Ocean and Coastal Research

BRIEF COMMUNICATION

http://doi.org/10.1590/2675-2824070.21095sa
ISSN 2675-2824

Length-weight relationship of 22 fish species (Osteichthyes) from the surf zone caught by seine net on the northern coast of Pernambuco - Brazil

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ABSTRACT

This study aims to analyze the length-weight relationship (LWR) of 22 fish species collected in the surf zone of Ponta de Pedras, northern coast of Pernambuco, Northeastern Brazil. The specimens were collected between August 2013 and July 2014 using a beach seine net, and their biometry were recorded in laboratory. The LWR was calculated using linear regression and, confidence intervals were estimated for the regression parameters a and b. A total of 1,433 specimens belonging to 22 species, 12 families, and six orders were collected. All species had b values within the expected range of 2.5–3.5 (except for *S. plagusia*). Additionally, 11 species have hyperallometry, eight have isometry, and three have hypoallometry. Herein, we present values of LWR for *Lycengraulis grossidens*, *Trachinotus goodei*, and *Umbrina coroides*, which are new to Northeastern Brazil, and *Albula vulpes and Sparisoma radius* which are new for the Brazilian coast.

Descriptors: Allometry, Beach seine, Tropical waters, Ichthyofauna, Coastal ecosystem.

The surf zone is a dynamic coastal ecosystem that changes with the tides and is defined mainly as the external limit of the wave breaking area. This feature is important for the control of the physicochemical aspects of the coastline, and consequently for the local fauna structure (McLachlan et al., 1981; Godefroid et al., 2001; Vasconcellos et al., 2007; Pessoa et al., 2019).

Several studies have been developed in those areas to elucidate the faunistic composition and community dynamics, including along the Brazilian coast (*e.g.*, Giannini and Paiva Filho, 1995; Stergiou and Moutopoulos, 2001; Vianna et al., 2004; Vasconcellos et al., 2007; Vasconcellos et al., 2010; Gondolo et al., 2011; Favero and Dias, 2013; Santana et al., 2013; Lima, 2016; Viana et al., 2016; Eduardo et al., 2018; Shah Emaeili et al., 2021). Despite the high number of research surveys related to Brazilian ichthyofauna, there is still a gap concerning the growth of fish species inhabiting the surf zone, which is essential for proper management of fisheries resources.

Understanding fish growth throughout its life cycle is important for discerning the status of a fish population. Length-weight relationships (LWR), calculated according to correlation coefficients

Submitted: 20-Oct-2021
Approved: 21-July-2022
Editor: Rubens M. Lopes

and regressions, are commonly used during stock assessments (Nomura, 1965; Schneider et al., 2000). As proposed by Froese (2006), fish growth may be classified into three allometric growth patterns: isometric, positive allometric, and negative allometric (Schneider et al., 2000; Braccini and Chiaramonte, 2002; Raeisi et al., 2012).

In Northeastern Brazil, the number of species which currently have a recorded LWR is low, even though this information is essential for fish stock assessments, ecological studies, taxonomic identification, and others (Stergiou and Moutopoulos, 2001; Kulbicki et al., 2005; Froese et al., 2014). In this context, our objective was to analyze the LWRs of 22 species captured in the surf zone, identify the types of growth for each species, and contribute to the understanding of the biology and ecology of the surf zone fish community of the northern coast of Pernambuco, Northeastern Brazil.

Collection permits were granted by the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), permit number: 41138-1, and the Committee of Ethics on Animals Use and Manipulation (CEUA) of the Federal Rural University of Pernambuco (UFRPE) (permit: 018/2015). The sampling was performed monthly from August 2013 to July 2014. Samples were obtained using a beach seine net that was 20 m long and 2 m high, with a 5 mm mesh size, operated manually for 50 meters along the coastline following the current directions, at depths of up to 1.5 m. Three seines were carried out in the morning and night for each location studied during the low tide period. Two locations were studied at Ponta de Pedras Beach, located on the northern coast of Pernambuco (7° 38' 15.71" S / 34° 48' 56.30" W and 7° 38' 29.01" S / 34° 49' 4.6" W).

