B) and frequency of occurrence (%FO), the relative abundance of the species was obtained, described as CPUE (Capture per Unit of Effort) and the dominance index for the species was also calculated. Additionally, the weight-length relationship, sex-ratio, and size at first maturity of the main species were obtained. A total of 2976 individuals were captured, belonging to 5 genera and 10 species. The species with higher N% were *H. aurolineatum* (66%) and *H. squamipinna* (23%). In B%, *H. plumierii* (37.6%), *H. aurolineatum* (35.4%) and *H. steindachneri* (10.5%) stood out. The highest CPUE values were recorded for the state of Pernambuco and Rio Grande do Norte. A greater number of species were found on the inner platform, in areas where the predominant habitat was coral and in latitudes higher than 8°S, being *H. plumierii*, *H. aurolineatum* and *H. squamipinna* considered dominant species. Regarding population aspects, *H. plumierii* presented a higher proportion of females than males, while *H. aurolineatum*, *H. squamipinna*, *H. steindachneri*, *Orthopristis ruber* presented a 1:1 ratio. The size of first maturity of *H. plumierii* was 14 cm, 11.8 cm for *H. aurolineatum* and 10.1 cm for *H. squamipinna*. The Haemulidae are abundant and biodiverse in the Northeast of Brazil, therefore increasing knowledge about the biology of these species, their respective relations with the habitat and the identification of areas with high ecological importance, are essential to better develop management and conservation strategies, as well as to preserve the integrity of the ecosystem, ensuring that the ecological processes, not only of the Haemulidae family, but also of the various species of reef fish distributed on the Northeast coast, are preserved.

Key words: (Reef fishes, Ecology, Corals, Spatial Management)

Lista de figuras

<i>Figure 1- Study site with bathymetry data and sample points along the continental shelf in the Northeast of Brazil.....</i>	<i>22</i>
<i>Figure 2 - Size at first maturity of H. plumierii in the Northeast coast of Brazil.....</i>	<i>26</i>
<i>Figure 3 - Distribution of the length frequency of females and males of H. plumierii and their estimated size at first maturity (L50 = 14 cm SL).....</i>	<i>26</i>
<i>Figure 4 - Length-weight relationship of H. plumierii for pooled sexes.....</i>	<i>27</i>
<i>Figure 5 – CPUE of H. plumierii a) in number of individuals b) in biomass (Kg) and (c) the ratio of adults and juveniles in the shelf (inner and outer) along the northeast coast of Brazil</i>	<i>27</i>
<i>Figure 6 – Size at first maturity of H. aurolineatum on the Northeast coast of Brazil.....</i>	<i>28</i>
<i>Figure 7 - Distribution of the length frequency of females and males of H. aurolineatum and their estimated size at first maturity (L50 = 11.7 cm SL).....</i>	<i>28</i>
<i>Figure 8 - Length-weight relationship of H. aurolineatum for pooled sexes</i>	<i>29</i>
<i>Figure 9 - CPUE of H. aurolineatum a) in number of individuals b) in biomass (Kg) and (c) the ratio of adults and juveniles in the shelf (inner and outer) along the northeast coast of Brazil.....</i>	<i>29</i>
<i>Figure 10 - Size at first maturity for pooled sex of H. squamipinna on the Northeast coast of Brazil.....</i>	<i>30</i>
<i>Figure 11 - Distribution of the length frequency of females and males of H. squamipinna and their estimated size at first maturity (L50 = 10.1 cm SL).....</i>	<i>30</i>
<i>Figure 12 - Length-weight relationship for H. squamipinna for both sexes.....</i>	<i>31</i>
<i>Figure 13 - CPUE of H. squamipinna a) in number of individuals b) in biomass (Kg) and (c) the ratio of adults and juveniles in the shelf (inner and outer) along the northeast coast of Brazil.....</i>	<i>31</i>
<i>Figure 14 - CPUE of H. steindachneri in number of individuals(a) and in biomass (Kg) (b) on the northeast coast of Brazil.....</i>	<i>32</i>
<i>Figure 15 - CPUE of O. ruber in number of individuals(a) and in biomass (Kg) (b) on the northeast coast of Brazil.....</i>	<i>33</i>

Lista de tabelas

Table 1 – Species of the Haemulidae family sampled in the ABRAÇOS 1st and 2nd campaigns, habitat type (Sand with Coral and Rocks – SWCR, Sand, Algae), depth range, total number of individuals (N), percentage in number N(%), biomass B(%) frequency of occurrence (FO%), minimum, medium and maximum size of standard length. Relative Importance Index for shelf position (Inner and Outer), latitude stratum (A (<6°), B (6°-7°), C (7°-8°), D (>8°)) and habitat type: higher abundant and frequent (1), higher abundant and rare (2), scarce and frequent (3) and scarce and rare (4)25

Sumário

Agradecimentos	5
Resumo	6
Abstract.....	7
Lista de figuras	8
Lista de tabelas	9
1. Introdução	11
2. Objetivos.....	13
2.1-Objetivo geral.....	13
2.2-Objetivos específicos	13
3. Referências	14
4. Artigo científico.....	18
4.1. Distribution patterns and population aspects of fish from Haemulidae family on the Brazilian continental shelf.....	18
5. Considerações Finais	47

1. Introdução

Segundo MENEZES et al. (2003), no Brasil, são registradas cerca de 1300 espécies de peixes marinhos compreendidas em 197 famílias. Dentre essas, Haemulidae, presente nos oceanos Atlântico, Índico e Pacífico (NELSON, 2016), se destaca por ser uma das mais abundantes ao longo da costa brasileira (RANGEL et al., 2007; SOUZA et al., 2007). Atualmente existem 19 gêneros e 133 espécies incluídas nesta família em todo o mundo (MENEZES e FIGUEIREDO, 1980; NELSON, 2016), sendo que no Brasil, registram-se 7 gêneros (*Anisotremus*, *Boridia*, *Conodon*, *Genyatremus*, *Haemulon*, *Orthopristis* e *Haemulopsis*), e 18 espécies, sendo o gênero *Haemulon* o que mais se sobressai devido sua maior quantidade de espécies. Na região Nordeste são encontrados 6 gêneros e 19 espécies (ROCHA e ROSA, 1999; LESSA E NOBREGA, 2000; MENEZES et al., 2003; FIGUEIREDO FILHO, 2016).

A costa Nordeste é demarcada por deltas e estuários e é banhada pela corrente sul equatorial, que por sua vez, é composta de águas relativamente quentes e oligotróficas, recebendo pouco aporte do continente (KNOPPERS et al., 1999). Em virtude da baixa quantidade de nutrientes e conseqüentemente baixa produtividade primária, não há grande abundância dos recursos aquáticos, no entanto, há grande diversidade de espécies, algumas de importância econômica, ainda que localmente (LESSA et al., 2006).

Segundo a estatística oficial do Nordeste, entre os anos de 1997 a 2007, os Haemulídeos foram responsáveis por cerca de 14 mil toneladas de captura, o que equivale a uma receita de aproximadamente 35 milhões de reais (IBAMA/CEPENE, 1997 a 2008), sendo os estados que mais exploram essa família; o Ceará, Rio Grande do Norte e Pernambuco. A produção média de Haemulídeos durante esse intervalo de tempo na região Nordeste, foi de 1.233 toneladas ao ano, sendo a menor produção em 1997 (711 toneladas) e a maior em 2007 (1.550 toneladas), destacando que a produção dobrou em 10 anos.

Os roncadores, como são popularmente conhecidos, são geralmente capturados por linha de mão, armadilhas e redes de emalhe, além de serem amplamente capturados como fauna acompanhante pelas redes de arrasto direcionadas à pesca de camarão (LINDERMAN, 2002). Dentre os mais capturados pela pesca, destacam-se, usando principalmente como artefato de pesca os covos de peixe, *Haemulon plumierii*, conhecido popularmente como biquara, e *Haemulon aurolineatum*, a xira-branca e o *Haemulon squamipinna*, a xira-amarela. (LESSA et al., 2009). Espécies como o *Conodon nobilis* (Coró) e o *Haemulopsis corvinaeformis* (Coró branco) são frequentemente associadas a fauna acompanhante na pesca camaroeira (EDUARDO et al., 2018, LIRA et al., 2019).

Segundo os critérios da IUCN (União Internacional para a Conservação da Natureza) e através da classificação regional do ICMBio (2018) as espécies da família Haemulidae presentes na costa nordeste, não estão sob iminente ameaça, encontrando-se na categoria Pouco preocupantes (LC), exceto a espécie *H. plumierii* que devido ao pouco aporte de informações publicadas e a sua reconhecida ameaça, encontra-se na categoria Dados Deficientes (DD).

Peixes dessa família também são considerados peixes de boa qualidade e carne branca, no entanto, são pouco consumidos, exceto em regiões tropicais onde são fontes de alimento para a população costeira e recursos de relativa importância para a pesca artesanal (MUNRO, 1996; LINDERMAN, 2002). Além de sua importância na pesca artesanal, os Haemulídeos também possuem importante papel ecológico nas comunidades pesqueiras, principalmente por contribuírem com o equilíbrio do ambiente em que habitam, regulando a abundância de invertebrados e transferindo nutrientes nos mais diversos tipos de ambientes (HOLMLUND & HAMMER, 1999; APPELDOORN et al., 2009; ARAÚJO et al., 2018).

