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Original Article

Biometric relationships and sex ratio for red-spotted shrimp *Farfantepenaeus brasiliensis* (Latreille, 1817) (Decapoda, Penaeidae) from the coast of Sergipe, northeastern Brazil

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Abstract

The goal of this study was to estimate the biometric relationships and sex ratio for the red-spotted shrimp *Farfantepenaeus brasiliensis* (Latreille, 1817) from the coast of Sergipe, northeastern Brazil. A total of 132 specimens of *F. brasiliensis* were collected and analyzed (65 females and 67 males) from May 2015 to May 2016. The overall sex ratio did not differ significantly from 1:1. Female size ranged from 20.73–46.43 mm of carapace length (CL), whereas male size ranged from 20.75–32.47 mm CL. Females were larger (34.78±6.05 mm CL, 152.61±19.68 mm of total length (TL)) and heavier (27.45±11.12 g of wet weight (WW)) than males (27.07±2.56 mm CL,

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123.77±11.37 mm TL and 14.48±3.98 g WW). All biometric relationships were different between females and males. Both TL *vs* CL and WW *vs* TL relationships indicated positive allometric growth. Data shown here correspond to an adult population exploited by local shrimp fleets and are an important contribution to the biological knowledge of this species, especially in northeastern Brazil, where there is no information available.

Keywords
Adult, allometry, length, pink shrimp, weight

Introduction

Marine shrimps of the genus *Farfantepenaeus* Burukovsky, 1997 are one of the most exploited fishing resources along the Brazilian coast due to their high market value (Dias-Neto, 2011; Boos *et al.*, 2016). Despite this commercial importance, all species belonging to this genus are commonly known as "camarões-rosa" (= pink shrimps) along the Brazilian coast (Paiva *et al.*, 2001; Dias-Neto, 2011). However, the exploitation rate of each species is variable along the coast due to their different latitudinal distributions. For example, *Farfantepenaeus subtilis* (Pérez-Farfante, 1967) can be found from the Caribbean Sea (20°N) to Cabo Frio (Rio de Janeiro, southeastern Brazil, 23°S), whereas *Farfantepenaeus paulensis* (Pérez-Farfante, 1967) occurs from Ilhéus (Bahia, northeastern Brazil, 14°S) to Mar del Plata (Argentina, 38°S) (Pérez-Farfante, 1988; Costa *et al.*, 2003). On the other hand, *Farfantepenaeus brasiliensis* (Latreille, 1817) shows a wider distribution than the two previously mentioned species, occurring from North Carolina (USA, 35°N) to Rio Grande do Sul (southern Brazil, 33°S) (Pérez-Farfante, 1988; Costa *et al.*, 2003).

The total catch of *Farfantepenaeus* spp. in Brazil was about 10.3 thousand tonnes in 2011, the last year for which catch statistics were available at a national level (Brasil, 2011). This amount was surpassed only by the Atlantic seabob shrimp, *Xiphopenaeus kroyeri* (Heller, 1862), with total catches of 15.4 thousand tonnes (Brasil, 2011). The total catch of *Farfantepenaeus* spp. on the coast of Sergipe (11°S) was about 176.6 tonnes in 2014 (Araújo *et al.*, 2016). However, it should be noted that in both national and local reports, there was no discrimination of catch by species, making it difficult to assess the exploitation status of each stock (Dias-Neto, 2011; Valentini *et al.*, 2012; Freire *et al.*, 2015).

Farfantepenaeus brasiliensis can be found from shallow water to 366 m of depth, inhabiting detritus-rich muddy to gravel-sandy bottoms, and reach a size at first maturity at about 150 mm of total length (Boos *et al.*, 2016). This species has a type II life cycle, in which reproduction and egg release take place offshore and the post-larvae migrate to estuarine areas where they grow up to juvenile/subadult stages and then move back offshore to complete their life cycles (Dall *et al.*, 1990). Therefore, *F. brasiliensis* fishery may target two population groups: juveniles/subadults in estuaries and inshore habitats and/or adults offshore (D'Incao *et al.*, 2002).