The fish sampled were identified to species level, measured for total length with a digital caliper to the nearest 0.01 mm, and weighed on a digital scale calibrated to 0.0001 g. The LWR was calculated from the linear regression equation $W = \log a + b * \log TL$, where W is the total weight (g), TL is the total length (cm), a is the intercept, and b the slope (Le Cren, 1951; Froese, 2006). Confidence interval (CI) is the range of maximum and minimum values indicating the variation of the average estimated according to a predetermined confidence level (Brooks et al., 2010; Braun et al., 2013; Magnusson et al., 2013). Here, we used a confidence level of 95% and would thus expect 95 of 100 treatments to have the true mean be within the range of reported CIs. We estimated the values of a and b (CI = 95%), as well as the coefficient of determination (R^2) of the regression. For a better description of the results, outliers were removed from the analysis when graphically observed, as suggested by Froese (2006). The analyses were performed with the Fishery Stock Analysis package (Ogle et al. 2020) in R Statistical Software, version 4.0.0 (R Development Core Team, 2017).

The LWRs of 1,433 specimens, corresponding to 22 species, 12 families, and six orders are presented. In all cases, the estimated regression showed significance ($p < 0.001$), with the coefficients of determination (R^2) ranging from 0.942 to 0.996. The total variation of intercepts was between 0.003 and 0.272, while the slope oscillated from 2.49 to 3.58 (Table 1).

The species *Oligoplites palometa* (Cuvier, 1832), *Ophioscion punctatissimus* (Meek & Hildebrand, 1925), and *Trachinotus falcatus* (Linnaeus, 1758) have hypoallometry, where the weight increase rate is lower than the length increase rate ($b < 3$; max CI $b < 3$) (Froese, 2006; Karachle & Stergiou, 2012; Panase & Mengumphan, 2015; Vasconcelos et al., 2018). Hyperallometry was observed in eleven species: *Albula vulpes* (Linnaeus, 1758), *Strongylura marina* (Walbaum, 1792), *Chaetodipterus faber* (Broussonet, 1782), *Conodon nobilis* (Linnaeus, 1758), *Haemulopsis corvinaeformis* (Steindachner, 1868), *Polydactylus virginicus* (Linnaeus, 1758), *Larimus breviceps* (Cuvier, 1830), *Menticirrhus americanus* Linnaeus, 1758, *Menticirrhus littoralis* (Holbrook, 1847), and *Symphurus plagusia* (Bloch & Schneider, 1801), where the length increase rate is lower than the weight increase rate ($b > 3$; min CI $b > 3$) (Froese, 2006; Panase & Mengumphan, 2015; Carvalho et al., 2022). Lastly, the species *Caranx latus* (Agassiz, 1831), *Lycengraulis grossidens* (Spix & Agassiz, 1829), *Trachinotus goodei* (Jordan & Evermann, 1896), *Umbrina coroides* (Cuvier, 1830), *Haemulon aurolineatum* (Cuvier, 1830), *Sphoeroides testudineus* (Linnaeus, 1758),

Table 1. Length-weight relationship of 22 species of fish caught in Ponta de Pedras Beach, northern coast of Pernambuco-Brazil. We used Betancur-R et al. (2017) for the taxonomic classification.