Os Haemulidae habitam uma grande diversidade de ambientes, ocorrendo em zonas recifais, baías costeiras e estuários, que são ambientes de grande complexidade, capazes de lhes proporcionar áreas de abrigo, reprodução e alimentação (LINDEMAN, 2002; ALMARY, 2004). Indivíduos dos gêneros *Haemulon* e *Anisotremus* são geralmente encontrados em áreas de corais e pedras, enquanto os representantes dos gêneros *Haemulopsys*, *Genyatremus*, *Boridia*, *Conodon* e *Orthopristis* são mais frequentes em praias arenosas e áreas estuarinas (MENEZES e FIGUEIREDO, 1980). A complexidade do habitat, aliado a outros fatores como profundidade e distância da costa, são determinantes nas variações de abundância, riqueza e distribuição diferencial desta família (MALCOM et al., 2007; 2011).

Mundialmente foram realizados alguns estudos sobre uso de habitat pelos Haemulidae, como na costa da Flórida (LINDEMAN et al., 2000; FAUNCE e SERAFY, 2007) e no Caribe (BURKE, 1995; KENDALL et al., 2003). No nordeste do Brasil, a maioria dos estudos estão relacionados com a reprodução (SILVA, 2012; SHINOZAKI-MENDES et al., 2013a; SHINOZAKI-MENDES et al., 2013b; EDUARDO et al., 2018), alimentação (DE ALMEIDA, 2005; PEREIRA et al., 2015) e idade e crescimento (VASCONCELOS-FILHO et al., 2018; EDUARDO et al., 2018). No entanto, as informações por vezes são restritas no espaço, ou não são integrativas em relação aos aspectos da estrutura populacional, distribuição, abundância e uso do habitat dessa família na costa do Nordeste.

Este trabalho tem o objetivo de descrever os padrões de distribuição e abundância das

espécies da família Haemulidae na região Nordeste do Brasil, considerando fatores como latitude, distância da plataforma e tipo de habitat. O uso diferenciado do habitat para reprodução e agregação de juvenis também será considerado neste estudo, além de dados referentes a estrutura populacional de algumas espécies desta família. Estas informações, relevantes por contribuir no conhecimento de como a família ocupa o espaço marinho, poderão ser utilizadas como subsídio na identificação de áreas prioritárias de conservação e no Planejamento Espacial Marinho das áreas recifais do Nordeste do Brasil.

2. Objetivos

2.1-Objetivo geral

Compreender a diversidade, aspectos populacionais, padrões de distribuição e abundância e o uso do habitat pelas espécies da família Haemulidae no Nordeste do Brasil, identificando os fatores que possam ser responsáveis pela ocupação diferencial na área.

2.2-Objetivos específicos

- Descrever diversidade e a distribuição e abundância das espécies da família Haemulidae no nordeste do Brasil.
- Descrever aspectos populacionais como a relação peso-comprimento, proporção sexual e tamanho de primeira maturação das espécies de Haemulídeos na costa nordeste do Brasil.
- Descrever espacialmente o uso da plataforma continental por ontogenia (jovem e adulto) pelas espécies de Haemulidae no Nordeste do Brasil.
- Avaliar a influência da latitude, tipos de fundo e posição na plataforma continental em relação às diferentes espécies de Haemulidae na costa Nordeste.

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4. Artigo científico

4.1. Distribution patterns and population aspects of fish from Haemulidae family on the Brazilian continental shelf

DISTRIBUTION PATTERNS AND POPULATION ASPECTS OF FISH FROM HAEMULIDAE FAMILY ON THE BRAZILIAN CONTINENTAL SHELF

Haemulidae represents one of the most abundant families along the Brazilian coast, inhabiting diverse types of habitats, playing an important ecological and socioeconomic role in fishing communities. This work aims to provide knowledge on population aspects, also describing patterns of distribution, abundance, and habitat use for adults and juvenile stages of Haemulidae in the northeast of Brazil. Data were collected in two scientific expeditions carried out in August to September 2015, and April to May 2017, at 37 stations along the continental shelf in northeastern Brazil (latitude 9° to 5°S), using trawls as fishing gears. The species were described as percentage in number (%N), biomass (%B) and frequency of occurrence (%FO). The relative abundance of the species, described as CPUE (Capture per Unit of Effort), was also obtained considering the latitudinal aspect, the distance from the coast and the bottom type. The use of habitat for juveniles and adults of the main species was also observed. Concerning population aspects, it was obtained the length-weight relationship, sex ratio, size of the first maturity for the most abundant species. A total of 2976 individuals were collected, belonging to 5 genera and 10 species. The species with a higher N% were *Haemulon aurolineatum* (66.1%) and *H. squamipinna* (22.7%). *H. plumierii* (37.6%), *H. aurolineatum* (35.4%) and *H. squamipinna* (10.5%) dominated in biomass. The highest CPUE values were recorded in the coast of Pernambuco and Rio Grande do Norte. A greater number of species were found on the inner shelf, in areas where the predominant habitat was coral and in latitudes higher than 8°S. Regarding population aspects, *H. plumierii* presented a higher proportion of females than males, while *H. aurolineatum*, *H. squamipinna*, *H. steindachneri*, *Orthopristis ruber* presented a 1:1 ratio. The length at first maturity obtained for *H. plumierii*, *H. aurolineatum* and *H. squamipinna* was 14, 11.8 and 10.1 cm SL respectively. Haemulidae are abundant and biodiverse in the Northeast of Brazil, due to the complex habitats that exist on the coast, which serve as refuge for a range of species, especially in reefs areas, where conservation initiatives should be priority.

Keywords: Reef fishes, Ecology, Reefs, Marine Spatial Planning, Tropical areas

INTRODUCTION

Haemulidae is one of the most abundant fish family along the Brazilian coast (RANGEL et al., 2007; SOUZA et al., 2007). Members of this family, present in the Atlantic, Indic and Pacific Oceans, are also known as grunts since they produce a sound by the friction between the pharyngeal teeth (SMITH & MCKAY, 1986). They inhabit a great variety of substrates, but mostly use the reef environment for the life-support services they provide (SOUTER et al., 2000), playing an important ecologic role since they contribute to the health and balance of this area, regulating the abundance of invertebrates and transferring nutrients across habitats (HOLMLUND & HAMMER, 1999; APPELDOORN et al., 2009; ARAÚJO et al., 2018).

Species of this family are also considered good quality white flesh fish and, although they are not widely consumed worldwide, in tropical regions, they are a food source for the coastal residents (MUNRO, 1996; LINDEMAN, 2002). According to the official statistics, in

the Northeast region, between 1997 to 2007, it was landed 14 thousand tons of grunts, generating a profit equivalent to 9.3 million dollars (IBAMA/CEPENE, 1997 - 2008). The average production of Haemulidae during this period doubled, from 711 t in 1997 to 1550 t in 2007.

Grunts are normally captured by pole and line, traps and gill nets, and it is also a common bycatch in the shrimp trawling (LINDEMAN, 2002). In Northeast Brazil, *Haemulon plumierii*, *Haemulon aurolineatum* and *Haemulon squamipinna* used to be bycatch of the lobster (*Panulirus laevicauda* and *P. argus*) and goatfish (*Pseudopeneus maculatus*) fishery. Currently, Haemulidae are commonly caught by artisanal fisheries also as target, given the decrease in abundance of the previous species (LESSA et al., 2009; MARQUES & FERREIRA, 2013).

Despite having ecological and economic importance, many ecology aspects of this family are still unknown or are restricted in terms of spatial coerture. Also, the available studies do not integrate aspects of the populational structure, distribution and abundance, and the relation of the species biology with abiotic factors. In the northeast of Brazil, most of the studies are mainly related to particular aspects of the population dynamic, such as reproduction (SILVA, 2012; SHINOZAKI-MENDES et al., 2013; SHINOZAKI-MENDES et al., 2013; EDUARDO et al., 2018), feeding (DE ALMEIDA, 2005; PEREIRA et al., 2015) and age and growth (VASCONCELOS-FILHO et al., 2018; EDUARDO et al., 2018). According to the IUCN (International Union for Conservation of Nature) criteria and through the regional classification of ICMBio (2018), species of the Haemulidae family are not under imminent threat, being hence classified as Least Concern (LC), except for the species *H. plumierii*, whose threats to the species are recognized, however, given the absence of information available, it is categorized as Data Deficient (DD).

This study describes the diversity and populational aspects of the main species of the Haemulidae family from the Northeast of Brazil. Considering that reefs are highly complex environments that provide areas for reproduction, feeding and shelter for several species (LINDEMAN, 2002; ALMARY, 2004), this work also evaluate the spatial patterns of distribution, abundance and habitat use for these species in the area. These joint information will improve the knowledge on the population dynamics of the studied species and how this family occupies the marine space, which could be used as a subsidy for the stock assessment and management of these resources, being also valuable for the Marine Spatial Planning concerning reef areas of Northeast Brazil, especially when identifying priority areas for conservation.

