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Leandro Nolé, Michael Maia Mincarone, Bárbara Teixeira Villarins, Thierry Frédou, Alex Souza Lira, Arnaud Bertrand, Flávia Lucena Frédou, Leandro Nolé Eduardo, Bárbara Villarins, Flávia Frédou

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1 **Length–weight relationships of eleven mesopelagic fishes from oceanic**  
2 **islands of the Southwestern Tropical Atlantic**

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4 Leandro Nolé Eduardo<sup>1\*</sup>, Michael Maia Mincarone<sup>2</sup>, Bárbara Teixeira Villarins<sup>2</sup>,  
5 Thierry Frédou<sup>1</sup>, Alex Souza Lira<sup>1</sup>, Arnaud Bertrand<sup>1,3,4</sup>, Flávia Lucena Frédou<sup>1</sup>

6  
7 <sup>1</sup> Universidade Federal Rural de Pernambuco, Departamento de Pesca e Aquicultura,  
8 Recife, PE, Brazil.

9 <sup>2</sup> Universidade Federal do Rio de Janeiro, Núcleo em Ecologia e Desenvolvimento  
10 Socioambiental de Macaé, Macaé, RJ, Brazil.

11 <sup>3</sup> Universidade Federal de Pernambuco, Departamento de Oceanografia, Recife, PE,  
12 Brazil.

13 <sup>4</sup> Institut de Recherche pour le Développement, Sète, France.

14  
15 \*Corresponding author: leandronole@hotmail.com; Tel: +55 81 3320 6015.

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17 **ABSTRACT**

18 This study provides the length-weight relationship for eleven deep-sea fishes from  
19 oceanic islands of the Southwestern Tropical Atlantic: *Bonapartia pedaliota*, *Sigmops*  
20 *elongatus* (Gonostomatidae), *Argyropelecus aculeatus*, *Argyropelecus affinis*,  
21 *Argyropelecus sladeni*, *Sternoptyx diaphana*, *Sternoptyx pseudobscura*  
22 (Sternoptychidae), *Malacosteus niger*, *Thysanactis dentex* (Stomiidae), *Melanonus*  
23 *zugmayeri* (Melanonidae), and *Ectreposebastes imus* (Setarchidae). Data were collected  
24 during a scientific survey (2017) around Rocas Atoll, Fernando de Noronha  
25 Archipelago and adjacent seamounts, using a micronekton trawl (side length of body  
26 mesh: 40 mm, side length of cod-end mesh: 10 mm) at 35 stations from 0 to 1113 m  
27 depth. A new maximum standard length for *Bonapartia pedaliota* and *Ectreposebastes*  
28 *imus* are also provided.

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31  
32 **INTRODUCTION**

33 In the western Tropical Atlantic, the Fernando de Noronha Archipelago, Rocas  
34 Atoll and adjacent seamounts host a remarkable biodiversity (Fiedler et al., 2016; Hazin  
35 et al, 1998). For this reason, the marine ichthyofauna of this large biogeographic unit  
36 categorized as Ecologically or Biologically Significant Marine Areas - EBSA (CBD,  
37 2014) has been studied by many authors (Dominguez et al., 2016; Kikuchi &  
38 Schobbenhaus, 2002; Oliveira et al., 2011). However, most efforts focused on fishes  
39 living near to the surface (0-200 m) and few studies described the mesopelagic zone  
40 (200-1000 m depth) of this region, which is considered as one of the most understudied  
41 of the world ocean (St. John et al., 2016).

42 The mesopelagic community is a key resource for higher trophic levels,  
43 maintaining part of the marine biodiversity and playing an important role in carbon  
44 sequestration and thus on the biological carbon pump (Proud et al, 2017; St. John et al.,  
45 2016). To better account for the role of this community in the ecosystem structure and  
46 function, a prerequisite is to have the necessary biological information. One of such key  
47 basic knowledge concerns the length-weight relationships (LWR) that are one of the  
48 requisites for fisheries management and conservation (Froese, 2006; Froese et al.,  
49 2011). Indeed, LWRs are used to estimate body weight by length measurements, assess  
50 the condition factor or well-being of species of interest, as well as for the calculation of  
51 production and biomass of a fish stock (Froese, 2006). Despite this, information on  
52 LWRs are still lacking for many deep-sea fishes. Here, we provide new LWRs for  
53 eleven mesopelagic fish species collected along the northeast Brazilian oceanic islands,  
54 in order to increase the biological data and general knowledge of these species.

## 55 MATERIAL AND METHODS

56 The study area comprises the northeast Brazilian oceanic islands, including  
57 Rocas Atoll (3°52'S, 33°49'W), Fernando de Noronha Archipelago (3°50'S, 32°25'W)  
58 and adjacent seamounts. Data were collected during the scientific survey ABRACOS  
59 (Acoustics along the BRAzilian COaSt) conducted on board the RV *Antea*, from 9th  
60 April to 6th May 2017. Mesopelagic sampling was conducted using a micronekton trawl  
61 (side length of body mesh: 40 mm, side length of cod-end mesh: 10 mm) at 35 stations  
62 from 0 to 1113 m depth. After capture, the material was fixed in a 4% formalin solution  
63 for one month and then preserved in a 70% alcohol solution for proximally six months  
64 before processing for length and weight. At the laboratory, species were identified,

65 measured (nearest 0.1 cm of standard length, SL) and weighed (nearest 0.01 g of total  
66 weight, TW). All specimens were deposited in the Fish Collection of the Núcleo em  
67 Ecologia e Desenvolvimento Socioambiental de Macaé (NPM), Universidade Federal  
68 do Rio de Janeiro (NUPEM/UFRJ).