Order	Family	Species	Total length (cm)			WeightWeight (g)						
			n	min	max	min	max	a	CI a (95%)	b	CI b (95%)	R^2
Albuliformes	Albulidae	*Albula vulpes* (Linnaeus, 1758)	23	2.7	21.9	0.14	96.2	0.0062	0.0052 - 0.0073	3.13	3.03 - 3.21	0.99
Beloniformes	Belonidae	*Strongylura marina* (Walbaum, 1792)	11	5.5	30.2	0.13	34.5	0.0003	0.0001 – 0.0007	3.36	3.02 – 3.70	0.98
Clupeiformes	Clupeidae	*Rhinosardinia bahiensis* (Steindachner, 1879)	9	3.0	4.1	0.14	0.5	0.0031	0.0013 - 0.0078	3.56	2.84 - 4.27	0.94
	Engraulidae	*Lycengraulis grossidens* (Spix & Agassiz, 1829)	15	11.4	16.1	11.3	32.0	0.0096	0.0031 - 0.0294	2.92	2.49 - 3.34	0.94
Carangiformes	Carangidae	*Caranx latus* Agassiz, 1831	30	3.7	11.0	0.7	14.3	0.0175	0.0118 - 0.0259	2.85	2.63 - 3.07	0.96
		Oligoplites palometa (Cuvier, 1832)	9	5.5	7.8	1.2	2.9	0.0177	0.0102 - 0.0306	2.49	2.19 - 2.79	0.98
		Trachinotus carolinus (Linnaeus, 1766)	215	1.1	15.6	0.02	46.0	0.0145	0.0124 - 0.0171	2.95	2.87 - 3.03	0.96
		Trachinotus falcatus (Linnaeus, 1758)	55	1.9	10.8	0.16	26.6	0.0272	0.0237 - 0.0312	2.83	2.75 - 2.90	0.99
		Trachinotus goodei Jordan & Evermann, 1896	70	6.3	19.0	3.2	79.4	0.0135	0.0087 - 0.0208	2.96	2.78 - 3.13	0.94
Ephippiformes	Ephippidae	*Chaetodipterus faber* (Broussonet, 1782)	31	2.4	9.2	0.36	37.1	0.0180	0.0113 - 0.0287	3.35	3.03 - 3.67	0.94
Labriformes	Labridae	*Sparisoma radians* (Valenciennes, 1840)	8	1.6	4.9	0.09	1.0	0.0097	0.0025 - 0.0043	3.07	2.2 – 3.95	0.89
Lutjaniformes	Haemulidae	*Conodon nobilis* (Linnaeus, 1758)	84	2.3	16.6	0.05	67.9	0.0091	0.0075 - 0.0110	3.20	3.10 - 3.31	0.98
		Haemulon aurolineatum (Cuvier, 1830)	9	4.9	10.1	1.3	12.3	0.0135	0.0060 - 0.0305	2.94	2.52 - 3.35	0.97
		Haemulopsis corvinaeformis (Steindachner, 1868)	111	2.2	14.8	0.11	46.2	0.0118	0.0106 - 0.0132	3.07	3.02 - 3.13	0.99
Pleuronectiformes	Cynoglossidae	*Symphurus plagusia* (Bloch & Schneider, 1801)	10	2.7	11.1	0.05	11.1	0.0031	0.0013 - 0.0077	3.58	3.15 - 4.01	0.98
Tetraodontiformes	Tetraodontidae	*Sphoeroides testudineus* (Linnaeus, 1758)	51	1.2	9.2	0.07	20.5	0.0338	0.0263 - 0.0433	2.86	2.66 - 3.06	0.94
Order-level *incertae sedis* in Eupercaria	Sciaenidae	*Larimus breviceps* (Cuvier, 1830)	54	1.9	18.4	0.08	87.8	0.0099	0.0084 - 0.0116	3.09	3.01 - 3.17	0.99
		Menticirrhus americanus Linnaeus, 1758	58	2.5	24.2	0.06	157.1	0.0039	0.0026 - 0.0057	3.35	3.15 - 3.55	0.95
		Menticirrhus littoralis (Holbrook, 1847)	139	2.5	27.5	0.12	149	0.0059	0.0049 - 0.0071	3.11	3.03 - 3.18	0.98
		Ophioscion punctatissimus Meek & Hildebrand, 1925	218	1.6	14.3	0.03	38.5	0.0133	0.0117 - 0.0154	2.92	2.85 - 2.99	0.97
		Umbrina coroides Cuvier, 1830	15	3.5	10.5	0.44	8.1	0.0144	0.0080 - 0.0259	2.74	2.40 - 3.07	0.96
Order-level *incertae sedis* in Carangaria	Polynemidae	*Polydactylus virginicus* (Linnaeus, 1758)	266	2.1	18.1	0.08	54.2	0.0053	0.0046 - 0.0060	3.22	3.15 - 3.29	0.97

Rhinosardinia bahiensis (Steindachner, 1879), and *Sparisoma radians* (Valenciennes, 1840), have isometry, with proportional weight and length increase rates (*b* = 3; min-max CI b varying within 3) (Ricker, 1958; Ricker, 1975; Froese, 2006; Carvalho et al., 2022). See Table 1 for the detailed values for all species.

Prior results based on LWR from beaches near estuarine systems of the Piraquê-Açu and Piraquê Mirim Rivers (Southeastern Brazil) showed a positive–allometric relationship (increase in relative body thickness; (Froese, 2006)) for *L. grossidens*, a negative–allometric relationship (decrease in relative body thickness; [Froese, 2006]) for *C. latus, T. carolinus, T. falcatus*, and *T. goodei*, and an isometric allometry for *P. virginicus* (Mazzei et al., 2011). However, in our data *C. latus*, *T. goodei*, *T. carolinus*, and *L. grossidens* have isometric growth, while *T. falcatus* and *P. virginicus* have hypoallometric and hyperallometric growth patterns, respectively. Furthermore, in the estuaries of Northern Brazil, positive allometric growth was described for *L. grossidens* (Joyeux et al., 2009), differing from the results found in the present study. However, the species *M. americanos*, *C. faber*, and *S. plagusia* had positive–allometric growth patterns in the same region (Joyeux et al., 2009), with a similar LWR to the results described for this study.