MATERIAL AND METHODS

Study area

The study area (Fig. 1) comprises the northeast Brazilian continental shelf, between the states of Rio Grande do Norte and Alagoas (4°–9°S). With a narrow shelf, the Northeast coast is demarcated for deltas and estuaries, and it is bathed by the south equatorial current, composed by warm, oligotrophic water (KNOPPERS et al., 1999). Due to the small amount of nutrients and consequently the little primary production, there is no great abundance of fish in that area. However, there is large biodiversity, some species with high economic importance (LESSA et al., 2006), and several Marine Protected Areas, such as “APA dos Corais”, ‘APA Costa dos Corais’, ‘APA Guadalupe’, ‘APA Santa Cruz’, ‘APA Barra de Mamanguape) (FERREIRA & MAIDA, 2007; PRATES et al., 2007).

Data collection and sample processing

The data for this study was obtained by the Acoustics Along Brazilian Coast (ABRACOS) project. There were two scientific expeditions performed by the research vessel ANTEA, from August 30 to September 20 of 2015, ABRACOS 1 (BERTRAND, 2015), and another one, from April 9 to May 9 of 2017, ABRACOS 2 (BERTRAND, 2017). A total of 37 stations were established along the continental shelf (5°- 9°S) (Fig. 1) and the samples were obtained using bottom trawler (mesh: 40 mm; bag mesh: 25 mm; mouth dimension: 28 x 10 m). The trawling was carried out between 15 and 65 m deep. Each haul lasted about 5 minutes. Net geometry was calculated through the SCANMAR system, estimating height, depth, and width of the net.

Habitat classification was performed by video, using a subaquatic camera. Major substrate was identified as: Sand; Algae; and Sand with rocks, corals, and sponges (SWCR) (EDUARDO et al., 2018). The classification of the shelf position was based on the distance of the sampling point from the shore: inner-shelf (<20 km to the shoreline) and outer-shelf (>20 km from the shoreline), considering the average width of the continental shelf, that is 40km. The latitudinal gradient was stratified, in accordance with Eduardo et al. (2018) for the same area, by each 1°, as following: A=<6°S, B=6 – 7°S, C=7 – 8°S and D=>8°S.

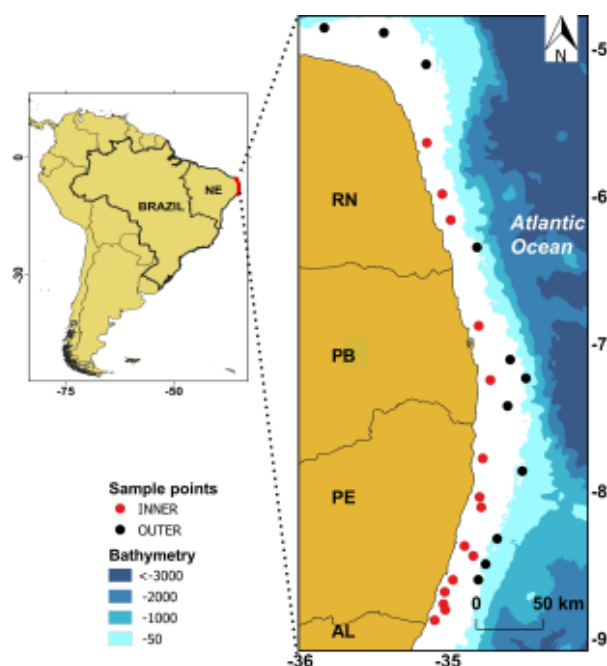


Figure 1- Study site with bathymetry data and sample points along the continental shelf in the Northeast of Brazil.

For each sample, the fish was identified to the lowest taxonomic group, weighted and preserved in formalin (4%) or it was frozen. At the laboratory, fish were sexed, measured in standard length (SL) and weighted in total weight (TW). Subsequently, it was performed a ventral-longitudinal incision, removing the gonads for weighing, sex macroscopic classification and gonadal development, classifying individuals as juveniles and adults.

Data Analysis

Abundance and diversity of Haemulidae in Northeast Brazil

The relative abundance index (Capture by Unit of Effort - CPUE) was calculated by biomass (Kg/km²) and number (n°/km²) in the trawled area. The trawled area was estimated by multiplying the distance covered by the net with the estimated mouth opening obtained through the SCANMAR sensors. For the CPUE calculations, it was used average mouth opening of 13 m. The following formula expresses the CPUE:

$$\text{CPUE} = ((n^{\circ} \text{ and Kg}) / \text{NW} \times \text{SD}) * 1000$$

Where: NW = Net Wide Area; SD = Sampled distance

The mean of CPUE (n° and Kg) and the mean length (SL) of the individuals was tested for possible differences between shelves, using t-test (0.05).

Species of the Haemulidae family were described by percentage in number (%N), biomass (%B) and frequency of occurrence (%FO). Minimum, maximum and mean size was also reported for each species. Dominance was obtained according to GARCIA et al. (2006), where species were classified based on the frequency of occurrence (%FO) and relative abundance (%CPUE) per latitude (1°), shelf position and habitat type. Species with %FO > average were considered frequent, whereas those with %FO < average were considered rare. The same method was applied to %CPUE, that was classified as Higher Abundant (%CPUE > average) and Scarce (%CPUE < average %CPUE). Basing on those parameters, species relative importance index was obtained and divided into four groups: (1) higher abundant and frequent, (2) higher abundant and rare, (3) scarce and frequent and (4) scarce and rare (GARCIA et al., 2006). Species were considered dominant when classified within first, second and third categories (GARCIA et al., 2006).

Populational aspects and distribution patterns of Haemulidae

The spatial distribution of abundance (through CPUE) and sex-ratio were obtained for all species. The population aspects, such as the length-frequency distribution, length-weight relationship, size at first maturity (L_{50}) (length that 50% of individuals achieve gonadal maturity for the first time) were obtained for the main caught species.

The Length-Weight relationship was calculated for pooled sexes, since no difference between sex was reported. This relationship was expressed by the formula: $TW = a(SL)^b$, where: TW = Total weight (g), SL = Standard length (cm), a = slope e b = allometry coefficient. The Allometry coefficient (b) was tested (T-test, level of significance of 5%) to statistical deviations from the expected coefficient $b = 3$. Sex-ratio was calculated according to the formula: total number of males/total number of females, and then tested for significant differences from the expected ratio (1:1), using Chi-square test ($\alpha = 0.05$) (DAGNÉLIE, 1975). Differences between the mean length by sex were tested using the t-test ($\alpha = 0.05$). L_{50} were estimated for pooled sexes, by calculating the proportion of adults by length, which was considered as dependent variable (Y), and the standard length as the independent variable (X). The package “sizeMat” (TORREJÓN-MAGALLANES, 2016) of R software was used. The L_{50} estimated was used to separate juveniles (< L_{50}) and adults (> L_{50}) and the differential distribution of juvenile and adults were plotted for each species. Maps were elaborated using the software Qgis, version 3.2.2 (QGIS, 2018).

RESULTS

Diversity of Haemulidae in Northeast Brazil

A total of 2.976 individuals, belonging to 5 genera and 10 different species of Haemulidae, were sampled: *Anisotremus virginicus*, *Conodon nobilis*, *Haemulon aurolineatum*, *Haemulon melanurum*, *Haemulon parra*, *Haemulon plumierii*, *Haemulon squamipinna*, *Haemulon steindachneri*, *Haemulopsis corvinaeformis* and *Orthopristis ruber*. In numeric percentage (%N), *Haemulon aurolineatum* (66.1%) and *H. squamipinna* (22.7%) dominated. Regarding the percentage of biomass (%B), *H. plumierii* (37.6%), *H. aurolineatum* (35.4%) and *H. squamipinna* (10.5%) represented the majority of the total weight captured. Considering the frequency of occurrence (%FO), *H. aurolineatum* (43.2%) were more frequent, followed by *H. plumierii* (35.1%) and *H. steindachneri* (27.0%) (Table 1).

Analyzing the relative importance index of the 10 species in Northeast Brazil, overall, *H. aurolineatum*, *H. plumierii* and *H. squamipinna* were considered higher abundant and frequent, present in all areas or mostly (Table 1). Taking into account their position on the continental shelf, mostly (9) occurred in the inner shelf, in shallower waters, and half (5) in outer shelf. The main species (*H. aurolineatum*, *H. plumierii* and *H. squamipinna*) were higher abundant and frequent in all shelf. Evaluating the relative importance index by latitude stratum, in $>8^{\circ}\text{S(D)}$, all species were reported and mostly (4) were higher abundant and frequent. When considered the habitat type, for the coral habitat, all species were observed. In algae habitat, only 3 species were reported (*H. plumierii*, *A. virginicus* and *H. aurolineatum*). Only *Haemulon plumierii* were higher abundant and frequent in all habitats (Table 1).