Several population studies have estimated biometric relationships for penaeids and these relationships have been highlighted as an important tool for assessing the status of shrimp stocks, as very often different morphological traits may reflect environmental influences or overfishing impacts (Leite-Jr and Petrere-Jr, 2006; Dumond and D'Incao, 2010; Segura and Delgado, 2012; Silva *et al.*, 2015, 2018; Reis-Jr *et al.*, 2019). Biometric relationships for *F. brasiliensis* have already been estimated for southern and southeastern Brazil (Mello, 1973; Villela *et al.*, 1997; Branco and Verani, 1998; Albertoni *et al.*, 2003; Leite-Jr and Petrere-Jr, 2006; Carvalho *et al.*, 2019) as well as for the Gulf of Mexico (Arreguín-Sánchez, 1981; Pérez-Castañeda and Defeo, 2002; May-Kú *et al.*, 2006). Nevertheless, there is no information about this species for northeastern Brazil. Here, *F. brasiliensis* from the coast of the Sergipe was studied to understand the biometric relationships and sex ratio of this species. Additionally, data from the present study were compared with those obtained from other populations to assess the variation of the traits studied along its distribution range.

Material and Methods

Samples of 3 kg each were collected monthly from each category separated manually by fishermen onboard, based on shrimp size ('espigão' – small size, 'escolha' – medium size, and 'pistola' – large size), before landing in the Port of Aracaju, state of Sergipe, from May 2015 to May 2016. No sample was collected during the closed seasons, which correspond to April 1st to May 15th and December 1st to January 15th (Brasil, 2004a). Artisanal shrimp trawlers along the coast of Sergipe are 8–13 m long and operate with double nets with a mesh size of 21 mm in the cod end (Fig. 1). It was not possible to collect information on local depth for each sample collected, as they were obtained from fishing boats at the port, right before landing. Each sample was taken to the Laboratório de Ecologia Pesqueira (LEP) of the Departamento de Engenharia de Pesca e Aquicultura (Depaq) at the Universidade Federal de Sergipe (UFS) and kept frozen until processing. Within each category, each specimen was identified according to Costa *et al.* (2003) and Teodoro *et al.* (2016), and all *F. brasiliensis* present in all samples were separated.

Each specimen of *F. brasiliensis* had its total length (distance from the tip of the rostrum to the tip of the telson, TL, mm), rostrum length (distance from the tip of the rostrum to the postorbital margin, RL, mm), and carapace length (distance from the postorbital margin to the mid-dorsal posterior edge of the carapace, CL, mm) measured with a digital caliper (precision: 0.01 mm) and was weighed (wet weight; WW, g) with a scale (precision of 0.0001 g). All individuals were sexed by checking the thelycum in females and the petasma in males. The maturation stage of the gonads was classified according to Peixoto *et al.* (2003). Females were defined as immature (I), developing (II), mature (III) and spent (IV), and males as immature (non-linked petasma) and mature (linked petasma).