The differences in species growth might be related to differences in the studied environments, such as variations in temperature, salinity, and food availability (Schaffer, 2005; Santos et al., 2006; Silva et al., 2014). The littoral system of Pernambuco is poor in organic material. At approximately 35 km, its continental shelf is insufficiently long to dissipate and reduce wave forces (Manso et al., 2003; Almeida, 2018), which promotes increased turbulence and a more stressful surf zone when compared with the larger continental shelves in Pará and Espirito Santo. Furthermore, the Amazonas River plume highly influences food availability and salinity in the Pará coastal (Lentz et al., 1995; Pailler et al., 1999; Masson and Delecluse, 2001; Ferry and Reverdin, 2004; MMA, 2006; Joyeux et al., 2009) and can change the growth strategy of these species.

In Southeastern Brazil, the beaches close to Piraquê-Açú and Piraquê Mirim estuary systems in Espirito Santo can undergo influences by the oceanography process of Cabo Frio upwelling (Schmidt et al., 1995; Prato, 2007), which can increase food availability. Furthermore, the region has had few anthropogenic changes, and is considered a natural system (Barroso, 2004; Laut et al., 2020) when compared to Ponta de Pedras, a residential area with ample fishing and leisure activity (Carvalho, 2009). Additionally, in Southern Bahia, the transition between the northern tropical climate and the southern temperate climate has different oceanic processes that drastically alter abiotic and biotic aspects (Amaral, 1999; Joyeux et al., 2009).

Specimens of *H. aurolineatum* collected by the artisanal fisheries in Ceará, Northeastern Brazil have hyperallometric growth patterns, contrary to those analyzed in the present study, which show an isometric growth pattern. Different ontogenetic features may justify the different growth types, since individuals in the surf zone are predominantly juveniles (Mclachlan et al., 1981; Pessanha & Araújo, 2003; Vasconcellos et al., 2007) in early life stages, while those caught by the artisanal fleet are larger individuals, usually adults.

In conclusion, the LWR for the species *L. grossidens*, *T. goodei*, and *U. coroides* described herein represent new information for Northeastern Brazil. For *A. vulpes* and *S. radians*, the LWR is a new parameter in Brazil. The LWR allometric coefficient (*b*) for all species was within the expected range of 2.5–3.5 (Froese, 2006), except for *S. plagusia* (3.58). Considering the significance of these results, we clarify that samples were fixed in alcohol and formaldehyde prior to analysis, which can affect length and weight measurements through shrinking and dehydration.

ACKNOWLEDGMENTS

The authors acknowledge the Federal Rural University of Pernambuco and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for financial and technical support in sample collection and analysis. In addition, we are thankful to the team members (Yuri Marins, Pollyana Roque, Paulo Almeida, Fabricio Gabriel, Josimar Robson, and Alessandra Pires) who were available to participate and perform the beach seine activity during one year of sampling.

AUTHOR CONTRIBUTIONS

S.A.: Investigation; Writing - original draft; Writing - review & editing; Software; Formal Analysis.

V.D.: Investigation; Writing - original draft; Software; Formal Analysis.

N.B.: Writing - review & editing; Conceptualization.

L.S.: Writing - review & editing; Data curation.

I.C.: Methodology; Data curation.

F.H.V.H.: Project Administration; Funding Acquisition.

S.B.: Writing - review & editing.

P.O.: Supervision; Resources; Project Administration; Funding Acquisition; Writing - review & editing.

REFERENCES

ALMEIDA, T. L. M. 2018. *Caracterização da dinâmica costeira de Itamaracá - PE: aplicação do sistema de modelagem costeira do Brasil* [online]. DSc. Recife: UFPE (Universidade Federal de Pernambuco). Available at: https://repositorio.ufpe.br/bitstream/123456789/30453/1/TESE%20Thiago%20Lopes%20de%20Melo%20Almeida.pdf [Accessed: 2022 April 25].