Table 1 – Species of the Haemulidae family sampled in the ABRAÇOS 1st and 2nd campaigns, habitat type (Sand with Coral and Rocks – SWCR, Sand, Algae), depth range, total number of individuals (N), percentage in number N(%), biomass B(%) frequency of occurrence (FO%), minimum, medium and maximum size of standard length. Relative Importance Index for shelf position (Inner and Outer), latitude stratum (A (<6°), B (6°-7°), C (7°-8°), D (>8°)) and habitat type: higher abundant and frequent (1), higher abundant and rare (2), scarce and frequent (3) and scarce and rare (4).

Species	N	Habitat	Depth (m) (Min-Max)	N%	B%	FO%	Size Min-Max (\bar{X}) (cm)	Relative Importance Index									
								Shelf Position		Latitude stratum				Habitat type			Total
								Inner	Outer	A	B	C	D	SWCR	Sand	Algae	
<i>Anisotremus virginicus</i> (Linnaeus, 1758)	6	Algae, SWCR	32 - 56	0.2	2.2	10.8	13.8–20.7 (18.5)	4	4				3	4		3	4
<i>Conodon nobilis</i> (Linnaeus, 1758)	1	SWCR	15	0.03	0.06	2.7	12.2-12.2 (12.2)	4					4	4			4
<i>Haemulon aurolineatum</i> (Cuvier, 1830)	1956	Algae, Sand, SWCR	17 - 61	66.14	35.4	43.2	4.5-19.5 (14.0)	1	1	1	1	1	1	1	1	3	1
<i>Haemulon melanurum</i> (Linnaeus, 1758)	6	SWCR	56 - 57	0.2	2.3	5.4	19.1-24.5 (21.5)		4			4	4	4			4
<i>Haemulon parra</i> (Desmarest, 1823)	1	SWCR	30	0.03	0.46	2.7	22.5-22.5 (22.5)	4					4	4			4
<i>Haemulon plumierii</i> (Lacépède, 1801)	202	Algae, Sand, SWCR	17 - 61	6.7	37.6	35.1	9.2-24.2 (16.6)	1	1	1	1	1	1	1	1	1	1
<i>Haemulon squamipinna</i> Rocha & Rosa, 1999	685	Sand, SWCR	17 - 65	22.72	10.5	21.6	9.2-16.3 (12.9)	1	1	1		2	1	1	2		1
<i>Haemulon steindachneri</i> (Jordan & Gilbert, 1882)	69	Sand, SWCR	15 - 43	2.29	5.7	27	10.7-18.0 (14.2)	1		1	1	2	1	1	1		3
<i>Haemulopsis corvinaeformis</i> (Steindachner, 1868)	10	SWCR	15 - 32	0.27	5.1	8.1	10.6-15.0 (13.1)	2					4	2			4
<i>Orthopristis ruber</i> (Cuvier, 1830)	40	Sand, SWCR	15 - 32	1.39	0.65	16.2	11.1-17.8 (14.7)	3		1		2	3	4	3		4

*Population structure and distribution patterns**Haemulon plumierii*

Haemulon plumierii ranged from 9.2 to 24.2 cm SL ($\bar{X} = 16.63 \text{ cm} \pm 3.94$) and the weight ranged from 23.1 to 385.7 g TW ($\bar{X} = 150.35 \text{ g} \pm 93.69$). The L_{50} estimated for combined sex was 14 cm SL (CI = 13 – 14.7) and 72.5% of the individuals collected were adults (SL > L_{50}) (Fig. 2). The most representative length class for females and males were respectively 16-18 and 18-20 cm SL (Fig. 3). There was a significant statistical difference between the mean length for females and males (*t-test*, $p < 0.05$), males being larger than females.

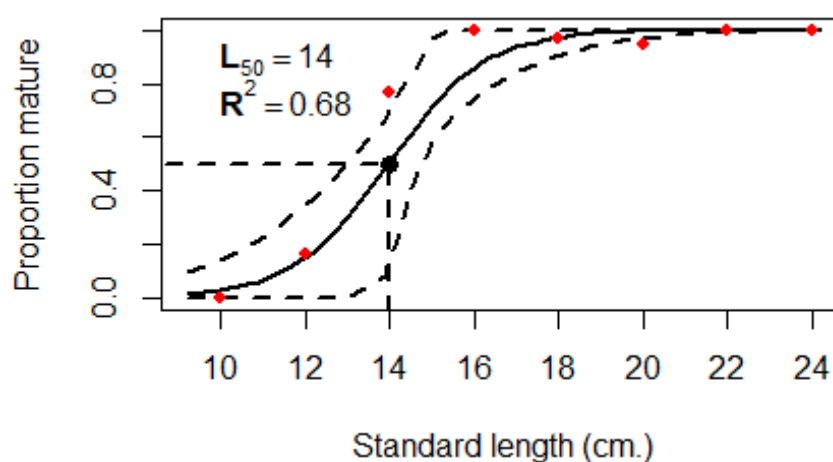


Figure 2 – Size at first maturity of *H. plumierii* in the Northeast coast of Brazil.

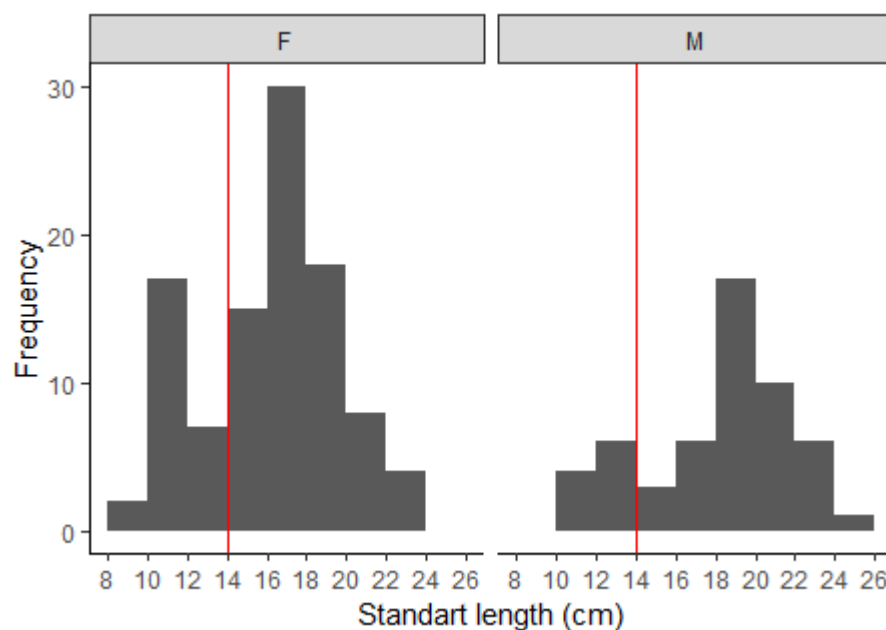


Figure 3 - Distribution of the length frequency of females and males of *H. plumierii* and their estimated size at first maturity ($L_{50} = 14 \text{ cm SL}$).

According to the length-weight relationship for pooled sexes, *H. plumierii* presented positive allometry ($b=3.18$; $p<0.05$) (Fig. 4). It was registered more females than males in the study area (sex ratio -1.9:1) ($\chi^2= 14.961$, $p<0.05$).

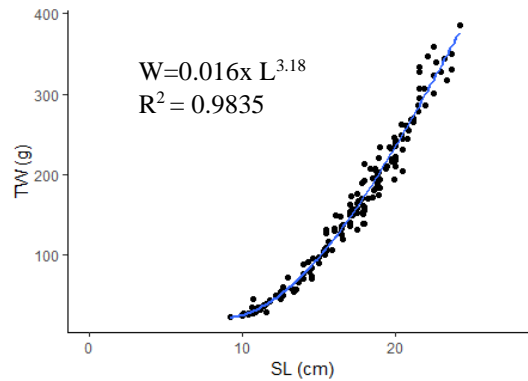


Figure 4 - Length-weight relationship of *H. plumierii* for pooled sexes.

Individuals of *Haemulon plumierii* are widely distributed in the northeast coast and the highest CPUE (n° and Kg) were observed in the south region of Pernambuco state (Fig. 5a, b). It was not observed significant differences between the mean CPUE (n° and Kg) and mean length when compared the inner and outer shelf ($P > 0.05$). Juveniles were found only at the inner shelf in the south region of Paraíba and in the central region of Pernambuco. In the whole area, adults dominated (Fig. 5c).