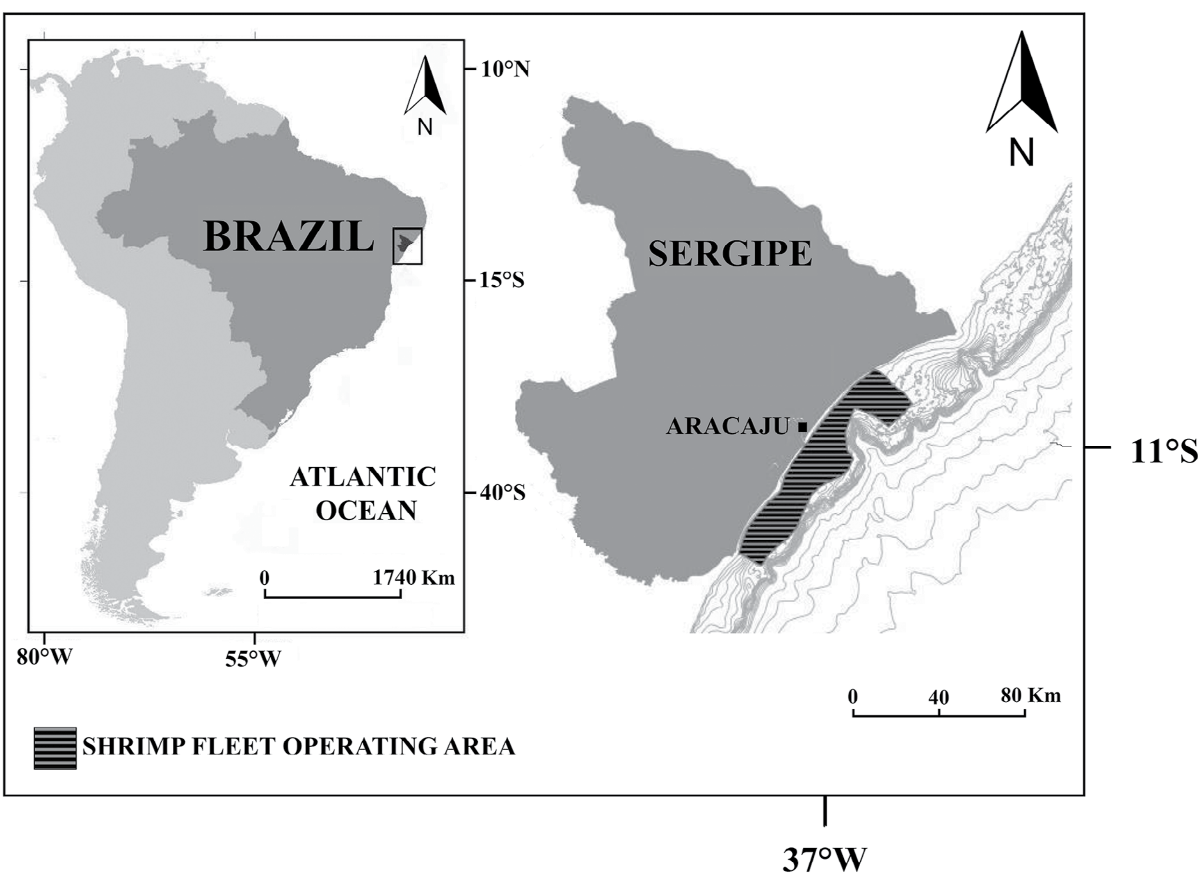

Figure 1. Map showing the approximate location of the Port of Aracaju and the shrimp fishing ground on the coast of Sergipe.

A chi-square test (χ^2) with the Yates correction (Zar, 2010) was applied to test if the sex ratio differed statistically from 1:1. The mean length and wet weight of females and males were compared using t-tests with different variances (Zar, 2010). The relationships TL *vs* CL, TL *vs* RL and RL *vs* CL were fitted using linear equations (Y=a+bX), while a power equation was fitted to both WW *vs* TL and WW *vs* CL relationships ($Y=a \cdot X^b$; Froese, 2006). All relationships were estimated for females and males, separately, and then compared using an analysis of covariance (Zar, 2010). The hypothesis of isometry was tested for the length-length relationships (b=1) and weight-length relationships (b=3) using t-tests (Froese, 2006; Zar, 2010). All statistical tests were performed with a significance level of 5%.

Results

In all samples collected from May 2015 to May 2016, there were only 132 specimens of *F. brasiliensis* and all of them were analyzed here (65 females and 67 males). The overall sex ratio did not differ significantly from the expected 1:1 (χ^2=0.007, p=0.93).

Regarding the maturation stage, all males were mature while most female individuals (48%) were in development. Mature and spent females were respectively 35% and 15% and only one individual (21.09 mm CL) was immature.

Female size ranged from 20.73 to 46.43 mm CL, whereas male size ranged from 20.75 to 32.47 mm CL (Fig. 2). Females were larger and heavier (34.78±6.05 mm CL, 152.61±19.68 mm TL, and 27.45±11.12 g WW) than males (27.07±2.56 mm CL, 123.77±11.37 mm TL, and 14.48±3.98 g WW) (Tab. 1). The TL/CL ratio was significantly lower for females than males (Tab. 1).

All morphometric relationships were significantly different between females and males (Tab. 2). Both TL *vs* CL and TL *vs* RL indicated a pattern of positive allometry, while the RL *vs* CL relationship indicated negative allometry (Tab. 2). On the other hand, WW *vs* TL relationship indicated a positive allometry pattern and WW *vs* CL relationship showed negative allometry (Tab. 2).

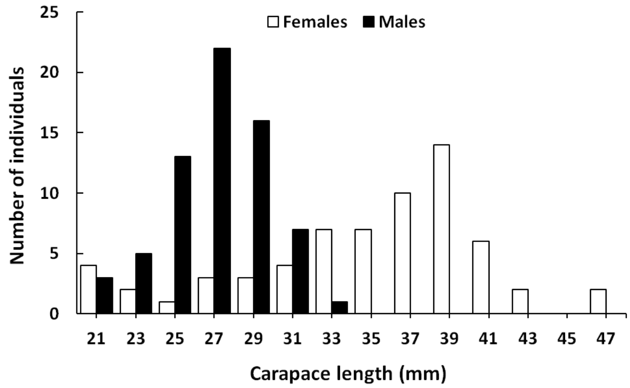

Figure 2. Number of *Farfantepenaeus brasiliensis* (Latreille, 1817) per carapace length class (CL) caught on the coast of Sergipe, northeastern Brazil, from May 2015 to May 2016.