AMARAL, A. C. Z., MORGADO, E. H., LEITE, F. P. P. & GIANUCA, N. M. 1999. *Diagnósticos sobre praias arenosas.* Campinas: UNICAMP (Universidade Estadual de Campinas).

BARROSO, R. G. 2004. *Development of an evaluation framework for sustainable bivalve aquaculture: a strategic plan approach in Espírito Santo, Brazil* [online]. DSc. Canada: University of Victoria.

BETANCUR, R. R., WILEY, E. O., ARRATIA, G., ACERO, A., BAILLY, N., MIYA, M., LECOINTRE, G. & ORTÍ, G. 2017. Phylogenetic classification of bony fishes. BMC Evolutionary Biology, 17(162), 1-40, DOI: https://doi.org/10.1186/s12862-017-0958-3

BRACCINI, J. M. & CHIARAMONTE, G. E. 2002. Intraspecific variation in the external morphology of the sand skate. *Journal of Fish Biology*, 61(4), 959-972. DOI: https://doi.org/10.1111/j.1095-8649.2002.tb01855.x

BRAUN, J. P., CONCORDET, D., GEFFRÉ, A., BOURGES ABELLA, N. & TRUMEL, C. Confidence intervals of reference limits in small reference sample groups. *Veterinary Clinical Pathology*, 42(3), 395-398, DOI: https://doi.org/10.1111/vcp.12065

BROOKS, E. N., POWERS, J. E. & CORTÉS, E. 2010. Analytical reference points for age-structured models: application to data-poor fisheries. *ICES Journal of Marine Science*, 67(1), 165-175, DOI: http://dx.doi.org/10.1093/icesjms/fsp225

CARVALHO, A. G. 2009. *Turismo e produção do espaço no litoral de Pernambuco* [online]. MSc. São Paulo: USP (Universidade de São Paulo).

CARVALHO, B. M., FARIA, L., MIILLER, N. O. R., SPACH, H. L. & VITULE, J. R. S. 2022. Length-weight relationships of native and non-native fishes in a subtropical coastal river of the Atlantic Rain Forest. *Acta Limnologica Brasiliana*, 34, e5), DOI: https://doi.org/10.1590/S2179-975X2821

DIAS, J. F., FERNANDEZ, W. S. & SCHMIDT, T. C. S. 2014 Length-weight relationship of 73 fish species caught in the southeastern inner continental shelf region of Brazil. *Latin American Journal of Aquatic Research*, 42(1), 127-136, DOI: http://dx.doi.org/103856/vol42-issue1--fulltext-10

EDUARDO, L. N., FRÉDOU, T., LIRA, A. S., SILVA, L. V. S, FERREIRA, P. B, BERTRAND, A., MÉNARD, F. & LUCENA-FRÉDOU, F. 2018. Length-weight relationship of thirteen demersal fishes from the tropical Brazilian continental shelf. *Journal of Applied Ichthyology,* 35(2), 590-593, DOI: https://doi.org/10.1111/jai.13831

FAVERO, J. M. & DIAS, J. F. 2013. Spatio-temporal variation in surf zone fish communities at Ilha do Cardoso State Park, São Paulo, Brazil. *Latin American Journal of Aquatic Research*, 41(2), 239-253, DOI: http://dx.doi.org/10.3856/vol41-issue2-fulltext-4

FERRY, N. & REVERDIN, G. 2004. Sea surface salinity interannual variability in the western tropical Atlantic: an ocean general circulation model study. *Journal of Geophysical Research*, 109(C5), C05026. DOI: https://doi.org/10.1029/2003JC002122

FROESE, R. 2006. Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22(4), 241-253, DOI: https://doi.org/10.1111/j.1439-0426.2006.00805.x

GIANNINI, R. & PAIVA FILHO, A. M. 1995. Análise comparativa da ictiofauna da zona de arrebentação de praias arenosas do Estado de São Paulo, Brasil. *Boletim do Instituto Oceanográfico*, 43(2), 141-152, DOI: https://doi.org/10.1590/S0373-55241995000200006

GODEFROID, R. S., SANTOS, C., HOFSTAETTER, M. & SPACH, H. L. 2001. Occurrence of Larvae and Juveniles of *Eucinostomus argenteus*, *Eucinostomus gula*, *Menticirrhus americanus*, *Menticirrhus littoralis*, *Umbrina coroides* and *Micropogonias furnieri* at Pontal do Sul beach, Paraná. *Brazilian Archives of Biology and Technology*, 44(4), 411-418, DOI: https://doi.org/10.1590/S1516-89132001000400012

GONDOLO, G. F., MATTOX, G. M. T. & CUNNINGHAM, P. T. M. 2011. Ecological aspects of the surf-zone ichthyofauna of Itamambuca Beach, Ubatuba, SP. *Biota Neotropica* [online], 11(2), 1-10. Available at https://www.scielo.br/j/bn/a/5g7hFNsVw86RfxcTsWFXQYg/?format=pdf&lang=en [Accessed: 2022 April 25].