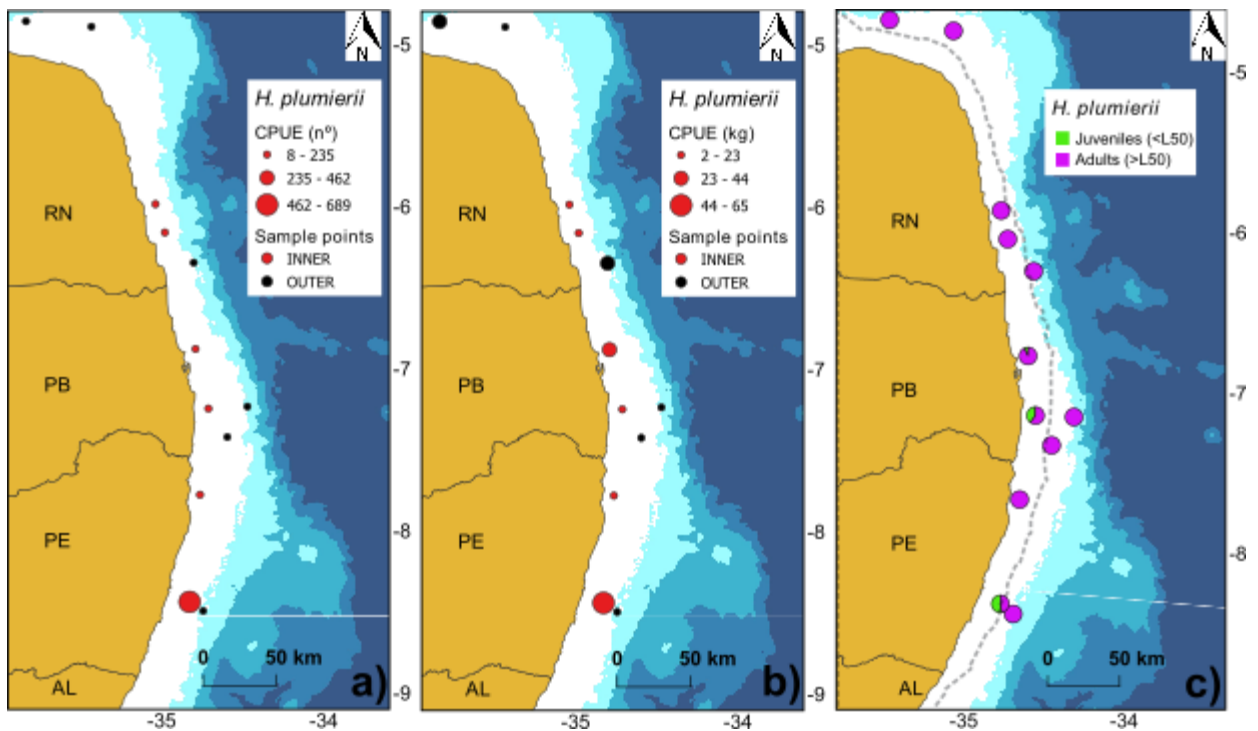


Figure 5 – CPUE of *H. plumierii* a) in number of individuals b) in biomass (Kg) and (c) the ratio of adults and juveniles in the shelf (inner and outer) along the northeast coast of Brazil.

Haemulon aurolineatum

Individuals of *Haemulon aurolineatum* ranged from 4.5 to 19.5 cm SL (\bar{X} =14.05 cm \pm 2.21), and 1.90 to 120.34 g TW (\bar{X} =72.64 \pm 26.22). The length at first maturity (L_{50}) for combined sexes was estimated as 11.7 cm SL (CI = 11.1 – 12.2), and 69.4% of the individuals in the samples were adults (SL > L_{50}) (Fig. 6). The length class of 14-16 cm were the most representative for females and males (Fig. 7). There was no significant statistical difference in the mean length of females and males (*t-test*, $p < 0.05$).

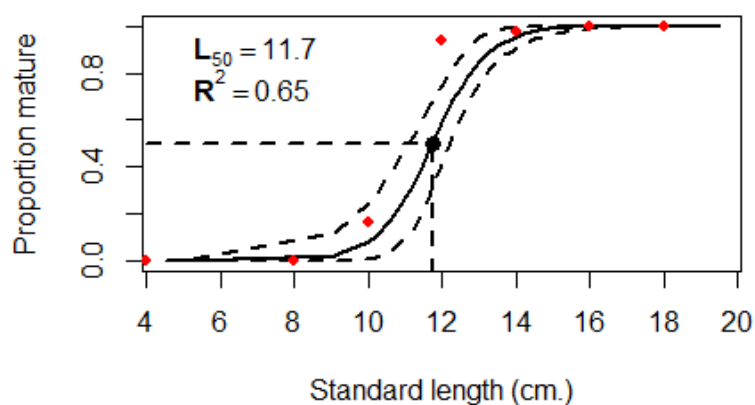


Figure 6 - Size at first maturity of *H. aurolineatum* on the Northeast coast of Brazil.

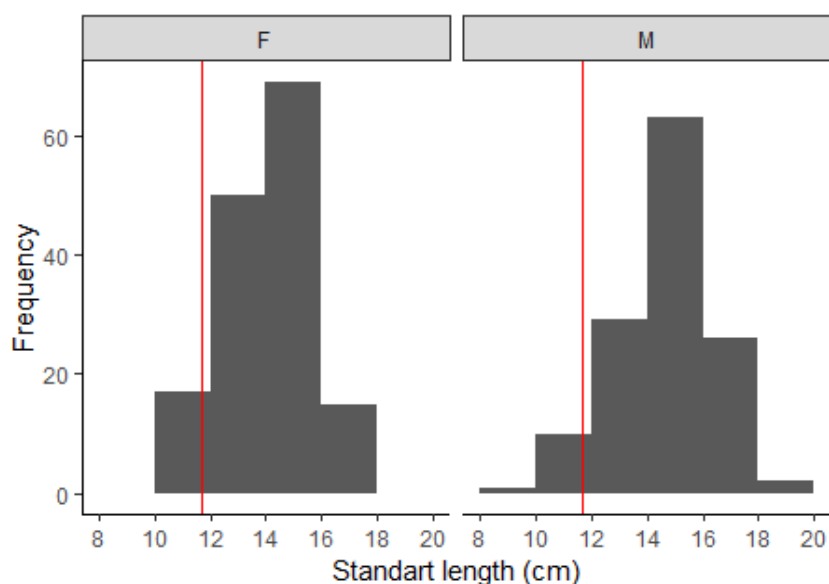


Figura 7 - Distribution of the length frequency of females and males of *H. aurolineatum* and their estimated size at first maturity ($L_{50} = 11.7$ cm SL).

The length-weight relationship for combined sex showed isometric growth ($b=2.96$; $p > 0.05$) (Fig. 8). Both sexes were equally abundant, since sex ratio did not significantly differ from 1:1 ($\chi^2 = 1.7042$, $p > 0.05$).

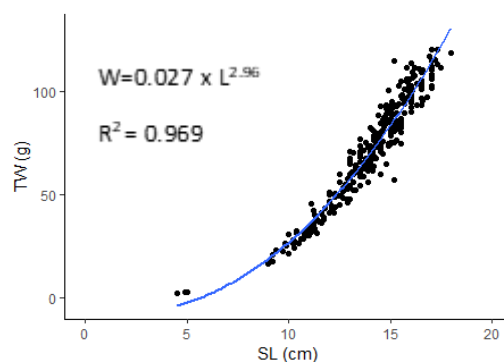


Figure 8- Length-weight relationship of *H. aurolineatum* for pooled sexes.

H. aurolineatum occurs all over the study area (Rio Grande do Norte to Pernambuco), with higher values of the abundance index (n° and Kg) reported in Rio Grande do Norte and South of Pernambuco (Fig. 9a,b). It was not observed significant differences between the mean CPUE (n° and Kg) when compared inner and outer shelf ($P > 0.05$). Nevertheless, individuals were larger in the outer shelf than those observed in the inner shelf ($P < 0.05$). There is a higher proportion of adults than juveniles, except in the inner shelf of the south of Rio Grande do Norte and in Pernambuco, where juveniles dominate (Fig. 9c).