Table 1. Length and weight data for females (F) and males (M) of *Farfantepenaeus brasiliensis* (Latreille, 1817) caught on the coast of Sergipe, northeastern Brazil. TL = total length, RL = rostrum length, CL = carapace length, WW = wet weight, n = sample size, SD = standard deviation, *t* = Student t-value comparing mean values between females and males, *p* = probability associated with t-values.

Variable	Sex	n	Mean ± SD	Range	*t*	*p*
TL (mm)	F	41	152.61±19.68	100.01–189.18	8.12	<0.01
	M	41	123.77±11.37	98.91–145.90		
RL (mm)	F	40	19.95±2.43	13.42–24.50	6.08	<0.01
	M	40	17.27±1.38	14.00–19.70		
CL (mm)	F	65	34.78±6.05	20.73–46.43	9.47	<0.01
	M	67	27.07±2.56	20.75–32.47		
TL/CL ratio	F	41	4.30±0.16	3.90–4.72	10.52	<0.01
	M	41	4.63±0.12	4.45–5.04		
WW (g)	F	65	27.45±11.12	5.73–57.27	8.86	<0.01
	M	67	14.48±3.98	6.31–25.66		

Table 2. Intercept (a) and slope (b) for length-length and weight-length relationships for females (F), and males (M) of *Farfantepenaeus brasiliensis* (Latreille, 1817) caught on the coast of Sergipe, northeastern Brazil. TL = total length, CL = carapace length, RL = rostrum length, WW = wet weight, n = sample size, CI = confidence interval, r^2 = coefficient of determination, p (b) = values of p for the analysis of covariance used to compare values of b from relationships estimated for females and males.

Relationship	Sex	n	a (CI)	b (CI)	r^2	Allometry	p (b)
TL=a+b·CL	F	41	29.167 (23.258–35.076)	3.459 (3.296–3.623)	0.979	+	<0.001
	M	41	16.161 (8.129–24.193)	4.029 (3.724–4.322)	0.950	+	
TL=a+b·RL	F	41	15.915 (5.228–26.601)	2.468 (2.277–2.659)	0.946	+	<0.001
	M	41	25.202 (12.289–38.115)	2.255 (1.961–2.548)	0.861	+	
RL=a+b·CL	F	41	4.489 (3.071–5.909)	0.436 (0.397–0.476)	0.928	-	<0.001
	M	41	5.561 (3.245–7.877)	0.436 (0.351–0.522)	0.735	-	
WW=a·TL^b	F	41	3.96×10^{-6} (1.90×10^{-6}–8.24×10^{-6})	3.134 (2.988–3.279)	0.979	=	0.040
	M	41	1.66×10^{-6} (0.47×10^{-6}–6.46×10^{-6})	3.303 (3.021–3.585)	0.935	+	
WW=a·CL^b	F	65	0.002 (0.001–0.003)	2.652 (2.546–2.757)	0.975	-	<0.001
	M	67	0.001 (0.001–0.002)	2.892 (2.726–3.057)	0.949	=	

Discussion

All individuals of *F. brasiliensis* smaller than 25 mm CL are considered juveniles in southeastern Brazil (Costa and Fransozo, 1999; Costa *et al.*, 2008). In this study, 28 specimens (22% of total) caught were lower than 25 mm CL, however only one female individual was immature. In this way, our data corresponds to an adult population, which is exploited by the shrimp fleet along the coast of Sergipe.

The largest specimens observed on the coast of Sergipe (11°S) (189.18 and 145.90 mm TL for females and males, respectively) were smaller than those recorded in southeastern Brazil (23°S). Mello (1973) recorded maximum sizes of 210 and 180 mm TL for females and males, respectively, while Leite-Jr and Petrere-Jr (2006) found values of 260 and 219 mm TL (both studies in coastal waters off the state of São Paulo). Larger values (266 and 219 mm TL for females and males, respectively) were also recorded off Mexico (21°N) (Arreguín-Sánchez, 1981). All three studies also analyzed data from shrimp fisheries landings. These variations in body size can be influenced by habitat conditions (*e.g.*, water temperature and food/nutrient supply) correlated with latitude (Castilho *et al.*, 2007), where an increase in body size is commonly observed with increasing latitude (Blackburn *et al.*, 1999), in this case in both hemispheres.