HILBORN, E. & WALTERS, C. J. 2001. *Quantitative fisheries stock assessment: choice, dynamics and uncertainty*. New York: Routledge, Chapman & Hall, Inc., DOI: https://doi.org/10.1007/978-1-4615-3598-0

JOYEUX, J. C., GIARRIZZO, T., MACIEIRA, R. M., SPACH, H. L. & VASKE JUNIOR, T. 2009. Length-weight relationships for Brazilian estuarine fishes along a latitudinal gradient. *Journal of Applied Ichthyology*, 25(3), 350-355, DOI: https://doi.org/10.1111/j.1439-0426.2008.01062.x

KARACHLE, P. K. & STERGIOU, K. I. 2012. Morphometrics and allometry in fishes. *In:* WAHL, C. (ed.). *Morphometrics*. London: IntechOpen, pp. 65-86, DOI: https://doi.org/10.5772/2138

KULBICKI, M., GUILLEMOT, N. & AMAND, M. 2005. A general approach to length-weight relationships for New Caledonian lagoon fishes. *Cybium*, 29(3), 235-252.

LAUT, L., CLEMENTE, I., PEIREIRA, E., NASCIMENTO, K. A., VASCONCELOS, S. C., BELART, P. & BASTOS, A. C. 2020. Registro das Oscilações Climáticas do Holoceno Tardio no Estuário do Rio Piraquê-Açu (ES - Brasil). *Anuário do Instituto de Geociências*, 43(2), 298-315, DOI: http://doi.org/10.11137/2020_2_298_315

LE CREN, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*, 20(2), 201-219, DOI: http://dx.doi.org/10.2307/1540

LENTZ, S. J. 1995. Seasonal variations in the horizontal structure of the Amazon Plume inferred from historical hydrographic data. *Journal of Geophysical Research*, 100(C2), 2391-2400, DOI: http://dx.doi.org/10.1029/94jc01847

LIMA, A. R. A., BARLETTA, M., COSTA, M. F., RAMOS, J. A. A., DANTAS, D. V., MELO, P. A. M. C., JUSTINO, A. K. S. & FERREIRA, G. V. B. 2016. Changes in the composition of ichthyoplankton assemblage and plastic debris in mangrove creeks relative to moon phases. *Journal of Applied Ichthyology,* 89(1), 619-640, DOI: https://doi.org/10.1111/jfb.12838

MANSO, V. A. V., CORRÊA, I. C. S. & GUERRA, N. C. 2003. Morfologia e sedimentologia da plataforma continental interna entre as praias de Porto de Galinhas e Campos – Litoral Sul de Pernambuco, Brasil. *Pesquisas em Geociências* [online], 30(2), 17-25. Available at: http://hdl.handle.net/10183/22603 [Accessed: 2022 April 22].

MASSON, S. & DELECLUSE P. 2001. Influence of the Amazon River runoff on the tropical Atlantic. *Physics and Chemistry of the Earth Part B: Hydrology Oceans and Atmosphere*, 26(2), 137-142, DOI: http://dx.doi.org/10.1016/S1464-1909(00)00230-6

MAZZEI, E., JOYEUX J. C. & SIMON, T. 2011. Length--weight relationships for juvenile and small-sized adult fishes of the surf zone. *Journal of Applied Ichthyology,* 27(4), 1137-1138, DOI: https://doi.org/10.1111/j.1439-0426.2011.01772.x

MCLACHLAN, A., COCKCROFT, A. C. & MALAN, D. E. 1984. Benthic faunal response to high-energy gradient. *Marine Ecology Progress Series,* 16, 51-63, DOI: http://dx.doi.org/10.3354/meps016051

MCLACHLAN, A., ERASMUS, T., VAN DER HORST, G., ROSSOUW G., LASIAK, T. A. & MCGMYNNE, L. 1981. Sand beach energetics: an ecosystem approach towards a high energy interface. *Estuarine, Coastal and Shelf Science*, 13(1), 11-25, DOI: https://doi.org/10.1016/S0302-3524(81)80102-8

MMA (Ministério do Meio Ambiente). 2006. *Programa REVIZEE. Avaliação do Potencial Sustentável de Recursos Vivos na Zona Econômica Exclusiva – Relatório Executivo*. Brasília (DF): Ministério do Meio Ambiente.