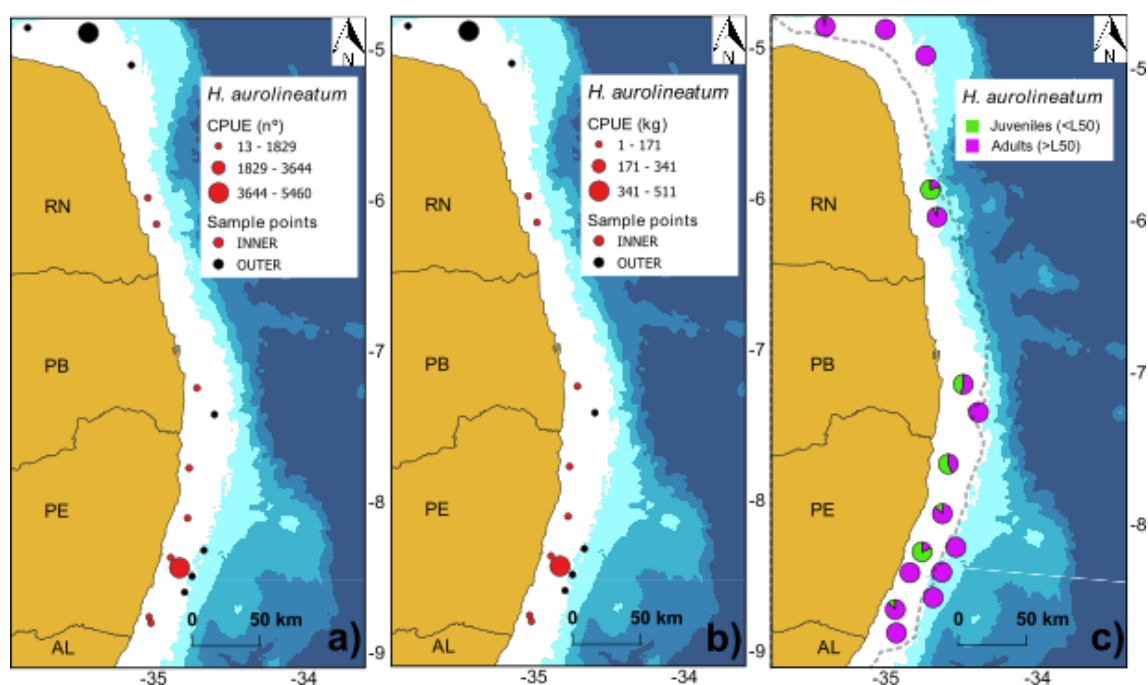


Figure 9 - CPUE of *H. aurolineatum* a) in number of individuals b) in biomass (Kg) and (c) the ratio of adults and juveniles in the shelf (inner and outer) along the northeast coast of Brazil.

Haemulon squamipinna

Individuals of *Haemulon squamipinna* ranged from 9.2 to 16.3 cm SL ($\bar{X} = 12.88$ cm ± 1.70) and 18.3 to 110.9 g TW ($\bar{X} = 60.51$ g ± 21.5). The length at first maturity (L_{50}) for combined sexes was estimated as 10.1 cm SL (CI= 8.6 – 11), and 92% of the individuals in the samples were adults (SL > L_{50}) (Fig. 10). The length class of 12-14 cm were the most representative for females and males (Fig. 11). There was no significant statistical difference in the mean length of females and males (*t-test*, $p > 0.05$).

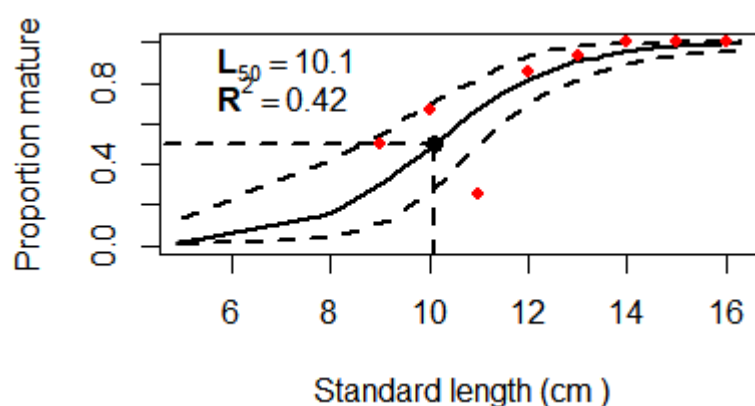


Figure 10 - Size at first maturity for pooled sex of *H. squamipinna* on the Northeast coast of Brazil.

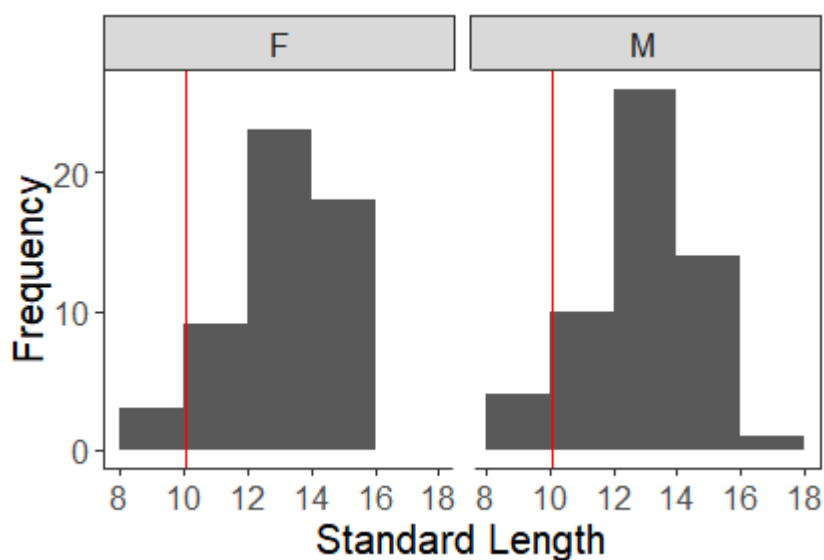


Figure 11- Distribution of the length frequency of females and males of *H. squamipinna* and their estimated size at first maturity ($L_{50} = 10.1$ cm SL).

According to the length-weight relationship for pooled sex ($b=2.96$ $p < 0.05$), this species presented isometric growth (Fig. 12). Both sexes were equally abundant, and sex ratio did not significantly differ from 1:1 ($\chi^2 = 0.037037$, $p > 0.05$).

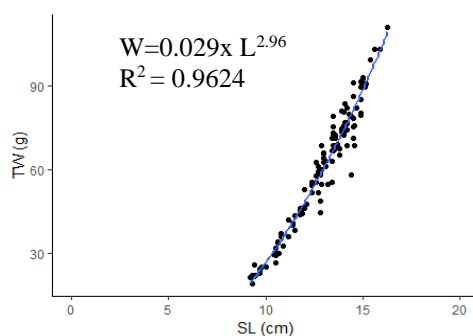


Figure 12 - Length-weight relationship for *H. squamipinna* for both sexes.

Individuals of *Haemulon squamipinna* were found in Paraíba and Pernambuco, with the highest CPUE (n° and Kg) values reported in the south coast of Pernambuco (Fig.13 a, b). It was not observed significant differences between the mean CPUE (n° and Kg) and mean length when compared the inner and outer shelf ($P > 0.05$). Overall, there is a higher proportion of adults than juveniles, although, juveniles dominated in the inner shelf of the coast of Pernambuco (Fig. 13c).

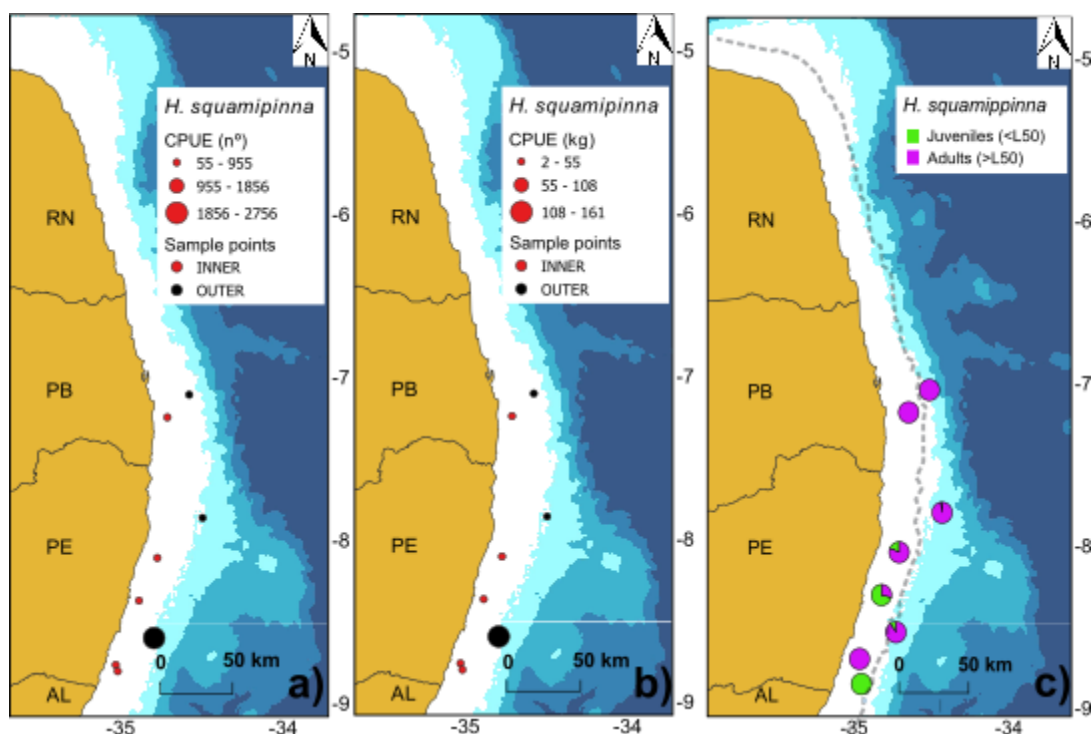


Figure 13 - CPUE of *H. squamipinna* a) in number of individuals b) in biomass (Kg) and (c) the ratio of adults and juveniles in the shelf (inner and outer) along the northeast coast of Brazil.