The sex ratio of 1:1 observed here is very common in penaeids (Dall *et al.*, 1990), especially for populations occupying relatively constant environments (Geisel, 1972). Likewise, sexual dimorphism is a very common trait in penaeids, with females being larger than males, which has also been observed for *F. brasiliensis* in our study, and also by Mello (1973), Arreguín-Sánchez (1981), Rabelo-Neto (1985), Leite-Jr and Petrere-Jr (2006), Freitas-Jr *et al.* (2011), and Souza *et al.* (2019). This dimorphism reflects a reproductive strategy, as larger size for females allows for larger gonads and higher fertility and, thus, maximizes egg production (Gab-Alla *et al.*, 1990). As most organs of shrimps, including the reproductive ones, are located in the carapace, differences between sexes in the TL/CL ratio are expected, with females having a proportionally larger carapace than males as an adaptation to maximize egg production. Indeed, these differences in the TL/CL ratio are not observed when analyzing juveniles (Carvalho *et al.*, 2019).

Morphometric relationships vary according to the length/age, with younger, smaller individuals having higher slopes than older, larger individuals requiring different equations for conversions (Arreguín-Sánchez, 1981; Primavera *et al.*, 1998; Reis-Jr *et al.*, 2019). Most of the morphometric data available for *F. brasiliensis* are from juveniles/subadults inhabiting coastal habitats such as estuaries and coastal lagoons (Villela *et al.*, 1997; Branco and Verani, 1998; Pérez-Castañeda and Defeo, 2002; Albertoni *et al.*, 2003; May-Kú *et al.*, 2006; Freitas-Jr *et al.*, 2011; Carvalho *et al.*, 2019), which differ from the equations for adults such as the ones obtained here in the coast of Sergipe.

All length-length relationships estimated here, except for RL *vs* CL, showed positive allometry corroborating previous records for this shrimp species in southeastern-southern Brazil (Rabelo-Neto, 1985; Leite-Jr and Petrere-Jr, 2006). The same pattern has also been reported for other penaeids (Leite-Jr and Petrere-Jr, 2006; May-Kú and Ardisson, 2012; Segura and Delgado, 2012; Reis-Jr *et al.*, 2019) suggesting that positive allometry for TL *vs* CL relationship is a common trait for these shrimps. Regarding the RL *vs* CL relationship, May-Kú *et al.* (2006) also reported a negative allometry for juveniles of *F. brasiliensis* off Mexico. However, studies carried out with *X. kroyeri* indicated differences in the RL *vs* CL relationship between juveniles and adults, with faster increase (positive allometry) being observed in juveniles (Moraes *et al.*, 2018). Faster increase of the rostrum length during the juvenile stage could be a strategy of this species to avoid predation, as observed in *X. kroyeri* (Moraes *et al.*, 2018)

The weight-length relationships showed contrasting patterns. When the WW *vs* TL relationship was estimated, the allometry was positive for both sexes indicating a higher increase in weight than expected by the increase in total length. Mello (1973) recorded a positive allometry for adult males and negative for adult females caught along the southeastern Brazilian coast. Later, an inverse pattern was recorded for the same region (Rabelo-Neto, 1985; Leite-Jr and Petrere-Jr, 2006). According to Leite-Jr and Petrere-Jr (2006), the positive allometric growth presented by females is associated with the gain in weight due to gonad development. For the Mexican coast, this relationship was negative for both sexes (Arreguín-Sánchez, 1981). When the WW *vs* CL relationship was estimated, the allometry was negative.

It is expected that species with wide distribution ranges and complex life cycles (estuary-open sea migrations), such as *F. brasiliensis,* experience different environmental conditions that will be reflected in different biological traits such as body size and allometric growth. Differences may also result from differential fishing effort (Couto *et al.*, 2013). However, it is very difficult to assess the exploitation status of the stock off Sergipe due to data scarcity.

Farfantepenaeus brasiliensis is overexploited or threatened with overexploitation along the Brazilian coast and a sustainable management plan should be implemented (Brasil, 2004b). One of the tools suggested was the establishment of closed seasons, which could vary among regions. The closed season defined for Sergipe according to Executive Order N. 14, which was published on October 14th/2004 (Brasil, 2004a) by the Brazilian Ministry of Environment, is from April 1st to May 15th and from December 1st to January 15th, but this measurement is for all shrimps caught in the region. More recently, *F. brasiliensis* was classified under the category "insufficient data" in a recent evaluation process conducted by the Chico Mendes Institute for Biodiversity Conservation (ICMBio) (Boos *et al.*, 2016). Thus, our results contribute to better knowledge on some biological traits of the red-spotted shrimp *F. brasiliensis*, especially for northeastern Brazil where there was no previous data.