69 The parameters of the LWR were estimated through the equation:  $TW = a \times SL^b$ ,  
70 where  $TW$  is the total weight (g),  $SL$  is the standard length (cm),  $a$  is a constant being  
71 the initial growth index and  $b$  is the slope of the regression. Prior to the calculation of  
72 LWRs, the relationship plots were executed for visual inspection and removal of  
73 outliers (Froese & Binohlan, 2000). The significance of the regression was tested by  
74 ANOVA and the degree of association between  $TW$  and  $SL$  was calculated by the  
75 determination coefficient ( $r^2$ ). We only included LWRs for species with  $n > 30$ , except  
76 for three species for which a wide fish-length range was available.

## 77 RESULTS

78 A total of 11 species belonging to five families and three orders were analysed  
79 (Table 1). All regressions were highly significant ( $P < 0.01$ ), with the coefficient of  
80 determination ( $r^2$ ) ranging from 0.9511 to 0.9862. The value of  $b$  varied between 2.66  
81 for *Sternoptyx pseudobscura* and 3.22 for *Sigmops elongatus*, while the parameter  $a$   
82 ranged between 0.0012 for *Thysanactis dentex* and 0.0250 for *Ectreposebastes imus*.

## 83 DISCUSSION

84 This work provides the first LWR for six species: *S. pseudobscura*, *B.*  
85 *pedaliota*, *S. elongatus*, *T. dentex*, *M. zugmayeri*, and *E. imus*. LWR information has  
86 been previously available for *A. aculeatus*, *A. affinis*, *A. sladeni*, *S. diaphana*, and *M.*  
87 *niger*, but it was based on a small length range, small sample size (<5) and/or without  
88 the descriptive statistics of the relationships (Alpoim et al., 2002; Davison et al., 2015).  
89 All species presented here but *A. aculeatus* and *M. niger*, have no LWRs available in  
90 FishBase. In addition, the highest standard-length values for *Bonapartia pedaliota* and  
91 *Ectreposebastes imus* are reported herein.

92 As established by Froese (2006), the allometric coefficients for all LWRs were  
93 within the expected range of 2.5–3.5. These values are reflection of intrinsic  
94 characteristics and process of adaptations of each species, as ontogenetic reproductive  
95 or environmental variations, mainly between sexes (Froese, 2006). In addition, fixation

96 in alcohol and formaldehyde can affect length and weight measurements through the  
97 shrinking and dehydration of specimens. For that reason, we recommend consider the  
98 LWRs presented here as being tentative.

99 Overall, this study increases the knowledge on mesopelagic fishes, providing  
100 basic biological information useful for further studies in ecology, conservation, and  
101 fisheries assessment.

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167 Table 1. Descriptive statistics and parameters of LWRs for 12 deep-sea fishes caught using a micronekton trawl at the northeast Brazilian oceanic  
 168 islands and seamounts, from 9th April to 6th May 2017. **SL** = Standard Length, **TW** = Total Weight, **a** = initial growth index, **b** =slope of the  
 169 regression and **r<sup>2</sup>** = determination coefficient.

170

Taxa	n	SL (cm)		TW (g)		Regression parameters		r <sup>2</sup>
		Min	Max	Min	Max	a	b (95% CL)	
Stomiiformes								
Gonostomatidae								
<i>Bonapartia pedaliota</i> Goode & Bean, 1896	85	3.7	7.5	0.4	2.7	0.0074 (0.0058-0.0094)	2.94 (2.80-3.08)	0.9571
<i>Sigmops elongatus</i> (Günther, 1878)	35	4.9	25	0.2	28	0.0015 (0.0009-0.0023)	3.229 (3.07-3.39)	0.9814
Sternoptychidae								
<i>Argyropelecus aculeatus</i> Valenciennes, 1850	49	3	8.2	0.8	20.9	0.0350 (0.0245-0.0496)	2.996 (2.77-3.21)	0.9529
<i>Argyropelecus affinis</i> Garman, 1899	260	2.8	7.8	0.31	6.09	0.0218 (0.0183-0.0258)	2.807 (2.70-3.91)	0.9511
<i>Argyropelecus sladeni</i> Regan, 1908	26	2	6.6	1.15	7.2	0.0425 (0.0257-0.0705)	2.703 (2.39- 3.01)	0.9618
<i>Sternoptyx diaphana</i> Hermann, 1781	600	1.2	4.3	0.1	4.3	0.0570 (0.0370-0.0770)	2.89 (2.79-2.99)	0.9275
<i>Sternoptyx pseudobscura</i> Baird, 1971	51	1.3	5.6	0.24	6.6	0.0754 (0.0582-0.0970)	2.663 (2.45-2.88)	0.9655
Stomiidae								
<i>Malacosteus niger</i> Ayres, 1848	33	6.3	18.1	1.5	34.4	0.0057 (0.0009-0.0030)	2.956 (2.74-3.17)	0.9635
<i>Thysanactis dentex</i> Regan & Trewavas, 1930	35	4.3	14.5	0.1	10.6	0.0012 (0.0009-0.0012)	3.197 (3.07-3.33)	0.9868
Gadiformes								
Melanonidae								
<i>Melanonus zugmayeri</i> Norman, 1930	20	6.4	19.1	1.06	32.31	0.0036 (0.0018-0.0071)	2.973 (2.68-3.26)	0.9623
Scorpaeniformes								
Setarchidae								
<i>Ectreposebastes imus</i> Garman, 1899	25	5.2	23.4	3.43	290.3	0.0250 (0.0138-0.0482)	3.025 (2.81-3.24)	0.9728