MAGNUSSON, A., PUNT, A. E. & HILBORN, R. 2013. Measuring uncertainty in fisheries stock assessment: the delta method, bootstrap, and MCMC. *Fish and Fisheries*, 14(3), 325-42, DOI: https://doi.org/10.1111/j.1467-2979.2012.00473.x

NOMURA, H. 1965. Length-weight tables of some fish species from Northeastern Brazil. *Arquivos de Ciências do Mar,* 5(2), 103-105, DOI: http://dx.doi.org/10.3750/AIP2016.46.3.12

OGLE, D. H., WHEELER, P. & DINNO, A. 2020. *FSA: fisheries stock analysis. R package version 0.8.30*. Boca Raton: Champman & Hall/CRC.

PAILLER, K., BOURLÈS, B. & GOURIOU, Y. 1999. The barrier layer in the Western Tropical Atlantic Ocean. Geophysical Research Letters, 26(14), 2069-2072, DOI: https://doi.org/10.1029/1999GL900492

PANASE, P. & MENGUMPHAN, K. 2015. Growth performance, length-weight relationship and condition factor of backcross and reciprocal hybrid catfish reared in net cages. *International Journal of Zoological Research*, 11(2), 57-64, DOI: https://dx.doi.org/10.3923/ijzr.2015.57.64

PESSANHA, A. L. M. & ARAÚJO, F. G. 2003. Spatial, temporal and diel variations of fish assemblages at two sandy beaches in the Sepetiba Bay, RJ. *Estuarine, Coastal and Shelf Science*, 57(5-6), 817-828, DOI: https://doi.org/10.1016/S0272-7714(02)00411-0

PESSOA, W. V. N., RAMOS, J. A. A. & OLIVEIRA, P. G. V. 2019. Composition, density and biomass of fish community from the surf zone as a function of the lunar cycle at Miramar Beach in Cabedelo, Paraíba. *Neotropical Ichthyology,* 17(2), e170042, DOI: http://dx.doi.org/10.1590/1982-0224-20170042

PRATA, P. M. 2007. *Caracterização do ambiente marinho do estado do Espirito Santo utilizando dados do Banco Nacional de Dados Oceanográficos*. MSc. Vitória: UFES (Universidade Federal do Espírito Santo).

RAEISI, H., PAIGHAMBARI, S. Y., BIBAK, M., HOSEINI, S. A. & SHABNI, M. J. 2012. Length-weights relationships and relative weights of some demersal fish species from the Persian Gulf, Iran. African Journal of Agricultural Research, 7(5), 741-746, DOI: https://www.doi.org/10.5897/AJAR11.1315

RICKER, W. E. 1954. Handbook of computations for biological statistics of fish populations. *Bulletin of the Fisheries Research Board of Canada* [online]. Available at: https://waves-vagues.dfo-mpo.gc.ca/Library/10161.pdf [Accessed: 2022 Apr 28]

RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Bulletin of the Fisheries Research Board of Canada* [online]. Available at: https://waves-vagues.dfo-mpo.gc.ca/Library/1485.pdf [Accessed: 2022 Apr 28]

R CORE TEAM. 2022. *R: A language and environment for statistical computing* [online]. Vienna: R Foundation for Statistical Computing. Available at: https://www.R-project.org/ [Accessed: 2022 July 14].

SALLES, R. & FEITOSA, R. D. 2000. Relação peso/comprimento das principais espécies de peixes marinhos capturados no estado do Ceará, Brasil. *Arquivos de Ciências do Mar,* 33(1-2), 93-98, DOI: https://doi.org/10.32360/acmar.v33i1-2.11815

SANTANA, F. M. S., SEVERI, W., FEITOSA, C. V. & ARAÚJO, M. E. 2013. The influence of seasonality on fish life stages and residence in surf zones: a case of study in a tropical region. *Biota Neotropica*, 13(3), 181-190, DOI: https://doi.org/10.1590/S1676-06032013000300021

SANTOS, A. A., COCENTINO, A. M. M. & REIS, T. N. V. 2006. Macroalgas como indicadoras da qualidade ambiental da praia de Boa Viagem – Pernambuco, Brasil. *Boletim Técnico-Científico do Cepene*, 14(2), 25-33.