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References

Albertoni, E.F.; Palma-Silva, C. and Esteves, F.A. 2003. Crescimento e fator de condição na fase juvenil de *Farfantepenaeus brasiliensis* (Latreille) e *F. paulensis* (Pérez-Farfante) (Crustacea, Decapoda, Penaeidae) em uma lagoa costeira tropical do Rio de Janeiro, Brasil. *Revista Brasileira de Zoologia*, 20: 409–418.

Araújo, A.R.R.; Barbosa, J.M.; Santos, J.P.; Carvalho, B.L.F.; Garciov-Filho, E.B.; Deda, M.S.; Silva, C.O. and Chammas, M.A. 2016. Boletim estatístico da pesca nos litorais de Sergipe e extremo norte da Bahia - 2014. São Cristóvão, Universidade Federal de Sergipe (UFS), 84p.

Arreguín-Sánchez, F. 1981. Tasa de crecimiento del camaron rojo (*Penaeus brasiliensis* Latreille, 1817) de las costas de Quintana Roo, Mexico. *Ciencia Pesquera*, 1: 61–70.

Blackburn, T.M.; Gaston, K.J. and Loder, N. 1999. Geographic gradients in body size: a clarification of Bergmann's rule. *Diversity and Distributions*, 5: 165–174.

Boos, H.; Costa, T.C.; Santos, R.A.; Dias-Neto, J.; Rodrigues, E.S.; Rodrigues, L.F.; D'Incao, F.; Ivo, C.T.C. and Coelho, P.A. 2016. Avaliação dos camarões peneídeos (Decapoda: Penaeidae). p. 300–317. In: M. Pinheiro and H. Boss (eds), Livro vermelho dos crustáceos do Brasil – Avaliação 2010-2014. Porto Alegre, Sociedade Brasileira de Carcinologia.

Branco, J.O. and Verani, J.R. 1998. Aspectos bioecológicos do camarão-rosa *Penaeus brasiliensis* Latreille (Natantia, Penaeidae) na Lagoa da Conceição, Florianópolis, Santa Catarina, Brasil. *Revista Brasileira de Zoologia*, 15: 345–351.

Brasil, Ministério do Meio Ambiente. 2004a. Proibição anualmente do exercício da pesca de camarão rosa, camarão sete-barbas e camarão branco, com quaisquer artes de pesca, na área compreendida entre a divisa dos Estados de Pernambuco e Alagoas e a divisa dos Municípios de Mata de São João e Camaçari no Estado da Bahia, nos períodos de 1º de abril a 15 de maio e 1º de dezembro a 15 de janeiro. Instrução Normativa nº 14, de 14 de outubro de 2004.

Brasil, Ministério do Meio Ambiente 2004b. Reconhece como espécies ameaçadas de extinção e espécies sobreexplotadas ou ameaçadas de sobreexplotação, os invertebrados aquáticos e peixes, constantes dos Anexos a esta Instrução Normativa. Instrução Normativa nº 5, de 21 de maio de 2004.

Brasil. 2011. Boletim Estatístico da Pesca e Aquicultura - 2011. Brasília, Ministério da Pesca e Aquicultura. Available at: <http://www.icmbio.gov.br/cepsul/images/stories/biblioteca/download/estatistica/est_2011_bol_bra.pdf> Accessed on 03 September 2018.

Carvalho, C.; Keunecke, K.A. and Lavrado, H.P. 2019. Morphometric variation in pink shrimp populations at Rio de Janeiro coast (SE Brazil): are they really similar in closer areas? *Anais da Academia Brasileira de Ciências*, 91: e20180252.

Castilho, A.L.; Costa, R.C.; Fransozo, A. and Boshi, E.E. 2007. Reproductive pattern of South American endemic shrimp *Artemesia longinaris* (Decapoda: Penaeoidea), off São Paulo state, Brasil. *Revista de Biología Tropical*, 55: 39–48.

Costa, R.C. and Fransozo, A. 1999. A nursery ground for two tropical pink-shrimp *Penaeus* species: Ubatuba Bay, northern coast of São Paulo, Brazil. *Nauplius*, 7: 73–81.

Costa, R.C.; Fransozo, A.; Melo, G.A.S. and Freire, F.A.M. 2003. Chave ilustrada para identificação dos camarões Dendrobranchiata do litoral norte do estado de São Paulo, Brasil. *Biota Neotropica*, 3: 1–12.

Costa, R.C.; Lopes, M.; Castilho, A.L.; Fransozo, A. and Simões, S.M. 2008. Abundance and distribution of juvenile pink shrimps *Farfantepenaeus* spp. in a mangrove estuary and adjacent bay on the northern shore of São Paulo State, southeastern Brazil. *Invertebrate Reproduction and Development*, 52: 51–58.