Haemulon steindachneri

Individuals of *Haemulon steindachneri* ranged from 10.7 to 18.0 cm SL (\bar{X} =14.2 cm \pm 1.84) and 33.40 to 135.90 g TW (\bar{X} =78.08 g \pm 24.52). Males and females presented sex ratio not significantly different from 1:1 ($\chi^2= 0.02439$, $p>0.05$). *H. steindachneri* individuals were observed since Rio Grande do Norte to Pernambuco, only in the inner shelf, with highest values of CPUE (N° and Kg) reported in the south of Rio Grande do Norte and south of Pernambuco (fig.14a, b).

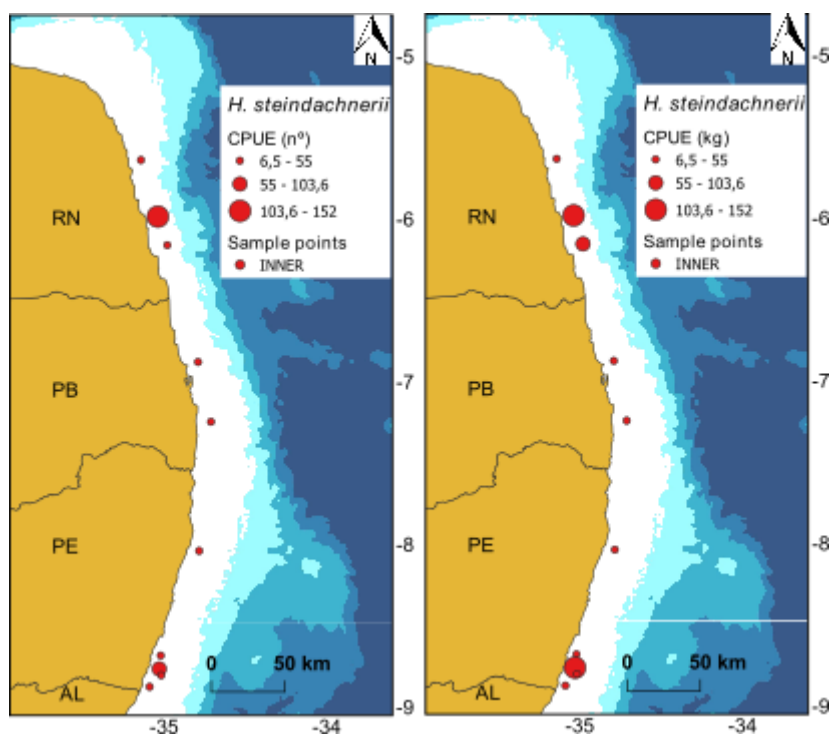


Figure 14 - CPUE of *H. steindachneri* in number of individuals(a) and in biomass (Kg) (b) on the northeast coast of Brazil.

Orthopristis ruber

Individuals of *Orthopristis ruber* ranged from 11.1 to 17.8 cm SL (\bar{X} 14.72; \pm 1,33) and 37.40 to 133.20 g TW (\bar{X} =83.23; \pm 21.44). Females and males were equally abundant, with sex ratio not significantly different from 1:1 ($\chi^2= 0.27273$, $p>0.05$). Individuals were observed since Rio Grande do Norte to Pernambuco, only in the inner shelf, with highest values of CPUE (N° and Kg) in the south portion of Paraíba (Fig.15 a,b).

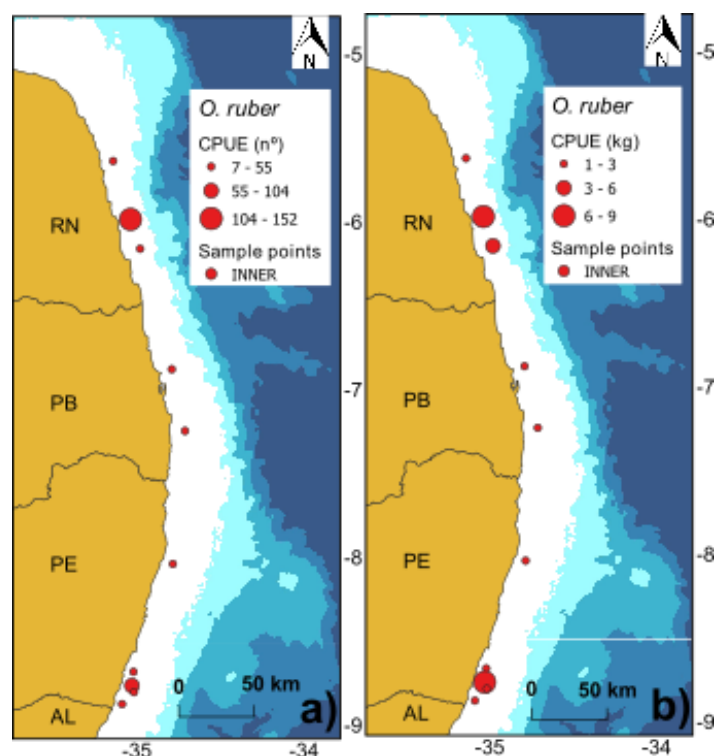


Figure 18 - CPUE of *O. ruber* in number of individuals(a) and in biomass (Kg) (b) on the northeast coast of Brazil.

DISCUSSION

Fish of the Haemulidae family inhabit mostly reef areas and, despite their low economic value, this group have a high capture ratio reported mainly by the artisanal fleet in tropical areas, where this fishery is important, either for generating income and, mostly, for providing food for millions of people (ALLISON & ELLIS, 2001; GARCIA & ROSENBERG, 2010). Also, fish of this family are an important piece of the trophic chain, feeding mostly on invertebrates and playing the role of prey and predator at the same time; their presence can regulate the abundance of invertebrates and predators in their habitat (ALEVIZON et al., 1985; PUGLISE et al., 2009; TENGGARDJAJA et al., 2014).

Despite its relevance, there is a deficiency of knowledge about the population structure, and the factors that control the distribution of these fish, essentially on the northeastern coast of Brazil, which is considered an Ecologically or Biologically Significant Marine Area (EBSAs) (CBD, 2014). In this study, it is provided some novel and integrated information concerning the diversity and populational aspects of the main species of the Haemulidae family from the Northeast of Brazil, also contributing to the knowledge of the spatial patterns of distribution, abundance and habitat use for these species in the area. This information may act as a subsidy for the stock assessment and

conservation of this fish family.

Haemulidae show a higher diversity in coral areas (WHITE, 1994; REAKA-KUDLA, 1997; JAIXON-HARM et al., 2012; HONDA et al., 2013), being dominated by the genus *Haemulon* (BROTTO ET AL., 2007; MADRID ET AL., 1997). In the present study, it was collected 10 species of Haemulidae, comprising 5 genus, dominated by the *Haemulon*. A similar result was found by LESSA & NÓBREGA (2000) in the same area - 11 species of Haemulidae were reported, 8 present in this study (except *A. surinamensis*, *Haemulon chrysargyreum* and *Haemulon macrostomum* which were not here observed). On the other hand, *H. squamipinna* and *H. corvinaeformis*, both collected in the present study, were not registered by the former authors. Hence, considering the studies carried out in Northeast Brazil, 13 species of Haemulidae is currently reported for the region. Comparing to others Atlantic coral regions, the northeast Brazilian coast showed more diversity than the southeast Brazilian coast (11 species, MENEZES, 2011), where 7 were also here observed; the coast of Costa Rica (7 species, FOURRIÉRE et al., 2017) and México (9 species, GALVÁN-VILLA et al., 2016). In the vicinity of the Indian Ocean, in Western Australia, there were reported 10 species, and, only 2 genera (*Diagramma* and *Plectorhinchus*) (HARRY, 2001). In the Pacific region, the Japanese coast presented a similar number of species (12 species), although those comprised only 4 genera (*Diagramma*, *Parapristipoma*, *Plectorhinchus*, and *Pomadasyss*) (MOTOMURA & HARAIZAKI, 2017).

Overall, in Northeast Brazil, Haemulidae dominates in coral area, in the inner shelf and below the latitude 8°S. Habitats as algae and coralline formations mediate competition and predation, facilitate cohabitation of an increased number of species, and provide essential habitats and resources for marine invertebrates and fish (BERTELLI & UNSWORTH, 2014; DARLING et al., 2017). Amongst the species, *H. aurolineatum*, *H. plumierii*, *H. squamipinna* were considered dominant by the relative importance index, as observed in other studies of the region (ROCHA et al., 1998; IVO et al., 2010; OLAVO et al., 2011). In the coast of Rio Grande do Norte, *A. virginicus* was considered rare and scarce (IVO et al. 2010), corroborating with the present study. *Conodon nobilis* and *Haemulopsys corvinaeformis* were also rare and scarce in the present study. These species have very coastal habits, entering in estuarine areas (VASCONCELOS FILHO & OLIVEIRA, 1999), which was not the main area of this study.