SCHAEFFER, J. K. 2005. *Variações da comunidade fitoplanctônica na região estuarina dos rios Piraquê-Açú e Piraquê-Mirim* (*Aracruz, ES*) *e suas relações com os fatores ambientais* [online]. MSc. Vitória: UFES (Universidade Federal do Espírito Santo). Available at: https://repositorio.ufes.br/handle/10/4376

SHAH, Y. E., CORTE, G. N., CHECON, H. H., BILATTO, C. G., LEFCHECK, J. S., AMARAL, A. C. A. & TURRA, A. 2021. Revealing the drivers of taxonomic and functional diversity of nearshore fish assemblages: implications for conservation priorities. *Diversity and Distributions*, 28(8), 1597-1609, DOI: https://doi.org/10.1111/ddi.13453

SCHMIDT, C., SCHAFER, H. & PODESTA, G. 1995. The Vitória Eddy and its Relation to the Brazil Current. *Journal of Physical Oceanography*, 25(11), 2532-2546, DOI: https://doi.org/10.1175/1520-0485(1995)025<2532:TVEAIR>2.0.CO;2

SCHNEIDER, J. C., LAARMAN, P. W. & GOWING, H. 2000. Length-weight relationships. *In:* SCHNEIDER, J. C. (ed.). *Manual of Fisheries Survey Methods II: With Periodic Updates, Michigan Department of Natural Resources*. Ann Arbor: Fisheries Special Report 25, pp. 1-18.

SILVA, J. C., GUBIANI, E. A. & DELARIVA, R. L. 2014. Use of food resources by small fish species in Neotropical rivers: responses to spatial and temporal variations. *Zoologia*, 31(5), 435-444, DOI: http://dx.doi.org/10.1590/S1984-46702014000500004

STERGIOU, K. I. & MOUTOPOULOS, D. K. 2001. A review of length-weight relationships of fishes from Greek marine waters. *Naga, The ICLARM Quarterly* [online], 24(1-2), 23-39. Available at https://digitalarchive.worldfishcenter.org/bitstream/handle/20.500.12348/2337/1666.pdf?sequence1= [Accessed: 2022 April 22].

VASCONCELOS, P., PEREIRA, F., CARVALHO, A. N. & GASPAR, M. B. 2018. Weight-length relationships and relative growth of the cuttlefish (*Sepia officinalis*): causes and cffects of hypoallometry. *Thalassas: An International Journal of Marine Sciences*, 34, 323-331, DOI: https://doi.org/10.1007/s41208-018-0067-0

VASCONCELLOS, R. M., ARAÚJO, F. G., SANTOS, J. N. S. & SILVA, M. A. 2010. Diel seasonality in fish biodiversity in a sandy beach in south-eastern Brazil. *Journal of the Marine Biological Association of the United Kingdom*, 91(6), 1337-1344, DOI: http://dx.doi.org/10.1017/S0025315410000652

VASCONCELLOS, R. M., SANTOS, J. N., SILVA, M. A. & ARAÚJO, F. G. 2007. Efeito do grau de exposição às ondas sobre a comunidade de peixes juvenis em praias arenosas do Município do Rio de Janeiro, Brasil. *Biota Neotropica,* 7(1), 93-100, DOI: https://doi.org/10.1590/S1676-06032007000100013

VIANA, A. P., LUCENA-FRÉDOU, F., MÉNARD, F., FRÉDOU, T., FERREIRA, V. & LIRA, A. S. F. 2016. Length-weight relations of 70 fish species (Actinopterygii) from tropical coastal region of Pernambuco, Northeast Brazil. *Acta Ichthyologica Et Piscatoria,* 46(3), 271-277, DOI: http://dx.doi.org/10.3750/AIP2016.46.3.12

VIANNA, M., COSTA, F. E. D. S. & FERREIRA, C. N. 2004. Length-weight relationship of fish caught as by-catch by shrimp fishery in the south- eastern coast of Brazil. *Boletim do Instituto de Pesca* [online], 30(1), 81-85. Available at https://www.pesca.sp.gov.br/boletim/index.php/bip/article/view/Vianna30_1 [Accessed: 2022 April 25].