Couto, E.C.G; Guimarães, F.J.; Oliveira, C.A.M.; Vasques, R.O. and Lopes, J.B.B.S. 2013. O camarão sete-barbas na Bahia: aspectos de sua pesca e biologia. *Boletim do Instituto de Pesca*, 39: 263–282.

Dall, W.; Hill, B.J.; Rothlisberg, P.C. and Staples, D.J. 1990. The biology of the Penaeidae. p. 1–487. In: J.H.S. Blaxter and A.J. Southward (eds). Advances in Marine Biology. San Diego, Academic Press.

Dias-Neto, J. 2011. Proposta de Plano Nacional de Gestão para o Uso Sustentável de Camarões Marinhos do Brasil. Brasília, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA). 242p.

D'Incao, F.; Valentini, H. and Rodrigues, L. F. 2002. Avaliação da pesca de camarões nas regiões sudeste e sul do Brasil (1965-1999). *Atlântica*, 24: 103–116.

Dumont, L.F.C. and D'Incao, F. 2010. Biometric relationships of the Argentinean prawn *Artemesia longinaris* (Decapoda: Penaeidae) in the South-western Atlantic. *Journal of the Marine Biological Association of the United Kingdom*, 90: 1385–1393.

Freire, K.M.F.; Aragão, J.A.N.; Araújo, A.R.R.; Ávila-da-Silva, A.O.; Bispo, M.C.S.; Velasco, G.; Carneiro, M.H.; Gonçalves, F.D.S.; Keunecke, K.A.; Mendonça, J.T.; Moro, P.S.; Motta, F.S.; Olavo, G.; Pezzuto, P.R.; Santana, R.F.; Santos, R.A.; Trindade-Santos, I.; Vasconcelos, J.A.; Vianna, M. and Divovich, E. 2015. Reconstruction of catch statistics for Brazilian marine waters (1950-2010). *Fisheries Centre Research Reports*, 23: 3–29.

Freitas-Jr, F.; Fracasso, H.A.A.; Branco, J.O. and Christoffersen, M.L. 2011. Ten-year variations in population structure of pink-shrimp in a southwestern Atlantic Bay affected by highway construction. *Brazilian Journal of Oceanography*, 59: 377–390.

Froese, R. 2006. Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22: 241–253.

Gab-Alla, A.A.F.A.; Hartnoll, R.C.; Ghobashy, A.F. and Mohammed, S.Z. 1990. Biology of penaeid prawns in the Suez Canal lakes. *Marine Biology*, 107: 417–426.

Geisel, J.T. 1972. Sex ratio, rate of evolution, and environmental heterogeneity. *American Naturalist*, 106: 380–387.

Leite-Jr, N.O. and Petrere-Jr, M. 2006. Growth and mortalities of the pink-shrimp *Farfantepenaeus brasiliensis* Latreille, 1970 and *F. paulensis* Pérez-Farfante, 1967 in southeast Brazil. *Brazilian Journal of Biology*, 66: 523–536.

May-Kú, M.A. and Ardisson, P.L. 2012. Morphometric relationships of juvenile *Metapenaeopsis goodie* (Smith, 1885) (Decapoda, Penaeidae) in the Yucatan Peninsula, Mexico. *Crustaceana*, 85: 937–952.

May-Kú, M.A.; Ordóñez-López, U. and Defeo, O. 2006. Morphometric differentiation in small juveniles of the pink spotted shrimp (*Farfantepenaeus brasiliensis*) and the southern pink shrimp (*F. notialis*) in the Yucatan Peninsula, Mexico. *Fishery Bulletin*, 104: 306–310.

Mello, J.T.C. 1973. Estudo populacional do camarão rosa, *Penaeus brasiliensis* (Latreille, 1817) e *Penaeus paulensis* (Pérez-Farfante, 1967). *Boletim do Instituto de Pesca*, 2: 19–65.

Moraes, S.A.S.N.; Alencar, C.E.R.D.; Fransozo, A.; Costa, R.C.; Castilho, A.L. and Freire, F.A.M. 2018. Sexual and ontogenetic morphometric variation in *Xiphopenaeus kroyeri* (Crustacea, Decapoda, Penaeidae): a new approach with linear and angular morphometric data. *Invertebrate Reproduction and Development*, 62: 143–153.

Paiva, M.P.; Menezes, A.A.S. and Andrade-Tubino, M.F. 2001. Pescarias industriais do camarão-rosa e da fauna acompanhante no estado do Rio de Janeiro, Brasil (1993-1997). *Arquivos de Ciências do Mar*, 34: 61–66.