The Capture Per Unit Effort (CPUE) is an index that reflect the relative abundance of a species, also accessing the fishing pressure towards a resource (KLEIVEN et al.,

2018). This index was used in this study in order to compare the abundance of the species along a latitudinal gradient and distance from the coast. Pernambuco was considered a “hotspot area” for Haemulidae, due to the high abundance of *H. aurolineatum*, *H. plumierii*, *H. squamipinna* and *H. steindachneri*. Rio Grande do Norte were also considered an area of high abundance for this family, given the high values of CPUE for *H. aurolineatum* and *H. steindachneri*. These areas present Marine Protect Areas - APA Costa dos Corais and APA Recifes de Coral (FERREIRA & MAIDA, 2006), spotted reefs and various artificial reefs that occur mainly in the state of Pernambuco, which may contribute aggregating fish schools and local fauna (DOS SANTOS et al., 2010). Particularly in Rio Grande do Norte, many complex sandstones reef formations “Parrachos”, that favor the fixation of corals and thus influence the diversity and abundance given the heterogeneity conformation of their habitat (CAMPOS et al., 2010, LOPES et al., 2014), are also reported. Also, small upwelling processes that occur on the shelf break (OLAVO et al., 2011; THÉVENIN et al., 2019), transferring nutrient from deep layers and increasing abundance of prey for fish assemblages (MMA, 2006), may also contribute for this high abundance. Pernambuco has previously been considered a “hotspot” for the whole demersal community (EDUARDO et al., 2018) and for another reef species, the spotted goatfish, *Pseudupeneus maculatus* (SOARES, 2019).

Although the adults dominated for most species and areas, the inner shelf of the coast of Pernambuco and south of Paraíba (*H. plumierii* and *H. aurolineatum*) and Rio Grande do Norte (*H. aurolineatum*), showed a high proportion of juveniles, in the inner shelf. The complex habitats in those sites, are used as a refuge for juveniles and indicate sensible areas for fisheries and other harmful activities for this ontogenetic stage. According to LINDEMAN (2000), reef environment is an area in which juveniles near maturation and adults live and spawn. During the larval and part of a juvenile phase, Haemulidae inhabits mangrove areas and seagrass beds and migrate to the reefs close to maturity (MUNRO, 1983; LINDERMAN et al., 2000; DE LA MORINIE et al., 2002; 2003).

As a consequence of the high productivity, the fishing fleet dominate in Pernambuco and Rio Grande do Norte. Haemulidae, mainly *H. plumierii*, *H. aurolineatum*, and *H. squamipinna*, is currently widely caught with traps by the artisanal fisheries (MARIANO & ROSA, 2010). *H. plumierii* is highly captured in Rio Grande do Norte and Ceará in the northeast Brazil (LESSA et al., 2004; IVO et al., 2010), and *H. aurolineatum* and *H. squamipinna* in the coast of Pernambuco (LESSA et al., 2004;

MARQUES & FERREIRA, 2010). In the past, those family of reef fishes were considered as bycatch of the lobster fishery, an important resource in the northeastern region, however, after the decrease of those stocks, the focus of the fishery was redirected to goatfish (*Pseudopenes maculatus*) and parrotfishes (*Sparissoma radians*) for example and, as their abundance also decreased, the target was replaced by other demersal fishes such as Lutjanidae (*Lutjanus synagris* and *L. analis*) and the Haemulidae (*H. plumierii*, *H. aurolineatum* and *H. squamipinna*) (OLIVEIRA et al., 2015), thus increasing the economic importance of these last family (COELHO et al., 1996; ROCHA et al., 1997; RIBEIRO, 2004). According to the official statistics of the Northeast region, the capture of Haemulidae doubled in ten years (1997-2007), and currently no data (statistics and status of the stock) is available, hampering any action in terms of fishery management and conservation for this group.

Population aspects of Haemulidae were also provided in this study. The length-weight relationship is used in fishery biology to convert length in weight, evaluate the growth of a species and to estimate the condition factor, that measure the well-being of a fish (KURIAKOSE, 2017). The positive allometry, which indicates more increase in height and width than in length, was observed for *H. plumierii*. VASCONCELOS-FILHO et al. (2018), for the same species in the northeast coast, observed negative allometry. This difference can be explained by the differential study area, which was closest to the coast. Isometry was observed for *H. squamipinna* (pooled sex, females and males) and for *H. aurolineatum* (pooled sexes). However, for the latter species, the relation carried out by sex showed a negative allometry, indicating more increase in length than weight. This can be explained by the absence of very small individuals in the equation, given the impossibility of sexing small-sized individuals. BOUCHON-NAVARO et al. (2006) in the Antilles also reported isometry for *H. aurolineatum*. Factors like food availability, temperature, oxygen and biology aspects (size, age and sexual maturity) can influence the growth of a fish and hence the different allometry between studies (KURIAKOSE, 2017).

H. plumierii presented more females than males in the sex ratio. *H. aurolineatum*, *H. squamipinna*, *H. steindachneri*, and *O. ruber* presented the same ratio between males and females. Also, in northeast of Brazil, LESSA et al. (2004) found the same sex ratio (1:1) for *H. aurolineatum* and SHINOZAKI-MENDES et al. (2013a) observed the sex ratio of 1:1 for *H. plumierii*. The sex-ratio is directly influenced by the reproductive strategy of the species and environmental variations of the ecosystems (MURUA et al., 2003, OSPINA-ÁLVAREZ and PIFERRER, 2008).

The size of the first maturity is the length that half of a population is able to reproduce and is used to define the boundary between juveniles and adults, also is often used as a fisheries management tool, to establish minimum catch size (FONTELES, 2011). In this study, L_{50} for *H. plumierii* and *H. aurolineatum* were 15.11cm FL and 15.3 cm TL respectively. *H. plumierii* values were slightly lower to observed by SHINOZAKI-MENDES et al. (2013a) (16.86 cm FL for females and 18.55 FL cm for males) however, was similar to the reported by LESSA et al. (2004) for *H. aurolineatum* (15 cm TL for females and 15.3 cm for males). The difference in the values may be due to environmental conditions and anthropogenic factors such as fishing (LOURENÇO et al., 2015; FROESE et al. 2016) or methodological aspects.

Fishing pressure, environmental pollution, and climate change are some of the factors that affect the dynamics, distribution, abundance, populational structure, and habitat use of fish (PAULY et al, 2002; HARLEY et al, 2006). Information about those aspects are important to access the evolution of the anthropic factors impacting the fisheries resources, and also to identify priority areas for conservation, as subsidy for the implementation of the marine spatial planning, to protect endangered or susceptible species, especially for reef environment, which is under several pressures (ARTHINGTON et al., 2016; BAX et al., 2016).

Increasing knowledge about the biology of the reef species, their respective relationships with habitat and the identification of high ecological importance areas are essential to better develop management and conservation strategies, as well as to preserve the integrity of the ecosystem, ensuring that the ecological processes, not only of the Haemulidae family, but also for the various species of reef fish distributed, are preserved. Considering our results, in terms of conservation and management actions, especially attention should be taken for the coast of Pernambuco, given the high abundance, richness and juveniles concentration of Haemulidae, as for other reef fishes previously reported.

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5. Considerações Finais

No presente trabalho, observou-se uma grande riqueza de Haemulídeos no nordeste do Brasil, principalmente em ambientes coralíneos e na plataforma continental interna, que por sua vez, também apresentou uma maior proporção de indivíduos jovens para as espécies.... Os habitats de corais apresentam uma maior riqueza e abundância, por serem áreas de abrigo para diversos tipos de organismos, além de serem potenciais locais de agregamento de jovens para várias espécies de peixes da família Haemulidae. Os estados de Pernambuco e Rio Grande do Norte são considerados “hotspots” de biodiversidade e abundância e, portanto, merecem maior atenção em relação à conservação.

Neste estudo, também contribuímos com o conhecimento acerca da biologia das espécies recifais, essencial para qualquer iniciativa de avaliação e consequente manejo dos estoques, até o momento ausentes na região. A maioria das espécies apresentaram igualdade entre machos e fêmeas, indicando equilíbrio no potencial reprodutivo dessas espécies, bem como isometria, sinalizando proporcional incremento no peso e no comprimento. Adicionalmente, foi determinado o tamanho de primeira maturação para as espécies; *H. plumierii*, *H. aurolineatum* e *H. squamipinna* mais frequentemente explorados pela atividade pesqueira.

A pescaria de membros desta família vem aumentando no decorrer dos anos devido à diminuição dos estoques da lagosta, tornando os Haemulidae também alvo da pesca, junto com peixes recifais de outras famílias. Informações já publicadas sobre biologia pesqueira (ex: idade e crescimento) e as aqui disponibilizadas, devem ser utilizadas para a avaliação dos estoques das principais espécies desta família em um futuro próximo, de forma a garantir esta atividade e os recursos por ela capturada, como fonte de renda e alimento para a população. Ainda sugerimos a elaboração de mais estudos e publicações referentes a xira-amarela (*H. squamipinna*) e a biquara (*H. plumierii*), já que o aporte de informações das espécies classificadas como Dados Deficientes (DD) pela IUCN é considerado prioritário.