Peixoto, S.; Cavalli, R.O.; D'Incao, F.; Milach, A.M. and Wasielesky, W. 2003. Ovarian maturation of wild *Farfantepenaeus paulensis* in relation to histological and visual changes. *Aquaculture Research*, 34: 1255–1260.

Pérez-Castañeda, R. and Defeo, O. 2002. Morphometric relationships of penaeid shrimps in a coastal lagoon: spatio-temporal variability and management implications. *Estuaries*, 25: 282–287.

Pérez-Farfante, I. 1988. Illustrated key to penaeoid shrimps of commerce in the Americas. *NOAA Technical Report NMFS*, 64: 1–38.

Primavera, J.H.; Parado-Estepa, F.D. and Lebata, J.L. 1998. Morphometric relationship of length and weight of giant tiger prawn *Penaeus monodon* according to life stage, sex and source. *Aquaculture*, 164: 67–75.

Rabelo-Neto, J.E. 1985. Relações biométricas para camarão-rosa (*Penaeus brasiliensis* e *Penaeus paulensis*) na região sul do Brasil. Superintendência do Desenvolvimento da Pesca – SUDEPE. Instituto de Pesquisa e Desenvolvimento Pesqueiro – PDP. Centro de Pesquisa e Extensão Pesqueira da Região Sudeste/ Sul - CEPSUL. Itajaí, SC. *Série Documentos Técnicos*, 2: 1–34.

Reis-Jr, J.J.C.; Freire, K.M.F.; Rosa, L.C.; Barreto, T.M.R.R. and Pauly, D. 2019. Population dynamics of Atlantic seabob *Xiphopenaeus kroyeri* (Decapoda: Penaeidae) off the state of Sergipe, north-eastern Brazil. *Journal of the Marine Biological Association of the United Kingdom*, 99: 143–153.

Segura, A.M. and Delgado, E.A. 2012. Size at sexual maturity and growth of the red shrimp *Pleoticus muelleri* (Decapoda: Penaeoidea) captured artisanally in the Atlantic coast of Uruguay. *Pan-American Journal of Aquatic Sciences*, 7: 125–134.

Silva, E.F.; Calazans, N.; Nolé, L.; Soares, R.; Frédou, F.L. and Peixoto, S. 2018. Population dynamics of the white shrimp *Litopenaeus schmitti* (Burkenroad, 1936) on the southern coast of Pernambuco, north-eastern Brazil. *Journal of the Marine Biological Association of the United Kingdom*, 99: 429–435.

Silva, E.F.; Calazans, N.; Nolé, L.; Viana, A.; Soares, R.; Peixoto, S. and Frédou, F.L. 2015. Population dynamics of the pink shrimp *Farfantepenaeus subtilis* (Pérez-Farfante, 1967) in northeastern Brazil. *Journal of Crustacean Biology*, 35: 132–139.

Souza, A.N.; Bernardes, V.P.; Hiroki, K.A.N.; Almeida, A.C.; Teixeira, G.M. and Fransozo, A. 2019. Nursery grounds of the commercially important shrimp *Farfantepenaeus brasiliensis* (Latreille, 1817) (Decapoda, Penaeoidea): comparison of the population structure between two periods. *Pan-American Journal of Aquatic Sciences*, 14: 24–33.

Teodoro, S.S.A.; Terossi, M.; Mantelatto, F.L. and Costa, R.C. 2016. Discordance in the identification of juvenile pink shrimp (*Farfantepenaeus brasiliensis* and *F. paulensis*: Family Penaeidae): an integrative approach using morphology, morphometry and barcoding. *Fisheries Research*, 183: 244–253.

Valentini, H.; D'Incao, F.; Rodrigues, L.F. and Dumont, L.F. 2012. Evolução da pescaria industrial de camarão-rosa (*Farfantepenaeus brasiliensis* e *F. paulensis*) na costa sudeste e sul do Brasil (1968-1989). *Atlântica*, 34: 157–171.

Villela, M.J.; Costa, P.A.S. and Valentin, J.L. 1997. Crescimento e mortalidade de juvenis do camarão rosa (*Penaeus brasiliensis* Latreille, 1817) na Lagoa de Araruama, Rio de Janeiro. *Revista Brasileira de Biologia*, 57: 487–499.

Zar, J.H. 2010. Biostatistical analysis. Fifth ed. Englewood Cliffs, NJ, Pearson Prentice Hall. 944p.